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Study of influence on harvesting point in Brazilian Tommy Atkins mangoes submitted to gamma radiation

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ABSTRACT

Brazil is a great producer of tropical fruits including mangoes. Among several purposes gamma radiation can be applied as phytosanitary treatment. This is well studied in scientific papers and more recently demonstrated through commercial advances like bilateral protocols established between India and USA. The whole experiment evolved two parts where each of them used fruits from different maturity stages (stages 2 and 3). This experiment was carried out with around 300 fruits in each part of the study. The main objective was to get the experience close to commercial conditions. The irradiation was realized in Multipurpose Cobalt-60 source belonging to IPEN–CNEN/SP (developed in house by own technology). The absorbed doses were 0.2, 0.5 and 0.75 kGy. After irradiation all fruits were kept at 12 °C in acclimatized chamber during 14 days. After this period the fruits were brought to environmental conditions (25 °C) for around 14 more days of duration. These conditions were established to simulate the exportation conditions from Brazil to distant countries. Physical–chemical analysis (pH, titrable acidity, total soluble solids (°Brix) and texture) as well as visual observation (mass loss, rotting, internal and skin color) were evaluated. The results from this experiment could demonstrate that the characteristics of the mangoes are more dependent on time and temperature storage rather than irradiation.

1. Introduction

Brazil is an important producer of mango (*Mangifera indica L.*) and its exportation occupies the third place in world. Mango is a tropical fruit and to be sent to others countries should be submitted to quarantine treatment in order to disinfested potential pests. Quarantine barriers require phytosanitary treatments that traditionally include thermal treatment (hot water dip or vapor treatment) or irradiation, as a potential commercial treatment.

Mango has an important role under nutritional aspect. Among several others components we can emphasize the ascorbic acid content that become the fruit in an excellent source of vitamin C. Its content varies from 32 to 200 mg for 100 g of edible pulp (Akinyele and Keshinro, 1980). Lacroix et al. (1993) evaluated the ionizing radiation effect on vitamin C and concluded that it is not affected up to 1 kGy.

Several studies have been carried out to demonstrate the disinfestations' purpose obtained by irradiation treatment in fruits (Camargo et al., 2007; Cetinkaya et al., 2006; Follet, 2004; Hallman, 1999, 2000; Paull, 1996).

The objective of this paper was to study the effect of the ionizing radiation on mangoes harvested at two different harvesting points.

2. Methodology

Mangoes, Tommy Atkins variety, were from Northeast region of Brazil supplied kindly by Fruit Fort Agrícola Exportação, Petrolina, Recife. The experiment consisted of two parts carried out at different dates and involving different harvesting stages 2 and 3. The harvesting stages are specified in terms of degree of maturity using the farmer's 5-point scale: stage 1 (100% green), stage 2 (75% green and 25% dark red), stage 3 (50% green and 50% red), stage 4 (25% green and 75% red) and stage 5 (25% yellow and 75% red). For both parts exactly the same procedure and methodology were applied.

Around 350 fruits were divided in two batches: for destructive analysis (visual observations) and for non-destructive analysis (physical–chemical analysis). The fruits from both batches were irradiated and part of fruits was kept without irradiation as control samples.

2.1. Irradiation and dosimeter

Fruits were irradiated in a Multipurpose Cobalt-60 source (90,000 Ci) belonging to IPEN–CNEN/SP (developed in house by own technology). The absorbed doses were 0.2, 0.5 and 0.75 kGy (±0.05 kGy). The dosimeter was done using routine dosimeter Gammachrome YR batch 64.

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2.2. Storage

After irradiation all fruits were kept at 12 °C in acclimatized chamber (66% RH) during 14 days. After this period the fruits were brought to environmental conditions (25 °C) for around 14 more days of duration. These conditions were established to simulate the exportation conditions from Brazil to distant countries.

2.3. Visual observations

Twenty fruits for each treatment (control and three levels of irradiation) were used. Each fruit was numbered and at each 4 days the fruits were submitted to non-destructive analysis: mass loss and visual observations related to defects and rotting.

2.4. Physical–chemical analysis

Around 48 fruits for each treatment (control and three levels of irradiation) were used in these analyses. At each day of analysis, 8 fruits from each treatment followed to physical–chemical analysis. Day's analyses were 1, 7 and 14 (during the acclimatized period) and 17, 21 and 24 (during environmental storage). The tests were:

- *Skin color*: the fruits were evaluated in a visual comparison according maturity scale used by the producer (described above). For each analysis day the fruits from each treatment were counted in each color degree.
- *Texture*: the texture was measured by the minimum force required to puncture the peel of the fruits, using a fruit tester penetrometer with crossheads of 8 mm (Gagnon et al., 1993).
- *Soluble solids (°Brix)*: the total solid soluble content was measured with a refractometer type Abbe, Model Q-767. The measurements were measured at environmental temperature and corrected to 20 °C.
- *Titrable acidity*: the measurements followed the AOAC method 22.058 (1995).
- *pH*: the measurements were made directly in the fruit with a digital pHmeter (Micronal, model B474) using a fruit electrode.

