

Quality of 'Sharpblue' Blueberries after Electron Beam Irradiation

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Abstract. Freshly harvested 'Sharpblue' blueberries (*Vaccinium* spp.), a hybrid of complex parentage (Sharpe and Sherman, 1976), were irradiated by electron beam at 0, 0.25, 0.5, 0.75, or 1.0 kGy to determine its effects on condition and quality after treatment and subsequent storage. Berry firmness was not affected by increased doses following 1 or 3 days of storage at 1C, but it declined with higher doses when stored for 7 days at 1C. In general, berry flavor and texture declined as dosage increased; however, neither flavor nor texture were rated unacceptable by a sensory panel. Weight loss, decay, soluble solids concentration, acidity, pH, skin color, or waxy bloom were not affected by dosage or storage.

Fresh blueberries shipped from U.S. production areas to some domestic and export markets require certification as being free of insects, such as the apple maggot (*Rhagoletis pomonella* Walsh), blueberry maggot (*R. mendax* Curran), or plum curculio (*Conotrachelus nenuphar* Herbst). Methyl bromide fumigation is currently the approved quarantine treatment for security certification against these three pests. However, the continued approval of this chemical treatment is uncertain.

Irradiation is a nonchemical treatment, approved for use by the U.S. Food and Drug Administration (FDA) in Apr. 1986 (FDA, 1986) on fresh fruits or vegetables for human consumption. Although irradiation currently is not approved as a quarantine treatment for any fresh fruit or vegetable except papaya (*Carica papaya* L.) [U.S. Dept. of Agriculture (USDA), 1992], considerable research has been conducted on the effect of irradiation on various commodities (Balock et al., 1966). Even though irradiation is effective, within the FDA-

approved dosage range of 1.0 kGy or less, against the Caribbean fruit fly for grapefruit (*Citrus paradisi* Macf.) (von Windeguth, 1982) and carambola (*Averrhoa carambola* L.) (Gould and von Windeguth, 1991), it is not yet approved for use by USDA/APHIS. No horticultural injury has been reported on grapefruit (Hatton et al., 1984) or carambola (Gould and von Windeguth, 1991) from irradiation treatment. Eaton et al. (1970) found considerable variation in skin color, pulp texture, and soluble solids concentration (SSC) of highbush blue-

berry (*Vaccinium corymbosum* L.) cultivars following irradiation at 1.0 to 5.0 kGy. Horticultural evaluations of 'Climax' blueberries, a major commercial rabbiteye (*V. ashei* Reade) cultivar, following irradiation treatment indicated physical and physiological tolerance to irradiation below 0.75 kGy; higher doses adversely affected pulp texture and flavor, which contributed to rejection by consumers (Miller et al., 1994a, 1994b).

'Sharpblue' is a low-chilling, "southern highbush" blueberry hybrid that matures early in Florida and is commercially valuable (Sharpe and Sherman, 1976). Harvesting begins in late March to early April when no other blueberries are on the market. This fruit is mainly shipped to the hotel and export trade and commands a premium price. Some markets in western Canada and certain states in the United States require quarantine certification against insect infestation. The purpose of this study was to determine the tolerance and quality of 'Sharpblue' blueberries after irradiation treatment and subsequent storage.

Materials and Methods

'Sharpblue' blueberries were hand-harvested on three occasions (10, 13, and 17 May 1993) from a plantation near Gainesville, Fla. Berries were harvested at the mature-blue stage before noon and taken directly to an on-site packinghouse and packaged by hand into 0.55-liter tills that were placed 12 each into commercial master trays. The berries were then placed into a large styrofoam cooler with ice and transported to the Florida Dept. of Agriculture and Consumer Services, Division of Plant Industry, Irradiation Research Facility, in Gainesville, for treatment. On arrival, tills

