# Use of technology radiation as a method of reducing the microorganism and conservation postharvest of caja during storage

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Abstract

The caja fruit (*Spondias* spp.) are among the species considered exotic presents excellent view of economic exploitation to the Northeast of Brazil. However, contamination by microorganisms is a major factor in postharvest losses of fruits and other cultivated in Brazilian territory. Use of ionizing radiation aiming to reduce the use of pesticide products in pest control and microorganisms phytopathological and maintaining the quality of agricultural products has been studied by several researchers of postharvest fruit. This technology meets the requirements of food safety imposed by the various organs of public health. In order to evaluate the action of ionizing radiation on agents phytopathological and the effects on the quality of postharvest of caja fruits when stored under temperature of shelf, the experiment was conducted with application of doses 1.0 and 2.0 kGy, dose zero as fruit control, and storage under temperature of 23°C for twelve days. Control fruit had higher contamination by microorganisms phytopathological throughout the storage period. Analysis of total soluble solids, total titratable acidity, hydrogen potential, soluble solids/titratable acidity ratio, ascorbic acid and color of the flesh have suffered minor variations between the different doses studied.

Keywords: *C*onservation; caja fruit; gamma radiation; postharvest storage; microorganism spoilage.

## *1. Introduction*

The Brazilian Northeast has a wide variety of species fruit considered exotic, with good acceptance by local consumers. Many species still have a inadequate harvest that affect their quality and cause heavy losses during the marketing because extensive contamination in fruit by microorganisms (Schöttler and Hamatschek, 1994; Mattietto et al., 2003; Mata et al., 2005).

The caja *(Spondias* spp.), is among the species that presents excellent prospects for economic exploitation for the Northeast Region of Brazil. Its fruit has excellent qualities, plus high vitamin C content and medicinal properties to fight infection and increases immune efficiency (Barroso et al., 1999, Lee et al., 2002). However, the consumption of fruits of *Spondias* species occurs mostly in the form of juice and ice cream industrialized, especially where exploitation occurs in the form of extraction and non-commercial planting (Gomes, 1990; Lima et al., 2002; Gouveia et al., 2003). The trade of raw fruits is almost nonexistent on supermarket shelves, situation which can be attributed to the lack of application of techniques for postharvest retention of fruits arrived at the consumer's table. The technical knowledge of the fate of qualitative traits of these species after harvest will increase raw caja consumption, with positive effect on population health, meanwhile to contribute to the economy of the northeast region as an additional source of income for small and medium producers in the region. Application of new technologies to reduce postharvest losses and maintain the quality of the fruit until the consumer has been the subject of research already for several decades. Use of ionizing radiation with the order of reducing the attack of pathogenic microorganisms and maintain the quality of agricultural products has been studied by several researchers in the field of postharvest. The results of these studies has been the basis to meet the requirements of food quality and safety required by various agencies related to public health, in view of the large amount of chemicals that has harmed the health of the population. Phytosanitary measures imposed for fresh fruit has favored the use of ionizing radiation, which has been recognized as effective method for food safety insurance and economy of many developed countries (Moraes, 2000; Marin-Huachaca et al., 2002). The objective of this research was to study the effects of

ionizing radiation on pathogenic microorganisms and the characteristics of postharvest quality of the caja (*Spondias* spp.), stored at a temperature of 23ºC during twelve days.

*2. Material and methods*

Caja fruit (*Spondias* spp.), taken with a complete development solution, average size of about 1.5 cm in diameter and free of injury, were placed in trays Izopor and covered with PVC film of 12 μm thickness, then irradiated at a dose of 1.0 and 2.0 kGy with a source of Cobalt-60 delivering 8.993 kGy/h (vs. zero-dose for control fruits). The fruits were stored for 12 days at 23ºC. Symptoms of leaf rust disease were observed every four days and the results expressed in percentage of fruit affected with rot. Chemical and sensory analysis were carried out at the end of storage.

*2.1. Sensorial analyses*

Acceptance test of acceptability with the participation of 38 panellists was conducted to evaluate the external appearance. We used a hedonic scale divided in seven levels (7 = like extremely; 6 = liked very much; 5 = like slightly; 4 = neither liked nor disliked; 3 = dislike slightly; 2 = dislike very much; 1 = disliked extremely). The samples were numbered with three-digit numeral and each evaluator received a sample treated by each dose (including control) in separate cabins and with appropriate lighting.

*2.2. Physical-chemical and biochemical analyzes*

Chemical analyzes were carried out in the pulp with two replicates per sample and the results expressed in the units described in the literature for each analysis.

*2.2.1. Total soluble solids*

They were determined by the method of refraction through the refractometer of brand Atago, model Master-T. The results were expressed in Brix' degree (°Brix), as recommended by the Institute Adolfo Lutz (IAL, 1985).

