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RIPENING OF FRUITS OF 'DWARF PRATA' BANANA (*Musa acuminata x Musa balbisiana*, AAB group) IRRADIATED AND TREATED WITH CALCIUM CARBIDE

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ABSTRACT

The competing effects resulting from the exposure of fruits of "dwarf prata" banana (*Musa acuminata x Musa balbisiana*, AAB group) to gamma radiation and to calcium carbide have been investigated in this work. The fruits were harvested in a pre-climateric stage (green colored though physiologically developed) in the city of Jaíba, state of Minas Gerais, and gamma irradiated with doses of 0.25 or 0.50 kGy in a research irradiating facility at the Brazilian Army Technology Center (CTEx) in the city of Rio de Janeiro. Some samples were also exposed to calcium carbide for 32 hours in order to accelerate ripening. Quantitative estimates of peel color, disease index and fresh mass loss were performed for 9 days while the fruits were kept at an average temperature of 23º C. The analyses were performed in the Federal Rural University of Rio de Janeiro, located in the city of Seropédica. The following treatments or combination of processes have been tested: untreated (control); treated only with irradiation with doses of 0.25 kGy or 0.50 kGy; treated with irradiation with doses of 0.25 kGy or 0.50 kGy and then exposed to calcium carbide. The fruits treated solely with irradiation with 0.25 kGy exhibited a better response during the first days of storage, although their initial green coloration vanished with time. In addition, the fungi *Colletotrichum musae* and *Lasidioplodia theobroma* were detected in samples submitted to the combination of both processes. In contrast, such fungi were not observed in fruits that had only been exposed to 0.25 kGy and exhibited low disease indices. Also, 1-2 cm lesions were detected on fruits

irradiated with 0.50 kGy. Regardless of the treatment, during the 9-day storage period, all samples were found to undergo fresh mass losses (due to breathing and transpiration) higher than the 10% limit recommended for commercialization. In addition, lower losses were found in bananas that had only been treated with 0.25 kGy. Finally, it was concluded that irradiation alone with a 0.25 kGy dose was considered the most efficient among the treatments tested for control of diseases in fruits of 'dwarf prata' banana.

1. INTRODUCTION

Being widely consumed in Brazil, banana is an inexpensive source of vitamins and minerals and those characteristics render the fruit an important social and economic role. It ranks fourth among the most important agricultural products worldwide, only lagging behind rice, wheat and corn [1].

Irradiation is a physical treatment that consists in the controlled exposure of a product to a known field of ionizing radiation (usually from a cobalt-60 source or an electron beam) so that it absorbs a certain amount of energy [2]. The process efficiently kills insects and bacteria and inactivates parasites and fungi. Thus it has been used in the control of foodborne diseases and pests and also for conservation purposes, improving the quality and safety of many types of foods and frequently rendering an extension in shelf life. Irradiation is also used to delay ripening of fruits and inhibit sprouting of bulbs, roots and tubers [3].

Ripening is the process that causes fruits to become sweeter, less green, and softer. Calcium carbide has been used in some countries for ripening fruits artificially. Once dissolved in water or when reacting with the moisture in air, it produces acetylene, which acts as an artificial ripening agent similarly to ethylene. As a climacteric fruit, banana can be treated with calcium carbide in order to produce a faster and more homogeneous ripening aimed at simplifying its handling and industrialization [4]. In addition, its highly sensitive and perishable characteristics require its commercialization to be fast and elaborate [5].

The experiments performed in this work have been aimed at investigating the effects on ripening resulting from the competition between the delaying action of irradiation and the stimulating influence originating from the exposure of the fruits of 'dwarf Prata' bananas bananas to calcium carbide.

2. EXPERIMENTS

Fruits of of 'dwarf Prata' banana (*Musa acuminata x Musa balbisiana*, group AAB) harvested in a preclimacteric stage in Jaíba (MG, Brazil) were then taken to CTEx, Rio de Janeiro, a day later where 80% of them were treated with gamma-ray doses of 0.25 and 0.50 kGy in a 47 kCi 137Cs-source research irradiator [6] at a dose rate of 1.7±0.2 kGy/h. In addition, a few hours after irradiation, half of the irradiated fruits were exposed to CaC_2 that produced an equilibrium concentration of acetylene at 7g per cubic meter of air for 32 hours in the Post-Harvest Laboratory of UFRRJ at a mean temperature of 23ºC.

