Physiological effects of phytosanitary irradiation in 'Fuji' apples

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Introduction

In the state of California, apples are harvested almost a month before Washington's harvest, therefore, California has the time advantage in exporting market, especially to Mexico, where irradiation has been recently approved for CA apples (PExd 2013). Irradiation is a time-saving alternative to cold treatment as a quarantine postharvest treatment for the apple industry, and it is an environmentally safer treatment compared with methyl bromide fumigation.

Apple is a climacteric fruit which shows a burst in ethylene and respiration rate after harvest. Postharvest irradiation can be understood as an "artificial abiotic stress" (Reyes & Cisneros-Zevallos, 2007), which can trigger a complex scenario of events leading to impairment of the normal cellular metabolism, reflected as changes in physiological parameters. One of the observed responses of stress in tissues is membrane damage, which can lead to further physiological reactions affecting quality and shelf-life.

The objective of this work was to assess the effects of irradiation on physiological changes of Fuji apples, simulating storage temperature conditions for export to Mexico and retail condition.

Experimental

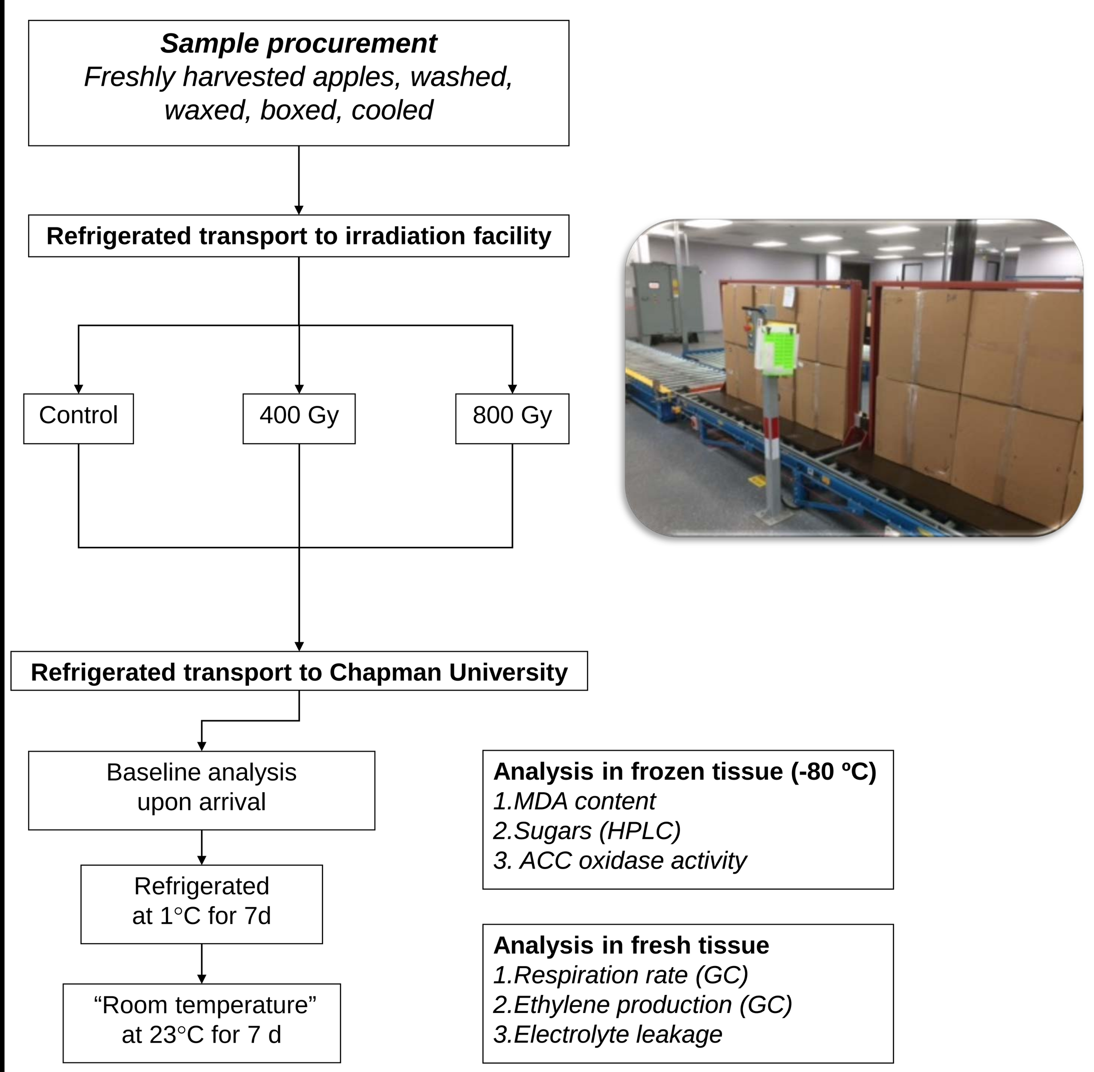

Figure 1. Diagram of sample procurement and analysis of 'Fuji' apples subjected to phytosanitary treatments and storage temperatures during 14 days

Statistical Analysis :
Linear Mixed Effects Model was used for analysis (R statistical software)

Results

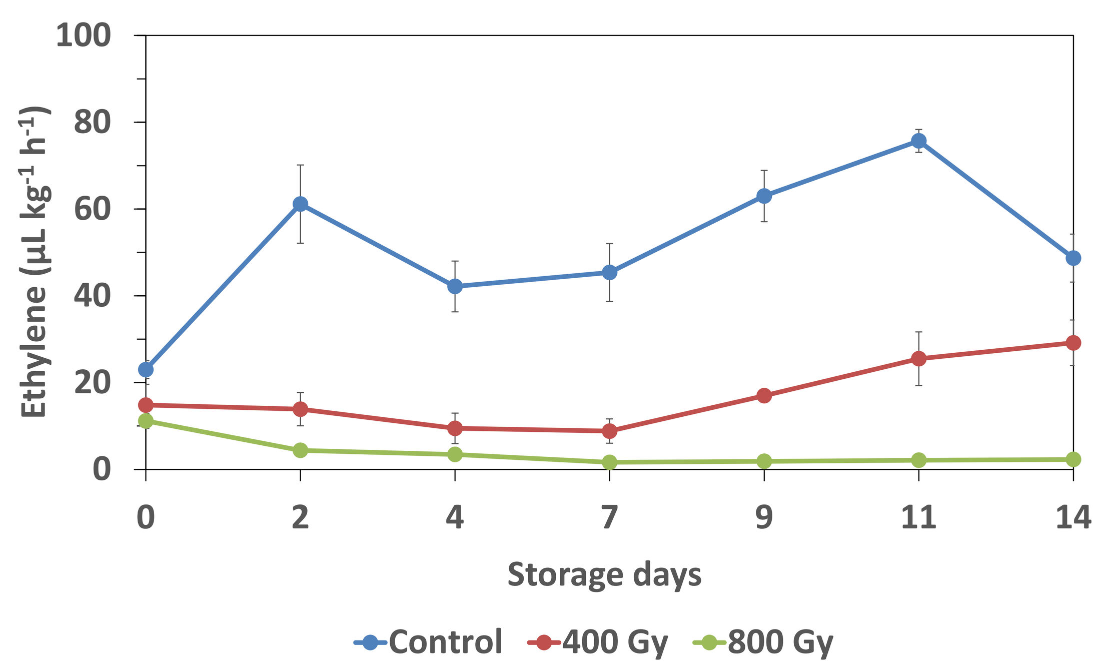

Figure 2. Ethylene production of irradiated 'Fuji' apples during 7 days in cold storage and 7 after days at room temperature.

