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# EFFECTS OF GAMMA IRRADIATION FOLLOWED BY CLIMATIZATION ON THE QUALITY OF 'PRATA' BANANA (*Musa acuminata x Musa balbisiana*, AAB)

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## ABSTRACT

Banana is a highly perishable climacteric fruit. In order to ensure fast and homogeneous ripening that will make its processing and commercialization easier, it is usually treated by climatization. On the other hand, irradiation is an interesting physical process capable of delaying ripening and extending the shelf life of fruits. This work investigated the competing effects of irradiation followed by climatization on the quality of 'Prata' banana (*Musa acuminata* x *Musa balbisiana*, AAB). All fruits were harvested in the preclimacteric stage, rinsed and stored at 27°C after being submitted to five different treatments. After hygienization, four out of five samples were exposed to gamma-ray at doses of 0.25 and 0.50 kGy. The unirradiated fruits were left for control and half of the irradiated samples were then climatized by exposure to $CaC_2$. Measurements of fresh mass loss, total soluble solids, peel coloration and disease index were performed on five different dates for up to nine days in order to monitor quality and the degree of ripening. It was found that high temperatures prevailing during climatization and storage accelerated maturation in all fruits in spite of the use of irradiation, with the control becoming ripe in 3 days only. In addition, based on the consistent results from the experiments performed, it can be concluded that irradiation at the doses tested was unable to overcome the maturation effects produced by climatization. However, the sole use of irradiation with 0.25 kGy yielded the lowest figures for fresh mass loss and disease index in the samples, thus becoming the most attractive among the treatments tested.

## 1. INTRODUCTION

Outsold only by orange, banana is the second most consumed fruit in metropolitan regions of Brazil. It is largely appreciated in all classes of the population not only as a dessert option but mostly as a food item [1].

As a climacteric fruit, banana is frequently treated by climatization in order to yield a faster and more homogeneous maturation aimed at simplifying the planning of its handling and

industrialization [2]. In addition, its sensitive and highly perishable characteristics require its commercialization to be fast and elaborate [3].

Irradiation is an alternative process that is capable of efficiently disinfesting and delaying ripening of fruits [4-7]. Low doses of gamma radiation or fast electron beams can be used to treat fruits of banana in a preclimacteric stage in order to delay ripening and extend shelf life, yielding some extra time for transportation. Climatization is then applied in order to accelerate and homogenize ripening when the fruits are ready to be commercialized [8].

This work investigated the effects of irradiation with 0.25 and 0.50 kGy promptly followed by climatization on the conservation of 'Prata' bananas.

## 2. EXPERIMENTS

Fruits of 'Prata' banana (*Musa acuminata x Musa balbisiana* group AAB) harvested in a preclimacteric stage in Angra dos Reis were rinsed with chlorinated water at 3% and 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 [9] 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 $CaC_2$ at 7g per cubic meter of air for 32 hours in the Post-Harvest Laboratory of UFRRJ at a mean temperature of 27$^{o}$C.

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 climatized; irradiated samples that were not subjected to climatization after exposure to (2) 0.25 kGy and (3) 0.50 kGy, and samples treated by climatization after irradiation with (4) 0.25 kGy and (5) 0.50 kGy. All fruits of banana were kept at room temperature (approximately 27$^{o}$C) 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 maturation.

Measurements of fresh mass loss, total soluble solids, peel coloration and disease index were performed. Fresh mass loss, determined by using an accurate scale, was expressed in percentage. The concentration of total soluble solids was directly measured with a traditional handheld refractometer and expressed in $^{o}$Brix [10]. 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 [11]. 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 [12]. Five repetitions were performed for each data point, obtained as the arithmetic mean of the measurements, and spline-smoothed curves were traced through the points. In addition, Tukey`s test at the 95% confidence level was used to investigate possible correlations among the data.

## 3. RESULTS AND DISCUSSION

Fresh mass loss increased with time roughly in a linear fashion for all treatments tested, as shown in Fig.1, with the rate for the control and for samples treated solely by irradiation with 0.25 kGy being about half those of the other samples. As a consequence, the former reached the recommended limit for fresh mass loss equal to 10% [13] 4 days later than the latter, that exceeded that figure on the fifth day and exhibited a 20% mass loss on the ninth day of storage, probably associated to complete maturation. The high temperatures prevailing during climatization are likely to have contributed to such difference, shortening the shelf life of the fruits.