*2.2.2. Total titratable acidity*

It was determined by the procedure electrometric titration with NaOH 0.1 N until pH reach 8.1 (referring to the pH color change indicator phenol phtaleín), as recommended by the Institute Adolfo Lutz (IAL, 1985). The results were expressed as percentage of citric acid equivalent in the pulp.

*2.2.3. Soluble solids / titrable acidity ratio*

This ratio was determined by dividing the values found in soluble solids and total acidity.

*2.2.4. Hydrogenic potential (pH)*

PH was determined with a digital pH-meter with a glass electrode immersed in the solution containing the pulp.

*2.2.5. Color of pulp*

The colour index was determined with the Minolta colorimeter CR-300 model, operating system illuminant D65 and 2° standard observer.The results were expressed by the color parameters L*, a* and b* according with McGuirre (1992).

*2.2.6. Amount of C vitamin*

The vitamin C content was determined in the pulp after addition of 0.8% oxalic acid solution as a stabilizer. We used the methodology specified by Carvalho et al. (1990), which uses as main reagent a solution of 2.6-dichlorophenolindophenol. The results were expressed in mg of ascorbic acid per 100 g of pulp.

*2.3. Delineation statistics*

We used the fully case-to-case delineation, represented by a cultivar, three doses of ionizing radiation and four replicates with twenty fruits. The results were submitted to analysis of variance by F test and mean differences by Duncan test at 5% probability according to Gomes (2002).

*3. Results and discussion*

After four days storage, the fruits control showed that 15% of control fruits already were contaminated byrot, while the fruits irradiated at doses of 1.0 and 2.0 kGy had no symptom of decay (Figure 1A). This indicated a very positive effect on the action of ionizing radiation on control of these phytopathogenic mould that cause rot in caja, affecting its external appearance during marketing, and preventing its raw consumption. Wen et al. (2006), studying the effect of radiation on various fungi and Lycium fruit on their sensory characteristics, concluded that a dose of 14 kGy was ideal for the decontamination of fruit and for the retention of sensory quality and the extension of the shelf life.

After eight days of storage, with the fruits receiving doses of 1.0 and 2.0 kGy, it was observed 11 and 9% of fruits, respectively, with evident symptoms of decay, to be compared with control fruits exhibiting a total of 38% with advanced disease (Figure 1A). However, it was observed that the colour of rot disease contaminated control fruits remained uniform, whereas irradiated fruits showed a slight unevenness in skin color. Similar results were found by Wani et al. (2007), who work with pear (*Pyrus communis* L.) stored at a temperature of 25ºC, which reported that doses of 2.0 and 2.5 kGy could reduce the microbiological inoculum charge and the delay of fruit ripening, but the color of the fruit was affected.

At the end of the experiment after a 12-d storage period, fruits that received dose of 1.0 kGy showed 21% beginning rot contamination, and those who received the dose of 2.0 kGy showed 15% beginning rot. However, 48% of non-irradiated fruits (control) presented a very advanced rot attack (Figure 1A). The results indicate a direct effect of ionizing radiation in reducing the amount of fruits affected by phytopathogenic microorganisms and also limiting the intensity of damage they caused. This sanitation effect can be attributed to the action of radiation in preventing or slowing the reproduction of quickly dividing cells, such as in the case of bacteria, fungi and yeasts (Jessup et al., 1988). Other studies have demonstrated the effect of radiation to extend the shelf life of fruits. Baghel et al. (2006), when they worked with different doses of ionizing radiation applied to lime (*Citrus* sp.) found that small dose of 100 Gy resulted in maintaining the physical-chemical composition of the fruit up to 22 days compared to control fruits.

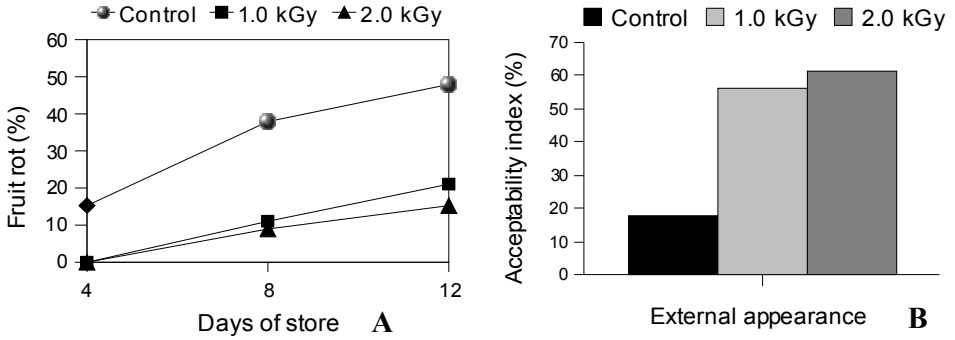


**Figure 1** Percentage of fruit with rot (FIG. A) and rate of acceptance (FIG. B) of caja (*Spondias spp*), irradiated and stored for 12 days at 23ºC.

