2009 International Nuclear Atlantic Conference - INAC 2009
Rio de Janeiro,RJ, Brazil, September27 to October 2, 2009
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-03-8**

COMPARISON OF QUARANTINE TREATMENTS ON SKIN AND PULP COLOR OF MANGOES

Juliana Nunes da Cruz[1], Marcel Wilke Caruso[2], Susy Frey Sabato[3]

[1] Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
juliananc@ig.com.br

[2] Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
macaruso_98@hotmail.com

[3] Instituto de Pesquisas Energéticas e Nucleares, IPEN - CNEN/SP
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
sfsabato@ipen.br

ABSTRACT

The mango (*Mangifera indica L.*) has shown the highest growth rates among the fruit exported by Brazil. This exportation implies specific treatments to attend phytossanitary requirements to attend USA and Europe market. Among them there are thermal treatments (hot water dip or vapor treatment) or irradiation witch it has ability to promote disinfestations and delaying the ripening of the mango. The main objective of this paper was to report the color behavior among treatments covering irradiation alone, thermal treatment combined with irradiation and control. The mangoes were irradiated in a Multipurpose Gamma Source from the Radiation Technology Center, CTR, of IPEN/CNEN-SP and divided in four groups – the control (C) , dose 0,75 KGy (I), dose 0,75 KGy with hot water dip (46°C during 70 min) (2A) and dose 0,75KGy with hot water dip (52°C during 5 min) (2B). All fruits were stored at 11°C in acclimatized chamber during 14 days, after this period the fruits were kept at environmental conditions (25°C) during more 14 days. The results showed that the group 2A had the color of the skin delayed by treatment, not reaching stage 4 on the 26th. This group showed significant difference compared to groups C ($p \leq 0.05$) however there was no difference among the others groups (2B and I). In general, these results indicate that the group 2A showed satisfactory results, concluding that combined treatment was beneficial for the mango, prolonging the process of development of its color.

1. INTRODUCTION

Mango (*Mangifera indica L.*) is a tropical fruits of great economic relevance and is the second tropical fruit more cultivated in the world. According to the Food and Agriculture Organization - FAO (2008) [1], Brazil is the third largest country that exports mangoes, mainly to the United States and Europe, losing only to Mexico and India.

The exportation of mangoes implies specific treatments to attend phytosanitary requirements in order to disinfest potential pests. The most conventional treatment used to attend USA and Europe market is the thermal treatment (hot water dip or vapor treatment) [2]. Usually, mangoes to USA and Japan are treated with hot water dip. This quarantine treatment must be

very strict and the conditions consist of immersion of the fruits in a bath at 46.1ºC for 75 minutes (fruits weighing up to 425g) or for 90 minutes (fruits weighing more than 425g) [3].

Another potential quarantine treatment is the irradiation. Ionizing treatment for fruits and vegetables has the main objective to assure the preservation through microorganism reduction, disinfestation and occasional maturation retard [4]. It is a versatile disinfestation treatment which can be used against a wide variety of organisms and is tolerated by many agricultural commodities [5].

Nowadays some Brazilian mangoes exporters are interested in studies representing commercial application of ionizing radiation technology, as there is a trend by some of the great exporters of mangoes in using it instead of conventional ones [6].

Disinfestation and shelf life extension by irradiation have been extensively studied and have a great deal of potential and promise, especially for tropical fruits [7; 8; 9].

The main objective of this paper was to report the color behavior among treatments covering irradiation alone, thermal treatment combined with irradiation and control.

2. MATERIAL AND METHODS

2.1. Material

The mango variety studied was Tommy Atkins in the stage 3. The mangoes were bought in São Paulo market and sent to Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP). Treatments were made at different dates: groups C, 2A and 2B at 2008 and group I at 2006.