The experiments included a total of five different lots of samples subjected to different treatments or combinations of treatments, namely: (1) Control – untreated samples, neither irradiated nor treated with CaC_2; Samples irradiated only with dose of (2) 0.25 kGy or (3) 0.50 kGy (not treated with CaC_2) and samples treated with CaC_2 after irradiation with (4) 0.25 kGy or (5) 0.50 kGy. All fruits of banana were kept at room temperature (approximately 23ºC) and had their physicochemical characteristics monitored on five different dates for up to 9 days of storage in order to determine their quality and stage of ripening. Measurements of fresh mass loss, peel color and disease index have been performed.

Fresh mass loss, determined by using an accurate scale, was expressed in percentages. Visual estimates of peel coloration followed a 1-7 scale where "1" corresponds to green fruits, "6" to yellow ones and "7" to fruits exhibiting yellow and brown colorations [7]. Finally, the disease index was visually estimated according to a 0-3 scale where "0" means no sign of black spots and 1-3 indicate the presence of lesions with diameters d(cm) such that 1, 2 and 3 correspond to: d<1, 1<d<2 and d>2, respectively [8]. Five repetitions were performed for each data point, expressed as the arithmetic mean of the measurements and spline-smoothed curves were traced through the points.

Two sets of experiments were performed for peel color and disease index and included 5 treatments and 5 repetitions (5 bouquets with 3 fruits) in a 5 x 5 factorial scheme (5 treatments and 5 evaluation periods) for the first data set and in a 5 x 4 (5 treatments and 4 evaluation periods) for the second data set. Data for fresh mass loss were compared in the form of means according to Tukey`s test at 5% confidence level and regression analyses were performed to predict the time variation of parameters.

3. RESULTS AND DISCUSSION

As shown in Fig. 1, the fruits treated only with irradiation with 0.25 kGy, exhibited the best response in the beginning of storage in terms of conservation, looking greener than the non-irradiated ones or those irradiated with 0.50 kGy.

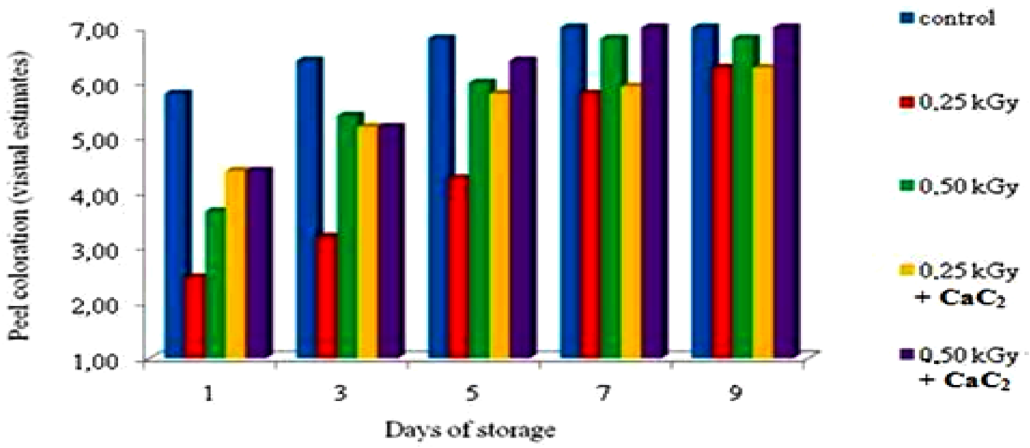

Figure 1. Visual estimates of peel coloration as function of storage time for fruits of 'dwarf Prata' banana submitted to five different treatments.

However, the peel of the fruits treated only with irradiation with 0.25 kGy did not remain green until the end of storage. Other investigations also reported little and gradual or no change whatsoever in color preservation with similar doses [9,10]. A finding worth reporting is that, independently of the treatment, even those samples graded as 7 regarding peel color (indicative of senescence) were found to exhibit pulps appropriate for consumption.

The disease index measured in the samples has been plotted as a function of storage time in Fig. 2. Signs of pathogenic deterioration were seen as early as on the third day of storage in control samples. Also, a remarkable difference could be noticed between the disease index of non-irradiated (control) and irradiated bananas, with irradiation alone with 0.25 kGy yielding the best fungal control and consequently the lowest values of contamination throughout the 9-day storage. Similar results, also supporting the protective role of irradiation, have been reported in other works [11,12] However, after one week, contamination by the fungi *Colletotrichum musae* (agent of anthracnose) *and Lasidioplodia theobroma* was detected in the form of stains or dark 1 to 2 cm-long lesions, more frequent in the control and in samples treated with 0.5 kGy and also with CaC_2. Apparently, the combined stress produced by both processes contributed to weaken the defense response of the fruits, facilitating the onset of microbiological degradation. Also, by accelerating ripening, exposure to CaC_2 could have also contributed to generate more suitable conditions for development of anthracnose [13].