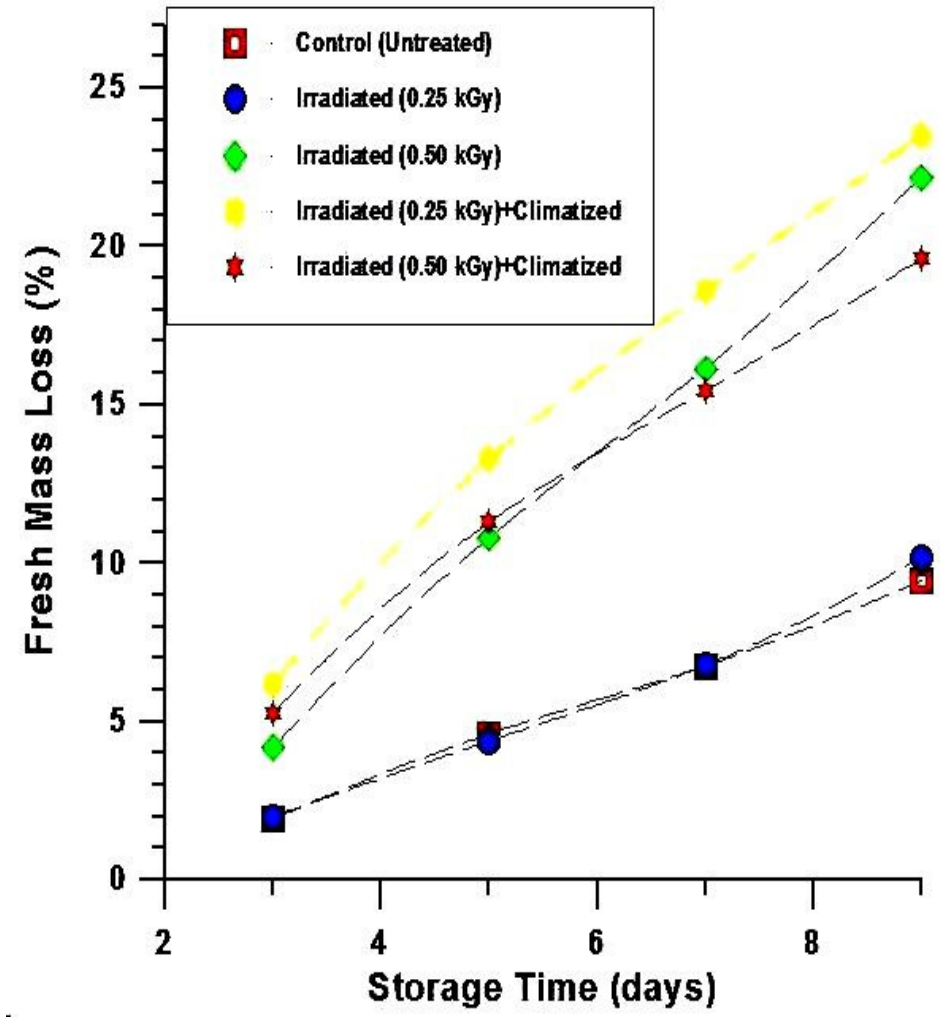


**Figure 1. Fresh mass loss determined as function of storage time for fruits of 'Prata' banana submitted to five different treatments.**

The levels of total soluble solids in the samples are depicted in Fig. 2 and show significant differences produced by climatization and irradiation in comparison with untreated samples (control). Natural maturing accounts for the gradual build-up of sugar concentration in the control from about 18° to 26° Brix during the 9 days of storage, contrasting with the approximately constant figures, straggling around 25° Brix, measured in samples treated by both irradiation and climatization. Those higher values measured for climatized samples are probably associated to the higher sugar contents produced by climatization as it promptly accelerates maturation of the fruits. In addition, in samples treated by irradiation with 0.50 kGy followed by climatization, a small decrease in the concentration of total soluble solids is observed between days 7 and 9, probably signaling the beginning of senescence, following the maximum concentration of total soluble solids, when the energy reserves, and consequently the number of sugar molecules, start to decline [13]. Regarding the irradiated samples not submitted to climatization, the sudden initial increase in the figures relatively to control is possibly due to the production of small molecules of sugar from the dissociation of larger ones by irradiation. Radiation-induced hydrolysis of amide, leading to the formation of fructose, glucose and saccharose is likely to be the major mechanism responsible for that process [14]. Moreover, the wavelike pattern of the curves hints at the presence of competing mechanisms affecting the concentration of soluble solids in the fruits treated by irradiation only.