Sensory analysis of external appearance of control fruit showed a significant decrease of 68 and 71% in the acceptability over fruits that received doses of 1.0 and 2.0 kGy, respectively (Figure 1B). These levels of reduction in acceptability of non-irradiated fruits was significant in the analysis of test ordering by Newell & Mac Fairlane, when compared with irradiated fruits (Table 1).

**Table 1** Statistical averages of the chemical analysis of caja (*Spondias spp*) irradiated and stored for 12 days at 23º C.

| Variable | Dose (kGy) | | |
|---|---|---|---|
| | **Control** | **1.0** | **2.0** |
| External appearance | 1.24 b* | 3.92 a | 4.27 a |
| Total soluble solids (ºBrix) | 7.85 a | 8.25 ab | 8.80 b |
| Total titra. acidity (% of ac. citric) | 1.45 a | 1.45 a | 1.53 a |
| Potential of hydrogen (pH) | 3.32 a | 3.34 a | 3.24 a |
| Soluble /acidity ratio | 5.43 a | 5.71 a | 5.78a |
| Ascorbic Acid (mg/100g) | 14.63 a | 11.38 a | 11.7 a |
| Colour of the pulp (L*) | 53.42 b | 47.36 a | 46.27 a |
| Colour of the pulp (a*) | 6.13 a | 4.03 a | 5.02 a |
| Colour of the pulp (b*) | 30.06 b | 23.28 a | 23.77 a |

For a given row, averages followed by the same letter do not differ statistically for the Duncans multiple range test ($P < 0.05$).

The amount of soluble solids was slightly higher in fruits irradiated with values of 8.25 and 8.80 °Brix in fruits with doses of 1 and 2 kGy, respectively, and 7.85 °Brix for control fruits (Table 1). Lira Junior et al. (2005), studying 19 genotypes of Spondias spp., found increased values of soluble solids, with a mean of 14.84 °Brix. Mata et al. (2005) found values closer to the present study who reported average value of 9.10 °Brix in the pulp of *Spondias lutea* L.

The values of total acidity showed little variation, and no significant difference between the different doses of radiation can be observed. With fruits irradiated at a dose of 2.0 kGy, it it was observed an increase in total acidity values, with an average of 1.53 g of citric acid per 100 g of fresh pulp values in agreement with the values obtained for pH, since these irradiated fruits have the lowest pH measured at 3.24 on average (Table 1). Silva et al. (1997) also found values of total acidity similar to the values reported in the present study, i.e. 1.47 g of citric acid per 100 g of fresh pulp of Spondias lutea L.

The ratio solids/acidity represents a good characteristic for quality assessment for caja fruit species (Spondias spp.), because it highlights the flavor of the pulp and may even be more representative than a separated measurement of sweetness (total solids) and acid (acidity). The ratio values ranged from 5.43 to 5.78 for control fruits and fruits that received the dose of 2.0 kGy (Table 1), respectively. These values, considered relatively low, are associated with the high value of the acidity found in fruits. Lira Junior et al. (2005) found slightly higher values, with an average of 9.05 in *Spondias* spp.

The amount of ascorbic acid is one of the properties of the fruits that is the most exposed to environment conditions changes depending on various factors external and internal to the fruit. The results found for this variable revealed that control fruits resulted in a greater amount of ascorbic acid, with a mean value of 14.63 mg per 100 g of fresh pulp, whereas irradiated fruits with 1.0 and 2.0 kGy showed average values of 11.38 and 11.70 mg per 100 g of fresh pulp, respectively. However, this reduction in ascorbic acid content after irradiation was not significant between the two studied doses (Table 1). Similar values have been found by Oliveira et al. (1999), which reported an average of 10.29 mg per 100 g of fresh pulp in their work with *Spondias lutea* L.

The color index f fruits pulp of control fruits showed the highest values for parameters L*, a*, b*, with a significant difference observed for L* and b* between control fruits and irradiated fruits (Table 1). The results for flesh color indicated a more yellow color, more red and higher luminosity for the pulp of control fruits, which may represent a greater degree of maturity in these fruits.

*4. Conclusion*

From the results found in this study it can be concluded that ionizing radiation has proven effective in controlling phytopathogenic microorganisms of caja fruits (Spondias spp.), without significant changes in the chemical characteristics of the fruit.

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