3. Results and discussion

3.1. Visual observations

Mass loss decayed for all treatments and for both harvesting stage. The fluctuations (percentage of final mass in relation to the initial one) for harvesting point 2 were 10.7% (control), 5.6% (0.2 kGy), 6.0% (0.5 kGy) and 6.7% (0.7 kGy) and for harvesting point 3 were 6.5% (control), 6.9% (0.2 kGy), 6.0% (0.5 kGy) and 11% (0.75 kGy). Fruits were discharged as soon as they presented some rot surface or softness by hand perception. Fruits started to be discharged at the same day within harvesting stage no matter the absorbed dose. For stage 2 the discharge started at day 20 and the experiment lasted until day 28; for stage 3 the discharge was at day 12 and the experiment ended at day 24.

3.2. Physical–chemical analysis

Skin color of control samples reached earlier degree 5 than irradiated samples for the two harvesting stages. Samples irradiated at 0.75 kGy presented more quantity of fruits in less maturity degrees (fruits at degree 4 for both harvesting stages and including at degree 3 for harvesting point 3). These results indicated radiation caused a maturity delay according visual observation.

The texture measurements reduced for all treatments no considering absorbed dose or harvesting point. Temperature storage affected fruits texture and this effect was preponderant for harvesting point 2 as one can observe in Fig. 1. At the end of the experiment fruits from all treatment had similar texture values. Tissue texture became progressively less resistant to compression with increasing doses of radiation. This reduction is associated

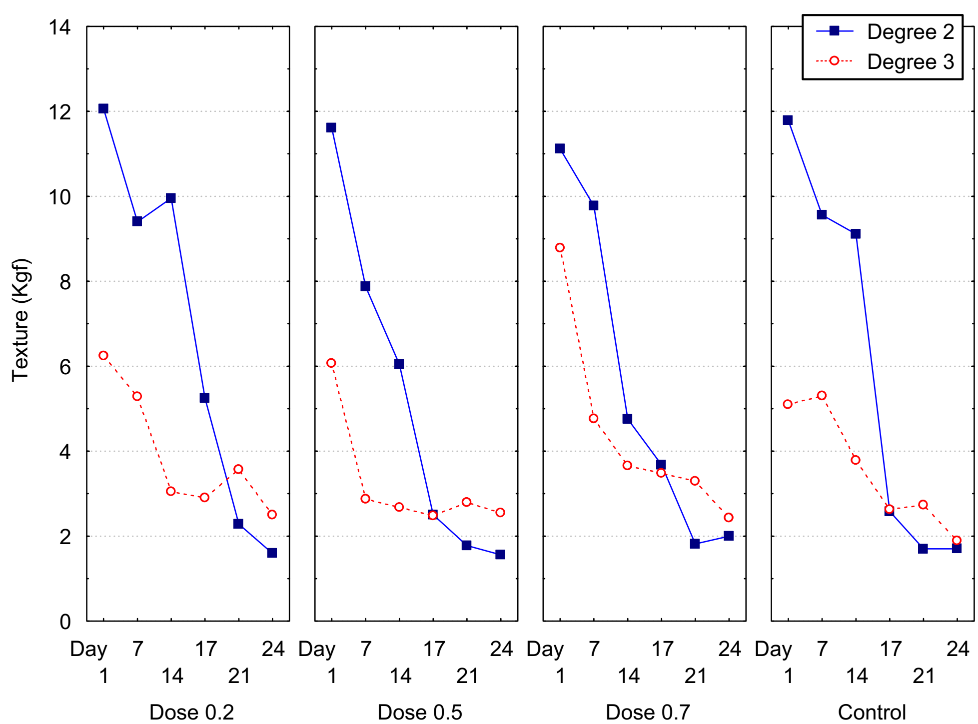

Fig. 1. Effect of radiation doses on texture measurements with storage time and two harvesting point.

Table 1
Means of total soluble solids and pH measurements as a function of absorbed dose, storage time and harvesting point.