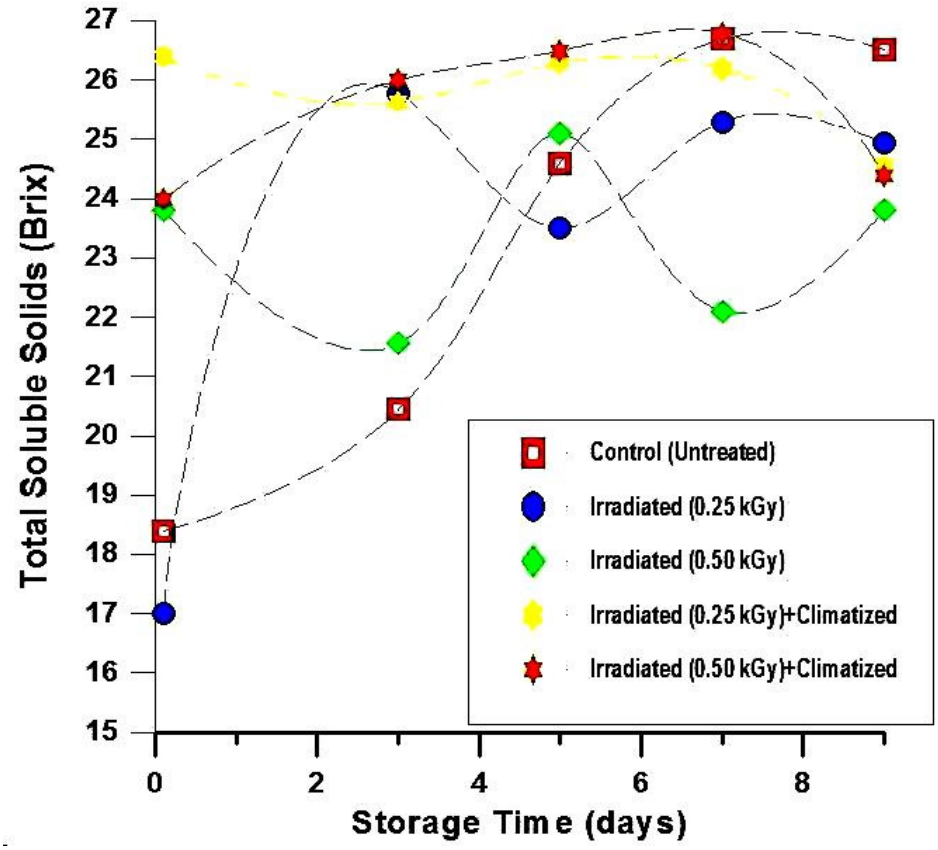


**Figure 2. Levels of total soluble solids measured as function of storage time for fruits of 'Prata' banana submitted to five different treatments.**

Peel coloration is known to result primarily from the gradual degradation of chlorophyll, also being affected to a lesser extent by synthesis of other pigments [15]. The estimates of peel coloration are plotted in Fig. 3. After three days of storage, the fruits of control were still completely green in severe contrast in appearance to those submitted to other treatments, that had become yellow, signaling full maturation.

