Recent studies of irradiated mangoes in Brazil: a trend towards commercial approach

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Abstract. Mango is an important commodity to our country as Brazil is a great producer and exporter of tropical fruits. Nowadays, Mexico and India are the main exporters of mango in the world and Brazil occupies the third position in this ranking. As these countries have adopted gamma radiation as a phytosanitary treatment and signed a bilateral agreement with the United States for exporting mango to this country, Brazil has to be up-to-dated with this trend. The Institute of Nuclear and Energy Researches together with field producers in the northeastern region and partners like the International Atomic Energy Agency, the Canadian Irradiation Center and Empresa Brasileira de Agropecuária joined to demonstrate this technology, its application and its commercial feasibility. The whole project was structured in two parts that involved around 1300 mangoes. The first step consisted mainly in studying the quality of irradiated mangoes within our territory, using a multipurpose semi-commercial cobalt facility, and comparing two harvesting points of the fruits. The second one was an international consignment of irradiated fruits from Brazil to Canada, where the control sample consisted of fruits treated with a hot water dip. The financial part of the feasibility study covers the scope of the investment, including the net working capital and production costs. In a summarized way to express, the results from physicochemical analysis and sensory evaluation were favorable, indicating that gamma radiation is a potential quarantine treatment.

Key words: gamma radiation • mangoes • physicochemical properties • sensory evaluation

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Introduction

Brazil is a great producer and exporter of tropical fruits where mangoes are very important commodity. Mexico, the first exporter in the world, has developed a gamma source facility in order to supply the North American market with fruits treated by irradiation. Recently, Mexico and the United States signed the Work Plans to apply irradiation to vegetable products and specify the approved articles for irradiation as a phytosanitary treatment for exportation to the USA that includes among others fresh mango (*Magnifera indica*) [2]. India, that since 2003 assumed the second place in the world exportation ranking, signed also an agreement with the USA in order to export irradiated mangoes [1]. There is an estimative that India will increase its mango exportation to the USA in approximately 1.25% related to 2007 exportations owe to irradiation used as phytosanitary treatment that allows their mangoes arrive at so distant market [3]. In order to keep up-dated to new trends, the Institute of Nuclear and Energy Researches has been collaborating in a project involving mango producer at the northeastern region, Petrolina (Pernambuco, Brazil), considered as very important exporter place of fruits. A project among field producer (Petrolina), Instituto de Pesquisas Energéticas e Nucleares (IPEN) (with radiation facility for irradiation) and the Canadian

Irradiation Center (CIC) was established in order to verify the quality of irradiated mangoes mainly under commercial point of view.

Methodology

Our study started around 2005 and the final part was in 2007. Initially, one study with around 700 mangoes was carried out to verify physicochemical properties, as well as sensory evaluation, of irradiated mangoes. In this study fruits were harvested in two different harvesting points, 2 and 3 (on a 5 point scale: degree 1 (100% green), degree 2 (75% green and 25% dark red), degree 3 (50% green and 50% red), degree 4 (25% green and 75% red) and degree 5 (25% yellow and 75% red), at different dates (350 fruits in each date). This study was totally performed in Brazil. Mangoes were harvested at Petrolina and sent by plane to IPEN (approximately 3000 km) where they were irradiated at 0.2 kGy, 0.5 kGy and 0.75 kGy and compared to control (non-irradiated fruits). After irradiation, the fruits were kept at a conditioned room (10°C and 66% RH) during 14 days and after this period they were kept in environmental conditions (around 23°C and 65% RH). Analyses were done every 4 days with eight fruits for each test: pH, total soluble solids, texture, skin and pulp color, visual observations and sensory evaluation.

In the second part of the project an international consignment of irradiated mangoes was carried out in order to verify the effect of long distance transportation associated with irradiation treatment. Around 600 fruits were harvested at Petrolina in point 3 and were sent to IPEN where they were treated. Around 200 fruits were treated with a hot water dip (46°C, 110 min) that was considered as control group. Around 400 mangoes were irradiated at doses of 0.4 kGy (based on USA regulations for mangoes disinfestations [6]) and 1.0 kGy (representing maximum dose if a dose uniformity of a commercial gamma source facility was considered to be 2.5). Treated mangoes were sent to CIC by a plane and they were stored in an environmental room (around 20°C) during the analysis period. Tests performed were: pH, total soluble solids, texture, skin and pulp color, visual observations and sensory evaluation.

This paper has the objective to show the main results obtained from the entire project. As the two parts involved around 1300 fruits and several analyses in each of detailed steps, the focus of this paper is essentially to emphasize the parameters that were more influenced by gamma radiation and some comparisons at a specific date considered optimal for consumption.

Results and discussion

The parts of the project occurred in very distinct dates but the behavior of the content of total soluble solids were independent of absorbed dose within each part, as shown in Table 1. The values for Part 2 were higher than the corresponding values from the other two parts, but they were in accordance with the accepted limits established for regulation [5].

The values of pH for Part 1 (1a and 1b) remained not affected by gamma radiation ($p \leq 0.05$), as presented in Table 1. The pH values for Part 2 showed a small decrease but statistically significant ($p \leq 0.05$) in function of the dose. Among the relevant quality factors for fruits, the most important one is the taste, which results from the balance among soluble solids and organic acids. During the mango development, the content of organic acids diminishes and the sugars content increases, resulting in a predominant sweet taste for mature fruit [4]. The lower pH value for mangoes irradiated at 1.0 kGy is still acceptable considering the official limit of 3.3 to 4.5 [5]. In fact some decrease in pH could be associated to maturity delay observed through visual observations of skin color of irradiated fruits compared to control (data not shown). Part 1 presented control fruits reaching the high maturity degree faster than the irradiated samples. The same behavior was repeated in Part 2, where irradiated fruits remained in lower degrees of maturity, while control reached the high degree faster.