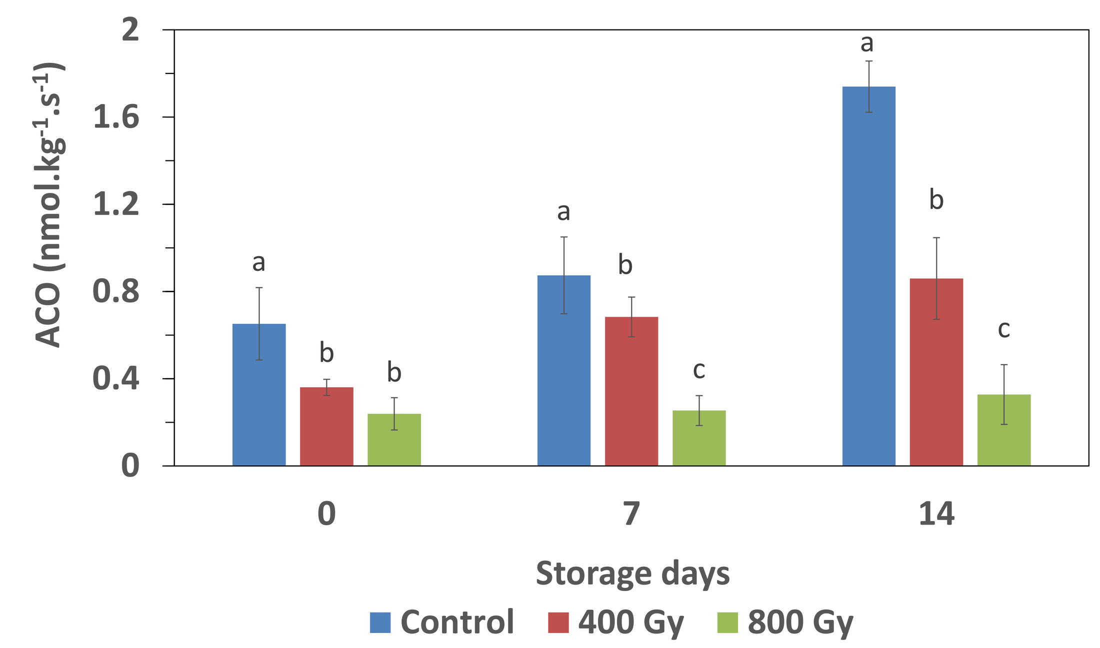

Figure 3. Activity of ACC oxidase enzyme of 'Fuji' apples at 0, 7 and 14 days after irradiation.

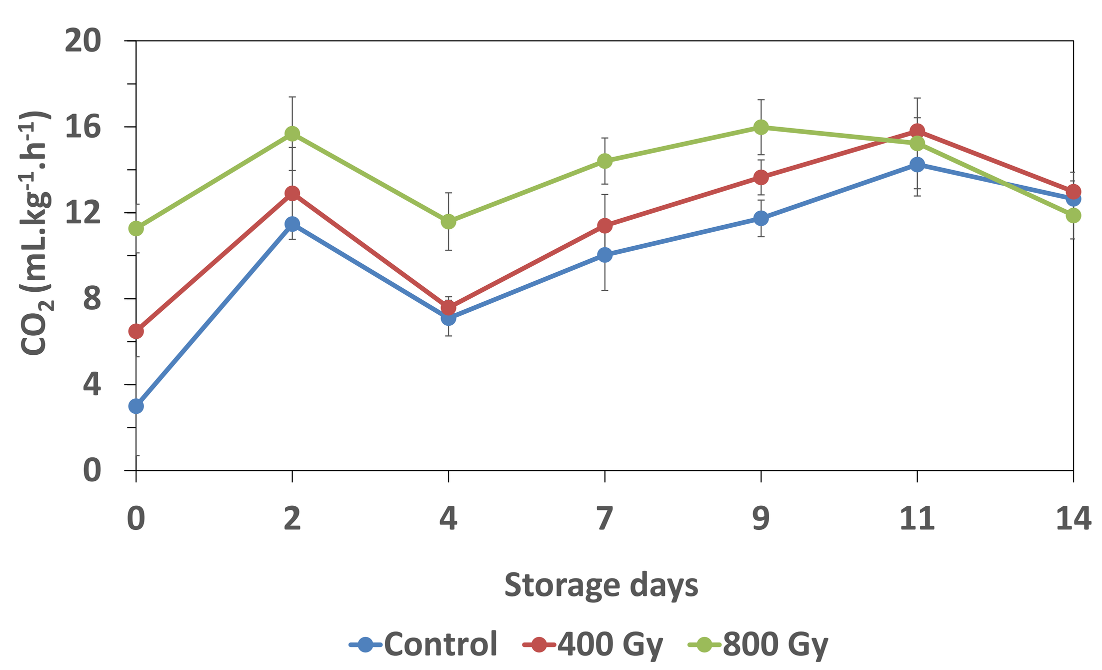

Figure 4. Respiration rates of irradiated 'Fuji' apples during 7 days in cold storage and after 7 days at room temperature.