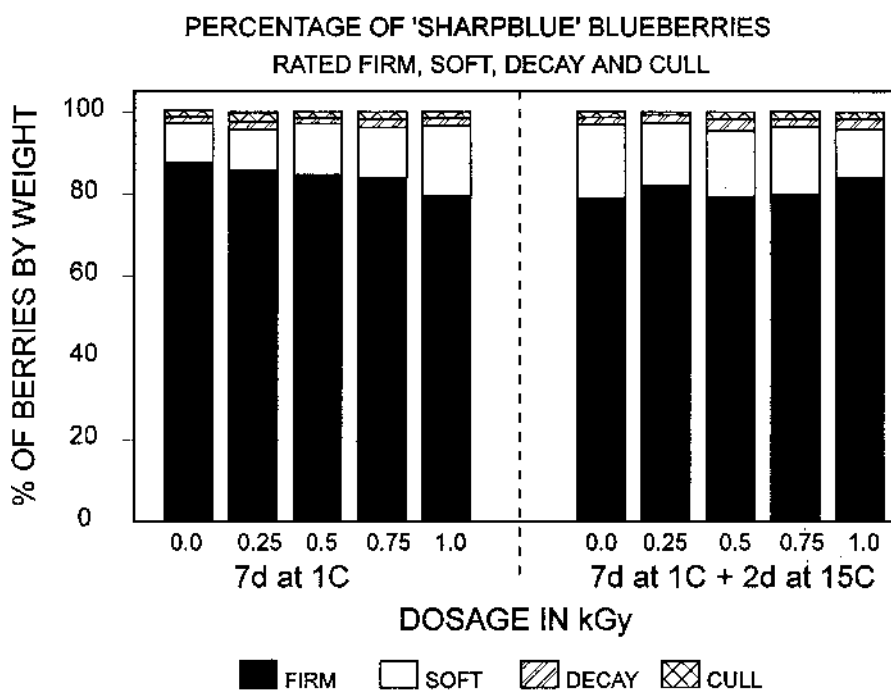


Fig. 1. Effect of irradiation on subjective firmness, decay, and cullage of 'Sharpblue' blueberries after 7 days storage at 1C and an additional 2 days at 15C. Berry firmness significantly ($P \leq 0.05$) declined as dose increased during 7 days at 1C storage; linear regression, $y = 88.4 - 8.03x$, $r^2 = 0.86$; no significant response to change in dosage for other categories or storage durations.

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of berries were removed from the master trays, weighed, and randomized into five treatments of 12 tills per master tray. Irradiation treatment commenced within 4 h of harvest for all treatments: 0 (not irradiated, but moved on the irradiator conveyor), 0.25, 0.5, 0.75, and 1.0 kGy (regimes 1 through 4). Berries were irradiated with a linear accelerator (GE-CGR, Paris, France) set to deliver a constant rate of 0.25 kGy during a single pass under the electron beam. Total dosage was applied by multiple passes under the electron beam. Treatment temperature was $\approx 22^{\circ}\text{C}$, and the total conveyance time required to deliver and return berries for each pass from the electron beam was ≈ 195 sec. After irradiation, berries were immediately taken by air-conditioned automobile to the U.S. Horticultural Research Laboratory, Orlando, Fla. (2-h trip), and placed in storage for subsequent evaluation.

Three tills from each treatment were inspected after each of four storage regimes: 1, 3, or 7 days at 1C, and 7 days at 1C plus 2 days at 15C. At each inspection, berries were placed at ambient temperature ($\approx 21^{\circ}\text{C}$) for 1 h then subjectively evaluated for firmness, juice leakage, decay, or scored as culls, and weighed as previously reported (Miller et al., 1988). Additionally, berries were rated for intensity of powdery bloom and shriveling (Miller et al., 1994a) and for split-stem scars. Flavor and mastication texture (mushiness, skin toughness) of berries were determined by a nine-member nontrained but experienced sensory panel using a modified hedonic scale ranging from 0 (extremely unacceptable) to 100 (extremely acceptable) comparing irradiated berries with control berries after each inspection. Objective peel color, SSC, titratable acidity (TA), and pH were determined as reported by Miller et al. (1994a).

Data were pooled over the three replications of harvest dates and subjected to analysis of variance procedures to test differences in quality characteristics among all treatments after each of the four storage periods.