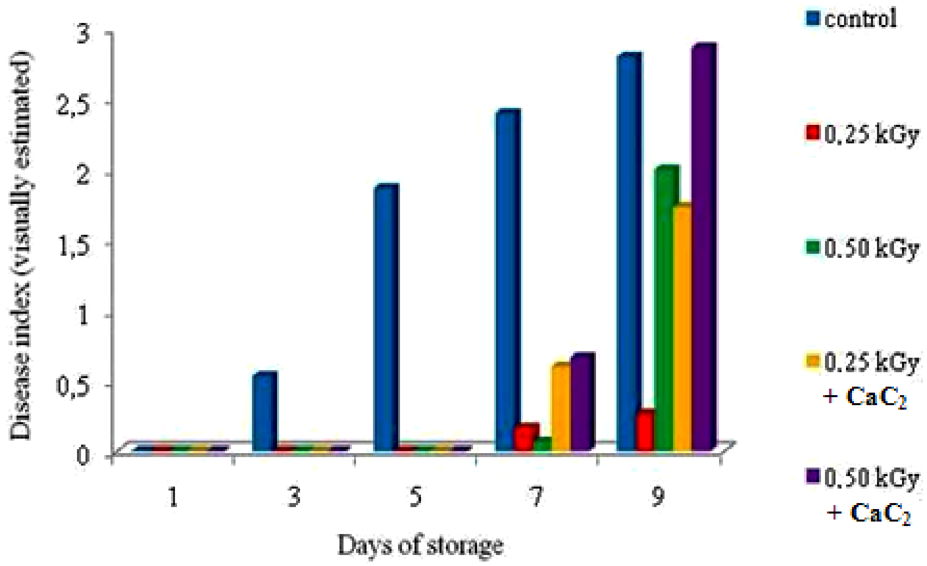

Figure 2. Estimates of the disease index as function of storage time for fruits of 'dwarf Prata' banana submitted to five different treatments.

Listed in Table 1 are the results for the loss of fresh mass in the fruits. The values have been found to increase with time in storage. Consequently, after one week, with exception of those samples solely treated with irradiation with 0.25 kGy, all other had exceeded the recommended limit of 10% loss (required to ensure quality [3]). In addition, no significant difference at the 5% level was observed among the treatments, with only one exception found after nine days of storage, between samples treated solely with irradiation at 0.25 kGy in comparison with those treated by exposure to gamma radiation at that same dose and also to CaC_2. However, the data for fruits only irradiated with 0.25 kGy are consistently lower than those associated to the other five treatments, indicating lower fresh mass loss throughout the storage period. Although not significant at the 5% level, such trend is indeed confirmed by Tukey`s test at 10% confidence level. Such findings somewhat differ from those found elsewhere [14].

Table 1. Fresh mass loss (%) measured in fruits of 'dwarf prata' bananas submitted to one of five treatments, including irradiation (with 0.25 or 0.50 kGy) and exposure to CaC_2 and monitored for up to 9 days.

Treatment	Fresh Mass Loss (%) Time in Storage (days)			
	3	**5**	**7**	**9**
Control (0 kGy)	3.8 a	7.2 a	10.2 a	13.5 ab
0.25 kGy	2.5 a	4.8 a	7.34 a	10.6 b
0.50 kGy	3.8 a	7.4 a	10.3 a	13.4 ab
0.25 kGy and CaC_2	3.9 a	7.4 a	10.2 a	13.3 ab
0.25 kGy and CaC_2	4.6 a	7.9 a	10.8 a	14.3 a
CV (%)				22.4

Means in the same column followed by the same letter do not differ significantly according to Tukey`s test at 5% significance.

3. CONCLUSIONS

Based on the results for the disease index obtained in this work, it can be concluded that the protective role of irradiation and its efficacy in fungus control in fruits of 'Dwarf Prata" bananas has been demonstrated, especially for the treatment with 0.25 kGy. However, irradiation with doses of 0.25 or 0.50 kGy was not able to inhibit the acceleration of ripening produced by exposure to CaC_2 that eventually limited the shelf life of the fruits. Comparing the results from the five treatments investigated in this work, it can be concluded that irradiation alone with 0.25 kGy dose yielded the best conservation effects, efficiently controlling fungal contamination and to a lesser extent delaying ripening and reducing fresh mass loss during storage.

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