Table 1. Physicochemical results of the treated mangoes from different parts of the experiment

Experiment detail	Harvesting point	Dose (kGy)	Total soluble solids (°Brix)	pH	Texture (Kgf)
Part 1a – Day 21	2	0	9.5 ± 0.8* a	4.2 ± 0.1 a	1.67 ± 0.29 a
		0.2	9.5 ± 0.4 a	3.9 ±.0.3 a	2.06 ± 0.47 a
		0.5	8.9 ± 1.7 a	4.1 ± 0.3 a	1.80 ± 0.33 a
		0.75	9.1 ± 1.1 a	4.5 ± 0.2 a	1.82 ± 0.91 a
Part 1b – Day 21	3	0	9.8 ± 0.8 a	4.2 ± 0.5 a	2.73 ± 0.73 a
		0.2	9.7 ± 0.4 a	4.4 ± 0.3 a	2.93 ± 0.90 a
		0.5	9.1 ± 1.7 a	4.0 ± 0.6 a	2.80 ± 0.77 a
		0.75	9.3 ± 1.1 a	4.4 ± 0.3 a	3.30 ± 0.69 a
Part 2 – Day 20	3	0	11.0 ± 0.3 a	4.8 ± 0.03 a	0.69 ± 0.15 a
		0.4	10.8 ± 0.5 a	4.6 ± 0.01 b	0.68 ± 0.14 a
		1.0	11.0 ± 0.6 a	4.4 ± 0.06 c	0.52 ± 0.24 b

For the same part of experiment, the means followed by the same letter are not significantly different within type of analysis ($p \leq 0.05$).

* Standard deviation.

Part 1a: Mangoes at harvesting point 2, from Petrolina (around 350 fruits), irradiated and analyzed at IPEN, Brazil.

Part 1b: Mangoes at harvesting point 3, from Petrolina (around 350 fruits), irradiated and analyzed at IPEN, Brazil.

Part 2: Mangoes at harvesting point 3, from Petrolina (around 600 fruits), irradiated at IPEN, Brazil and analyzed at CIC, Canada.

Table 2. Scores obtained from panelists (the means and standard deviation) of the parameters for the sensorial evaluation of mangoes

Experiment detail	Dose (kGy)	Odor	Taste
	0	7.5 ± 1.3* a	7.5 ± 1.5 a
Part 1	0.5	6.6 ± 1.8 b	7.6 ± 1.2 a
	0.75	7.1 ± 1.6 ab	7.2 ± 1.7 a
	0	7.8 ± 1.4 a	7.4 ± 1.7 a
Part 2	0.4	7.0 ± 1.0 ab	6.6 ± 2.0 ab
	1.0	6.6 ± 1.7 b	6.1 ± 1.9 b

For the same part of experiment, the means followed by the same letter are not significantly different within parameter of evaluation ($p \leq 0.05$).
* Standard deviation.
On hedonic scale for all parameters a score of 1 = extremely dislike, 5 = neither likes nor dislikes and 9 = extremely like.
Part 1a: Mangoes at harvesting point 2, from Petrolina (around 350 fruits), irradiated and analyzed at IPEN, Brazil.
Part 1b: Mangoes at harvesting point 3, from Petrolina (around 350 fruits), irradiated and analyzed at IPEN, Brazil.
Part 2: Mangoes at harvesting point 3, from Petrolina (around 600 fruits), irradiated at IPEN, Brazil and analyzed at CIC, Canada.

For texture, the results were significantly different only for the 1.0 kGy irradiated mango from Part 2 and the rest of the results presented no difference ($p > 0.05$) (Table 1). The texture measurements from Part 2 compared to those from Part 1 resulted in lower values that can be associated to overseas transportation as well as differences in cultivars (mangoes were from different farms in each part of the experiment), harvesting point and even packaging during transportation.

The fluctuations of the results are more related to mango variability and maturity harvesting point than to radiation effect on the fruits.

Sensory evaluation for Part 1 showed some difference in odor parameter (Table 2) for the 0.5 kGy irradiated mangoes ($p \leq 0.05$) compared to control sample, but not significantly different from the 0.75 kGy irradiated fruit. Taste was very well accepted indistinctly from doses at this part of the experiment. For Part 2, odor and taste results decreased in function of dose, but only the 1.0 kGy irradiated mango showed a significant difference from control ($p \leq 0.05$). Even the smallest scores, obtained for 1.0 kGy mangoes, were above the average score from the hedonic scale, indicating a good acceptation for irradiated mangoes at higher doses. The panelists' comments, in general, were very favorable but some indicated the texture from 1.0 kGy mangoes was softer.

Conclusions

From the whole experiment consisting of 1300 fruits and parts of project carried out in different dates and with Tommy Atkins mangoes from different cultivars (different farms), gamma radiation applied to mangoes for disinfestations purposes resulted in very good results. Some concerns with texture of the fruits noted during the international consignment should be considered in future studies that can be delineated with different maximum doses, improved packaging and issues related to bilateral agreements in order to minimize the doses to be delivered respecting the plagues existing in Brazilian environment. The fluctuations of the results are more related to mango variability and maturity harvesting point than to radiation effect on the fruits.

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