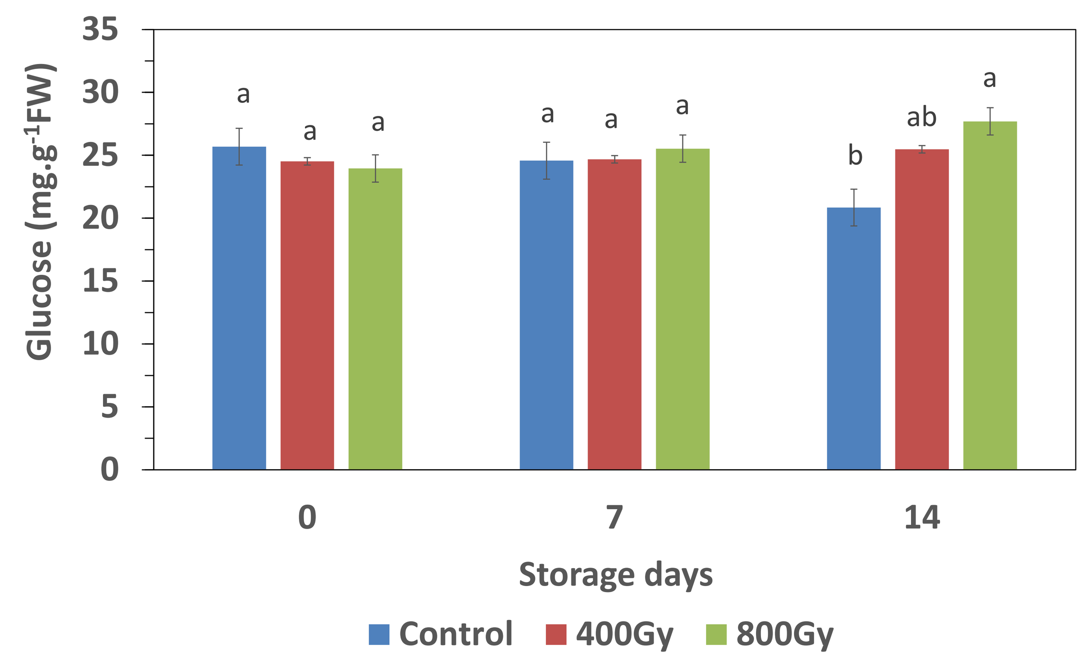

Figure 5. Glucose content of 'Fuji' apples at 0, 7 and 14 days after irradiation.

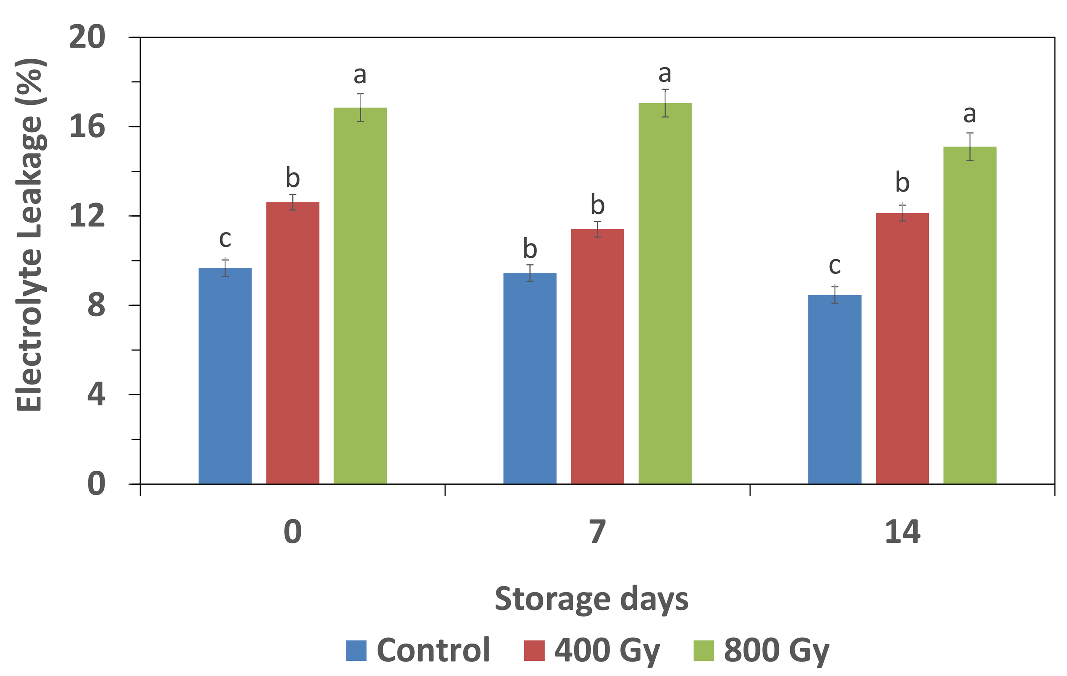

Figure 6. Electrolyte leakage of 'Fuji' apples at 0, 7 and 14 days after irradiation.