	Total soluble solids (°Brix)		pH	
	Stage 2	Stage 3	Stage 2	Stage 3
Day1; Dose 0.2	8.7±1.5A, a	9.5±2.0A, a	3.6±0.2A, a	3.3±0.5A, a
Day1; Dose 0.5	8.1±1.0A, a	9.0±1.5A, a	3.8±0.2A, a	3.2±0.3A, a
Day1; Dose 0.7	7.0±1.8A, a	9.4±1.1A, a	3.7±0.1A, a	3.2±0.3A, a
Day1; Control	6.9±0.6A, a	10.1±1.0A, a	3.8±0.2A, a	3.4±0.3A, a
Day7; Dose 0.2	10.1±1.7A, a	10.7±1.2A, a	3.4±0.2A, a	3.4±0.2A, ab
Day7; Dose 0.5	9.6±1.5A, a	9.5±2.8A, a	3.7±0.3AB,a	3.8±0.5A, ab
Day7; Dose 0.7	8.9±1.0A, a	9.7±2.7A, a	3.8±0.2B, a	3.6±0.4A, a
Day7; Control	9.7±1.5A, b	8.6±3.3A, a	3.6±0.3AB,a	3.7±0.3A, ab
Day14; Dose 0.2	9.2±0.8A, a	9.4±0.8A, a	3.6±0.2A, a	3.7±0.3A, abc
Day14; Dose 0.5	10.0±1.3A, a	10.2±1.3A, a	3.5±0.1A, a	4.1±0.7A, b
Day14; Dose 0.7	9.1±1.9A, a	9.3±1.9A, a	3.6±0.2A, a	3.7±0.4A, a
Day14; Control	9.7±1.9A, b	9.9±1.9A, a	3.7±0.1A, a	3.6±0.4A, ab
Day17; Dose 0.2	10.5±2.4A, a	10.7±2.4A, a	3.5±0.2A, a	3.9±0.7A, abc
Day17; Dose 0.5	10.1±1.3A, a	10.4±1.3A, a	3.8±0.3A, a	4.5±0.4A, b
Day17; Dose 0.7	9.6±1.1A, a	9.8±1.1A, a	3.5±0.3A, a	3.8±0.4A, a
Day17; Control	9.3±1.0A, ab	9.6±1.0A, a	3.7±0.2A, a	4.2±0.4A, ab
Day21; Dose 0.2	9.5±0.8A, a	9.8±0.8A, a	4.2±0.1A, b	4.2±0.5A, bc
Day21; Dose 0.5	9.5±0.4A, a	9.7±0.4A, a	3.9±0.3A, a	4.4±0.3A, b
Day21; Dose 0.7	8.9±1.7A, a	9.1±1.7A, a	4.1±0.3A, a	4.0±0.6A, a
Day21; Control	9.1±1.1A, ab	9.3±1.1A, a	4.5±0.2A, b	4.4±0.3A, b
Day24 Dose 0.2	8.1±2.1A, a	8.4±2.1A, a	4.7±0.2A, b	4.3±0.5A, bc
Day24; Dose 0.5	9.8±1.0A, a	10.1±1.0A, a	4.6±0.2A, b	4.5±0.2A, b
Day24; Dose 0.7	9.3±2.3A, a	9.6±2.3A, a	4.5±0.0A, ab	4.0±0.7A, a
Day24; Control	9.6±1.6A, ab	9.9±1.6A, a	4.8±0.2A, b	4.4±0.2A, b

For the same day, means followed by the same capital letter are not significantly different ($p \leqslant 0.05$); for the same dose, means followed by the same lower-case letter are not significantly different ($p \leqslant 0.05$).

with degradative changes in the middle lamella of plant cell walls resulting in a lower resistance of the tissues to shear and compression forces (Gagnon et al., 1993).

The values for total soluble solids were independent of radiation or storage as demonstrated in Table 1. They fluctuated in function of fruit variability what can be expected for working with a more quantity of fruits and once there were fruits with some mixture of maturity indexes in each stage, even if they were harvested in categories (stages 2 and 3).

The acidity decreased in function of time for all doses and for the two harvesting stages. At the start of the experiment acidity measurements (average for all doses) were around 0.76 for stage 2 and around 0.57 for stage 3. At the end, the values were around 0.15 and 0.09, respectively, demonstrating the normal maturity behavior of the fruits with time where acidity decreases and sweetness increases. This diminishing agreed with the pH values measured that showed an increasing trend (Table 1). Once again, radiation showed little influence in these parameters, and they were more influenced by storage time. The lower pH values measured were for mangoes treated at 0.75 kGy for both stages, which could demonstrate some delay of this characteristic in relation to the other doses. pH values increase with maturity time and can oscillated from 3.3 to 4.5 (Ministério Da Agricultura E Do Abastecimento, 2000) and acidity, from 0.17% to 3.66% (for green mangoes) and from 0.11% to 0.56% (mature fruits) (Manica et al., 2001).

4. Conclusion

Physical–chemical properties for both stages of harvesting seemed to have the same behavior no matter the absorbed dose of the fruits. Mangoes irradiated at 0.75 kGy presented fruits in lower maturity degrees according to skin color evaluation and also presented lower values of pH that could agree with this trend. Fruits had their texture values reduced where temperature and time storage were more relevant than radiation or harvesting point.

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