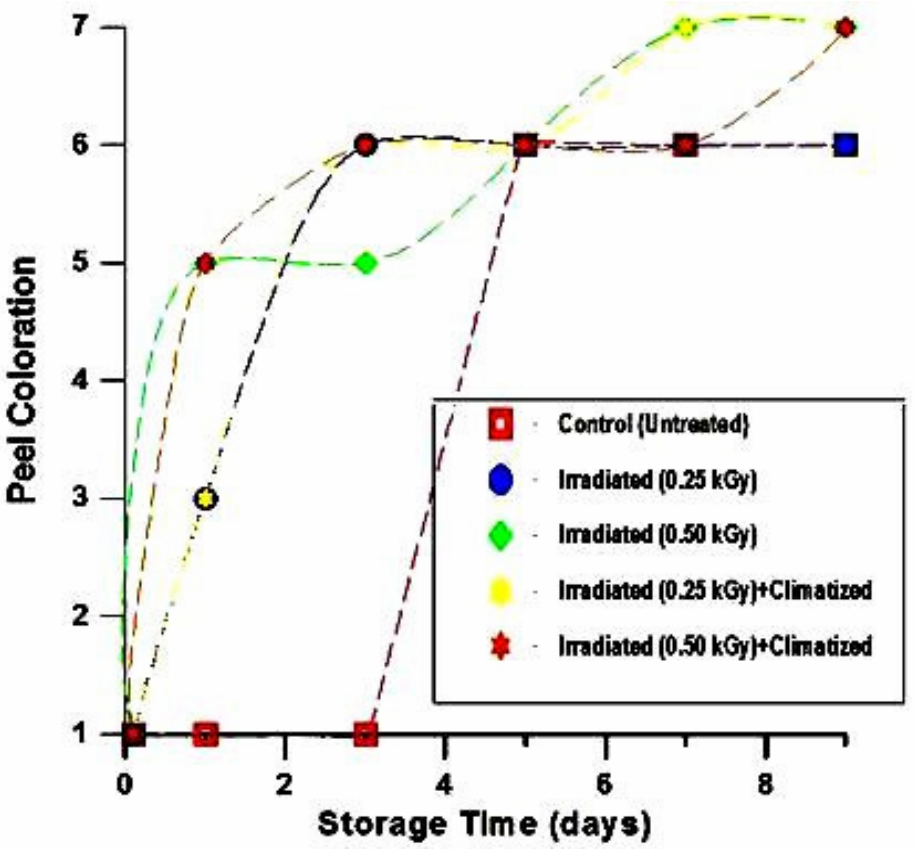


**Figure 3. Visual estimates of peel coloration as function of storage time for fruits of 'Prata' banana submitted to five different treatments.**

Estimates of the disease index are shown in Fig. 4. Samples irradiated with 0.25 kGy presented no signs of diseases whatsoever throughout the 9-day period of monitoring. A possible explanation for that feature is that such low dose, while being sufficient to significantly retard maturation and reduce the number of microorganisms, was not capable of harming the protection barriers of the fruits. Moreover, in severe contrast the other samples exhibited black and brown spots on the peel due to an increased susceptibility of the fruits to microorganisms associated to the onset of senescence [13] after 7 days of storage.

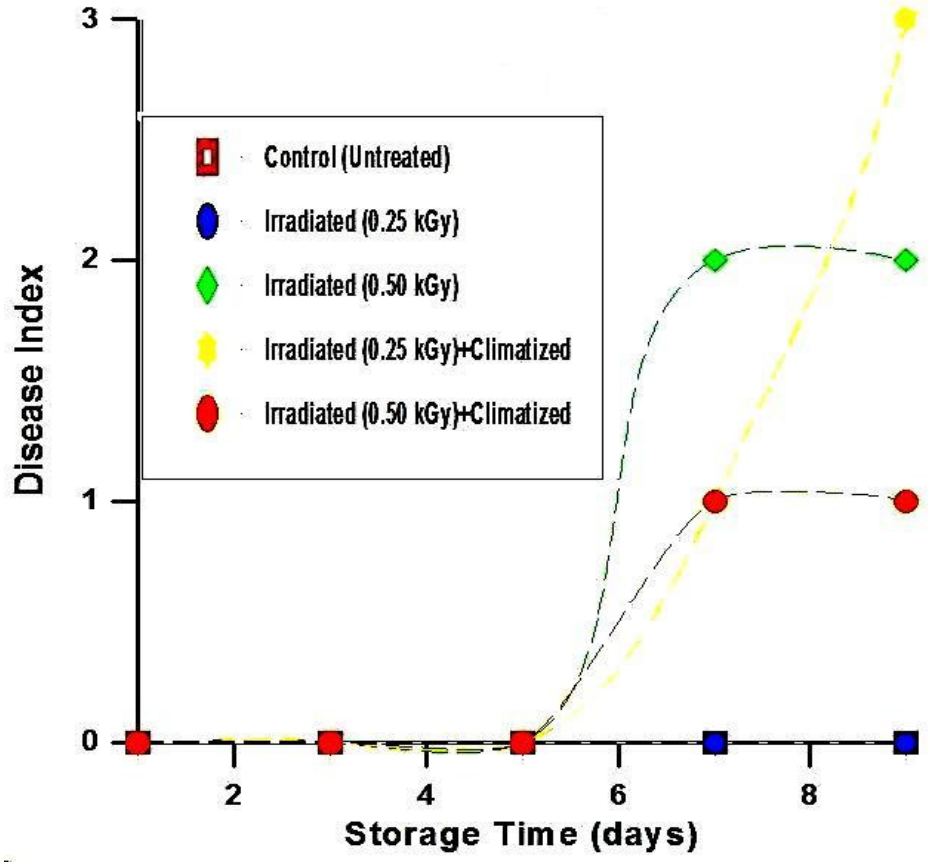


**Figure 4. Estimates of the disease index as function of storage time for fruits of 'Prata' banana submitted to five different treatments.**

## 4. CONCLUSIONS

Based on the experiments performed in this work, it can be concluded that irradiation with doses of 0.25 and 0.50 kGy was not capable of avoiding early maturation of fruits of 'Prata' bananas. However, the treatment with 0.25 kGy of samples not subjected to climatization efficiently led to a smaller fresh mass loss, while also efficiently preventing diseases in the fruits.

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