2.2. Treatments: Irradiation and Hot Water Dip

The mangoes were irradiated in a Multipurpose Gamma Source (IPEN, São Paulo, Brazil) and were divided in four groups – the control (C), dose 0.75 kGy (I), dose 0.75 kGy with hot water dip (46°C during 70 min) (2A) and dose 0.75kGy with hot water dip (52°C during 5 min) (2B).

Dosimetry was assessed using Amber routine dosimeter (Harwell, United Kingdon) and dose rate was established using Fricke reference dosimeter to plot calibration curves. The whole dosimetry system is in IDAS program from International Atomic Energy Agency.

2.3. Storage and measurements

After treatments, all fruits were stored at 11°C in acclimatized chamber during 14 days, after this period the fruits were kept at environmental conditions (25°C) during more 14 days. This condition represents the exportation conditions from Brazil to other countries.

Mango physical characteristics were analyzed, i.e, the behavior of the skin and the pulp color during its ripening. Analysis were performed at days 1, 7, 14, 19, 22 e 26.

Skin color was evaluated visually using the following 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).

Pulp color was evaluated visually using the following scale: degree 1 (100% white), degree 2 (75% white and 25% yellow), degree 3 (50% yellow), degree 4 (25% yellow and 75% orange) and degree 5 (100% orange).

The results were submitted to analysis of variance (ANOVA) and the significant statistical differences were identified by multiple comparisons Duncan's test, at 5% significance, using Statistica version 7.0.

3. RESULTS AND DISCUSSION

The results of the skin color of mangoes are presented in Table 1 and Figure 1.

Table 1. Average of skin color results according to storage.

	Day 1	Day 7	Day 14	Day 19	Day 22	Day 26
C	2.67 ±0.58ab	3.00 ±0.00a	3.00 ±0.00a	3.67 ±0.58a	4.67 ±0.58a	5.00 ±0.00a
I	3.62 ±1.06b	4.37 ±0.74a	3.62 ±0.74a	3.75 ±0.71a	3.75 ±0.71a	4.33 ±0.64ab
2A	2.33 ±0.58ab	3.00 ±0.00a	3.00 ±0.00a	3.33 ±0.58a	3.33 ±0.58a	2.67 ±0.58b
2B	2.00 ±0.00a	2.67 ±0.58a	2.67 ±0.58a	3.33 ±0.58a	3.33 ±0.58a	4.33 ±0.58ab

For the same day, averages followed by the same letter present no statistical difference ($p<0.05$).

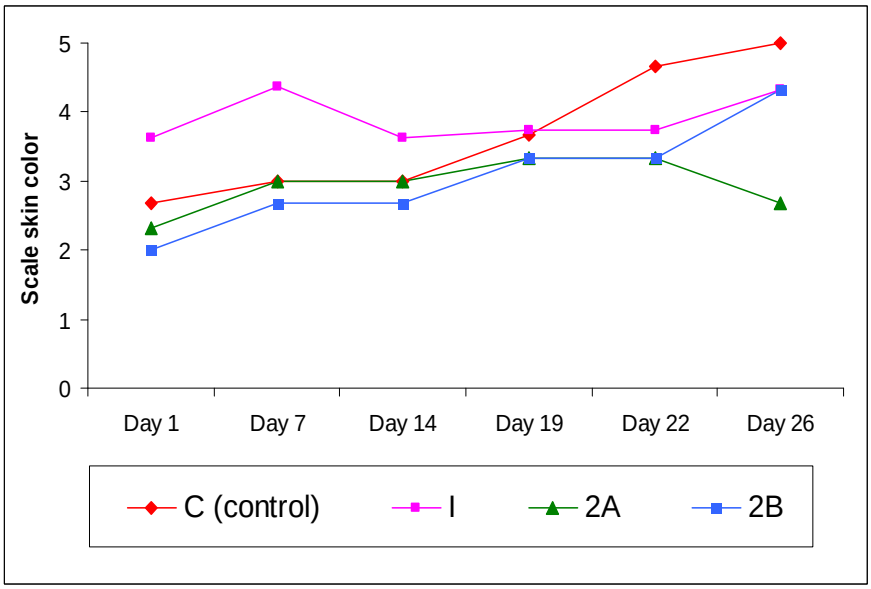

Figure 1. Skin color according to storage.