Results

After 7 days of storage at 1C, berry firmness had significantly decreased linearly ($P \leq 0.05$), but relatively slightly in a practical sense, as irradiation dosage increased (Fig. 1). There was no effect of dosage on berry firmness during two additional days of storage at 15C. The percentage of decayed berries or those scored as culls was not affected by dosage regardless of storage duration.

Berry flavor declined linearly ($P \leq 0.05$) as dosage increased after each storage period (Fig. 2), but flavor remained sensorially acceptable even at 1.0 kGy. A sensory rating of < 50 would indicate strong consumer rejection of either texture or flavor. Berry mastication texture (Fig. 3) also was negatively affected by increasing dosage at all storage durations except after the final 2 days at 15C. The similarity in texture among berries treated at different doses after the final storage duration at 15C may be caused by increased moisture loss, which averaged 3.3% after 7 days at 1C but

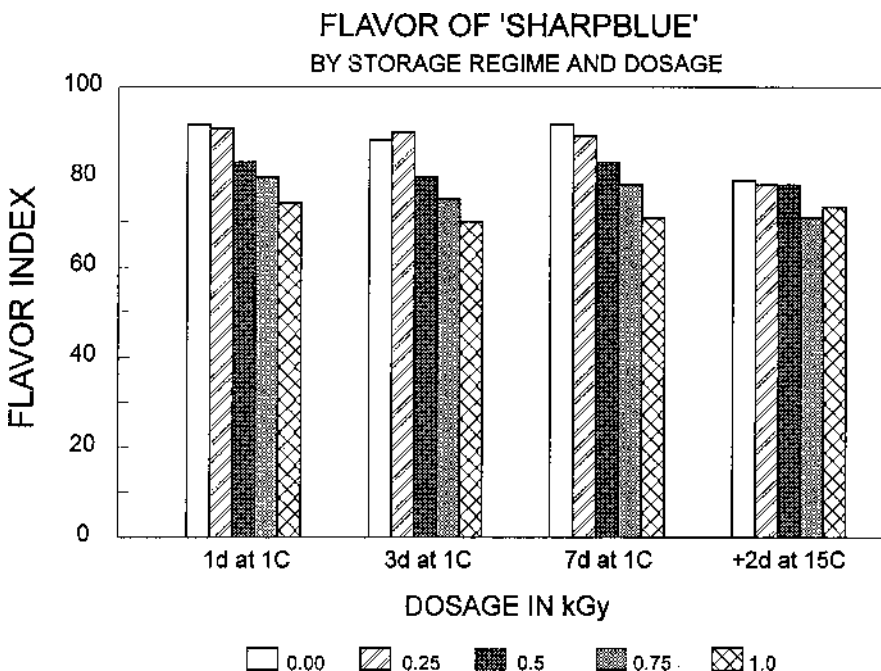


Fig. 2. Effect of irradiation and storage on flavor of 'Sharpblue' blueberries. Flavor significantly ($P \leq 0.05$) decreased as dose increased; linear regression after 1 day at 1C, $y = 95.0 - 26.0x$, $r^2 = 0.84$; 3 days at 1C, $y = 95.4 - 24.0x$, $r^2 = 0.83$; and two additional days at 15C, $y = 81.1 - 9.2x$, $r^2 = 0.34$.