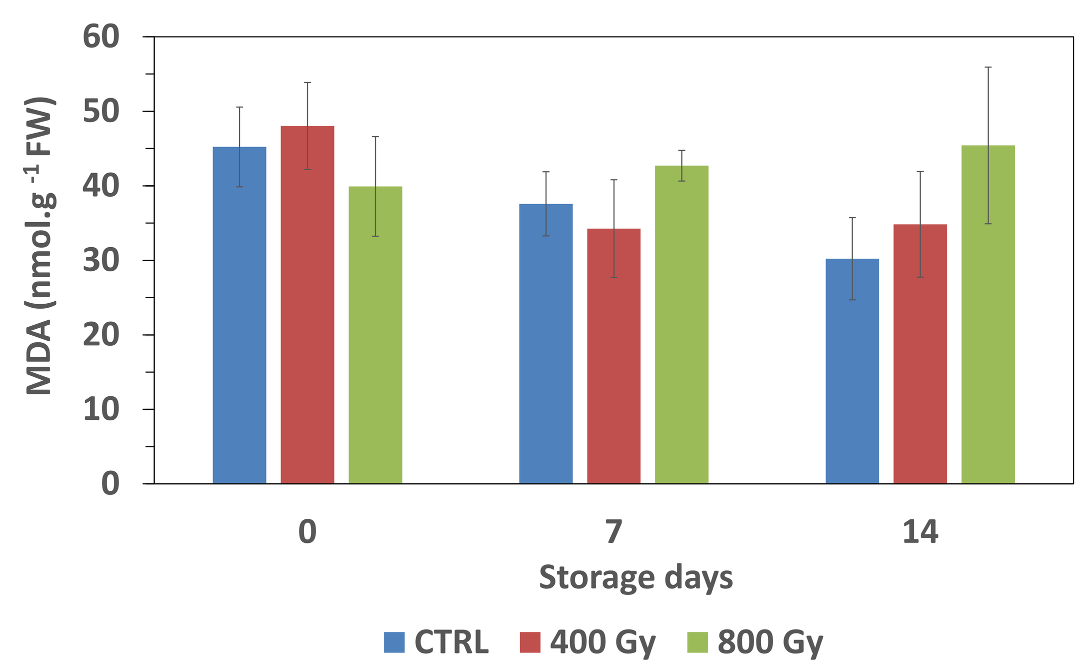

Figure 7. MDA content of 'Fuji' apples at 0, 7 and 14 days after irradiation.

Discussion

Ethylene production was strongly inhibited by irradiation. Although apples irradiated at 400 Gy produced less ethylene compared to the controls, it was still significant, in contrast to 800 Gy, which had almost a complete inhibition. Similarly to observed in 'Gala' apples (Fan et al. 2001), the low dose irradiation in climacteric 'Fuji' apples also caused a dose-dependent decrease in ethylene production. In breaker tomatoes (Larrigaudière et al. 1990), found inhibition of ACO at doses of 1 kGy and above, suggesting an impairment in the membranes, since ACO is considered a highly integrated membrane bound enzyme. The observed increase in reducing sugar (glucose) content in the highest dose compare to control may be related to the increased activity of catabolic enzymes such as invertases and phosporylases induced by irradiation which can promote hydrolysis of photosynthates into reducing sugars, providing energy to maintain the higher respiration rates. The significant increase in electrolyte leakage in apple tissues was not correlated with higher MDA content. Membrane leakage may reflect a physical damage in membranes, rather then the known effect of ROS as senescence inducers.

Conclusions

- Irradiation at results in increased physiological responses related to stress in late harvested 'Fuji' apples, in a dose dependent manner, including increased respiration rate, and electrolyte leakage. The effect of irradiation in reducing the ethylene production in Fuji apples is related to membrane damage, which affects the activity of the ethylene forming enzyme (ACO).
- It is important to note that while these physiological responses were detected, there was little physically obvious manifestation of changes in apple quality.

Acknowledgements

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Larrigaudiere, C., Latche, A., Pech, J. C., Triantaphylides, C. Short-term effects of λ-irradiation on 1-aminocyclopropane-1-carboxylic acid metabolism in early climacteric cherry tomatoes. **Plant Physiol.** 1990, 92, 577-581.

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