The group 2A had the skin color delayed by treatment, showing that the radiation associated with the hot water dip directly affects the color of the fruit, not reaching stage 4 on the 26th according to the Figure 1. However this was not observed in Group 2B. This fact can be justified by the assumption that the hot water dip somehow accelerated the development of color offsetting the effect of the radiation dose received.

On the 22nd fruit of groups 2A, 2B and I were still in stage 3 while the group C has already been in stage 5. Although there is no statistical difference, group (C) showed higher values than other groups in this day (Table 1).

The group I presented difference significant on the 1st day from control and groups 2A and 2B ($p \leq 0.05$). It had a small decrease value of maturation in relation to control group on the last day, however it was not significant difference ($p \leq 0.05$) between them. It is important to consider that this group irradiated at 0,75kGy (I) has already presented high values of the skin color in the scale on the first day. In general, irradiated fruits at 0.75 kGy (I) remained in low degree of maturity in all days during the storage.

The results of groups 2A were more satisfactory than group I and 2B regarding the skin color during the storage showed in the Figure 1. LACROIX *et al* [8] analyzed the effect of gamma irradiation (0.49 to 0.77 kGy) with or without hot water dip and observed a significantly delay in ripe skin color for irradiated mangoes compared to control ($p \leq 0.05$). The authors also concluded that the irradiation with or without hot water dip is able to increase the shelf-life of mango.

These results indicate that the group 2A showed satisfactory results, presenting low degree of maturity on the 26$^{th.}$ This group showed significant difference compared to groups C ($p \leq 0.05$) however there was no difference among the others groups (2B and I).

The results of the pulp color of the mango are presented in Table 2 and Figure 2.

Table 2. Average of pulp color results according to storage.

	Day 1	Day 7	Day 14	Day 19	Day 22	Day 26
C	2.33 ±0.58a	3.00 ±0.00a	3.00 ± 0.00a	3.67 ±0.58a	4.67 ±0.58a	4.67 ±0.58a
I	3.33 ±0.52a	3.85 ±1.21a	3.75 ± 1.04a	3.50 ±0.53a	3.50 ±0.53a	4.00 ±1.00ab
2A	2.33 ±0.58a	3.00 ±0.00a	3.00 ± 0.00a	3.67 ±0.58a	4.00 ±0.00a	2.33 ±0.58b
2B	2.00 ±1.00a	2.67 ±0.58a	2.33 ± 0.58a	3.33 ±1.53a	4.33 ±0.58a	4.00 ±1.00ab

For the same day, averages followed by the same letter present no statistical difference (p<0.05).