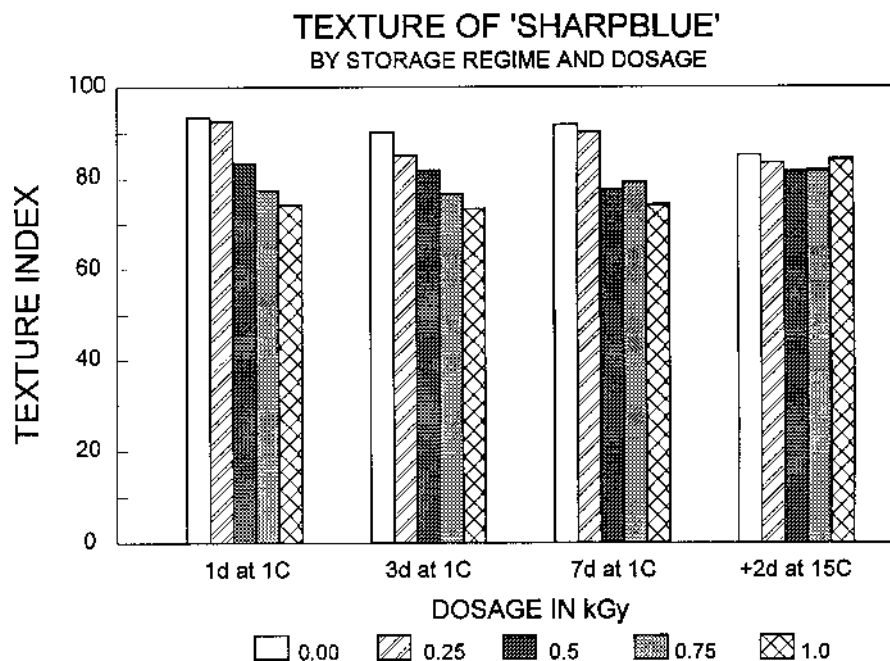


Fig. 3. Effect of irradiation and storage on mastication texture of 'Sharpblue' blueberries. Texture significantly ($P \leq 0.05$) decreased as dose increased; linear regression after 1 day at 1C, $y = 97.1 - 24.3x$, $r^2 = 0.90$; 3 days at 1C, $y = 89.2 - 16.0x$, $r^2 = 0.44$; 7 days at 1C, $y = 91.7 - 18.3x$, $r^2 = 0.59$; and nonsignificant at two additional days at 15C.

5.4% after 7 days at 1C plus 2 days at 15C.

Mean SSC, TA, and pH values were 14.3%, 0.55%, and 3.50% 1 day after treatment, and 14.5%, 0.53%, and 3.56%, respectively, after the final inspection. PeelL*, a*, and b* Hunter color (CIE, 1976) means were 28.1, 1.13, and -0.18 after 1 day following irradiation and 27.6, 0.98, and 0.20 after the final inspection, and were not affected by dosage. Mean weight loss percentage was 1.2, 1.6, 3.3, and 5.4 after

storage regimes 1, 2, 3, and 4, respectively. None of these quality factors were influenced by irradiation dosage.

Stem-scar tearing was present on $\approx 80\%$ of berries after harvest. This condition is characteristic of 'Sharpblue' (Sharpe and Sherman, 1976). We saw no decay development due to stem-scar tearing, but stem tearing did contribute to infrequent juice leakage from some berries.

Discussion

Flavor and texture of 'Sharpblue' berries were two characteristics negatively affected as irradiation dosage increased. We previously reported that flavor and texture declined for 'Climax' berries as dosage increased, but the negative impact of dosage was greater on 'Climax' fruit (Miller et al., 1994a) than for 'Sharpblue' in this study. The percentage of 'Climax' berries rated as firm after irradiation declined to $\approx 30\%$ at doses of 0.75 kGy or higher, whereas $\approx 80\%$ of 'Sharpblue' berries remained firm at all irradiation doses. Our findings confirm those of Eaton et al. (1970), who showed considerable differences in the horticultural responses of highbush blueberry cultivars after irradiation and storage. 'Sharpblue' berries may be irradiated at doses to 0.75 kGy with some decline in sensory attributes such as flavor and texture; however, the magnitude of decline should have little impact on consumer acceptance of treated berries. Although stem-scar tearing was noted in this study, irradiation had no related deleterious consequence. *Rhagoletis indifferens* and Tephritidae larvae succumb to irradiation lev-

els < 0.75 kGy (Burditt, 1994), which likely also would be effective for the control of *R. pomonella* and *R. mendax*. Investigations on the efficacy of irradiation on *Conotrachelus nenuphar* have not been done. Provided that insect infestations can be controlled by a treatment no higher than 0.75 kGy, 'Sharpblue' blueberries appear to tolerate irradiation as an acceptable nonchemical quarantine treatment.

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