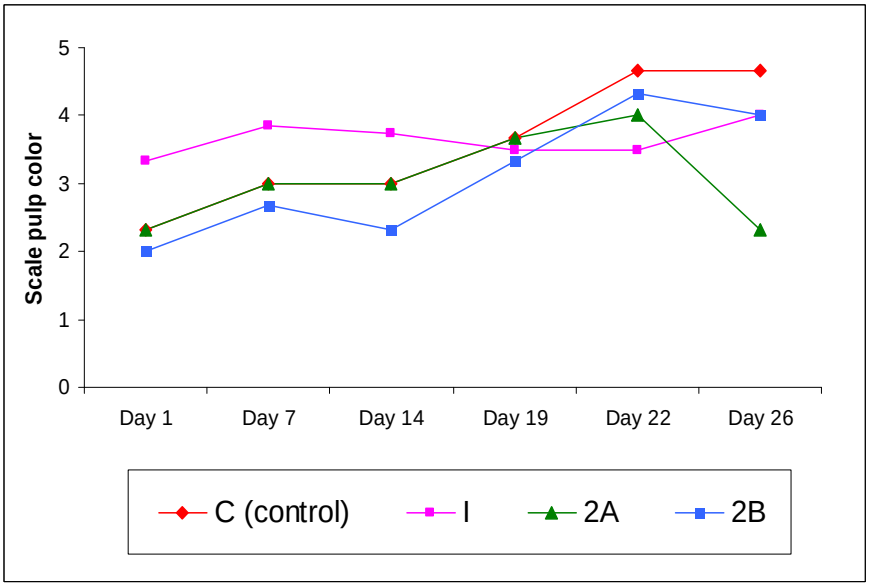

Figure 2. Pulp color according to storage.

The skin and pulp color of the fruit followed a similar development in all groups. In both cases the control group (C) showed the color more intense on the last day evaluated (Table 2).

The same behavior of skin color can be observed in the measurements of the pulp color during its ripening according to Figure 2. On the last day, the group 2A showed difference significant from control group ($p \leq 0.05$). It had the color of the pulp delayed by treatment, remaining in the degree 2. The control group (C) was the only one to approach the degree 4 to 5, while the groups I and 2B remained in degree 4 (Table 2).

4. CONCLUSION

The results obtained in this paper indicated that the treatment consisting of irradiation at 0.75 kGy plus hot water dip at 46°C during 70 min showed satisfactory results. This permits the conclusion that combined treatment was beneficial for the mango, prolonging the process of development of its color.

ACKNOWLEDGEMENTS

Authors are grateful to Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP, for the financial support (project nº 05/53652-9) and to MSc and IC fellowships (nº 05/52055-7, 06/53051-8 and 05/60642-0).

REFERENCES

1. **FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS – FAO,** 2008.
< http://www.fao.org/es/ess/toptrade/trade.asp> (2008).

2. CINTRA, R.F.; VITTI, A.; BOTEON, M. Análise dos impactos de certificação das frutas brasileiras para o mercado externo, 2003.
<http://www.cepea.esalq.usp.br/pdf/certificacao.pdf. (2007).

3. **EMPRESA BRALISEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA**, 2004.
<http://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Manga/CultivodaMangueira/colheita.htm> (2007).

4. IEMMA, J.; ALCARDE, A.R.; DOMARCO, R.E.; SPOTO, M.H.F.; BLUMER, L.; MATRAIA, C., Radiação gama na conservação do suco natural de laranja, *Sci. agric*. v.56 n.4 supl. Piracicaba 1999.

5. HALLMAN, G.J. Expanding radiation quarantine treatments beyond fruit flies. *Agricultural and Forest Entomology*, v.2, p.85-95, 2000.

6. APHIS - Animal and Plant Health Inspection Service, USDA (2007).
http://www.aphis.usda.gov/publications/plant_health/content/printable_version/faq_imp_indian_mango.pdf (2007).

7. LACROIX, M, VACHON, C. Utilization of irradiation in combination with other process for preserving food products. *Recent Research and Development in Agricultural & Food Chemistry*, v.3, p.313-328, 1999.

8. LACROIX, M.; GAGNON, M.; PRINGSULAKA, V.; JOBIN, M.; LATREILLE, B.; NOUCHPRAMOOL, K.; PRACHASITTHISAK, Y.; CHARON, S.; ADULYATHAM, P.; LETTRE, J. GRAD, B. Effect of gamma irradiation with or without hot water dip and transportation from Thailand to Canada on nutrional qualities, ripening index and sensorial

characteristics of Thai mangoes (Nahng Glahng Wahn variety). *Radiation Physics and Chemistry*, v.42, n.1-3, p.273-277, 1993.

9. SABATO, S. F.; SILVA, J. M. da; CRUZ, J. N.; SALMIERI, S.; RELA, P. R., LACROIX, M. Study of physical-chemical and sensorial properties of irradiated Tommy Atkins mangoes (Mangifera indica L.) in an internacional consignment. *Food Control*, 2008.