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Electron Beam Technology for Preserving Quality Attributes of Mandarins for Enhancing Export Potential

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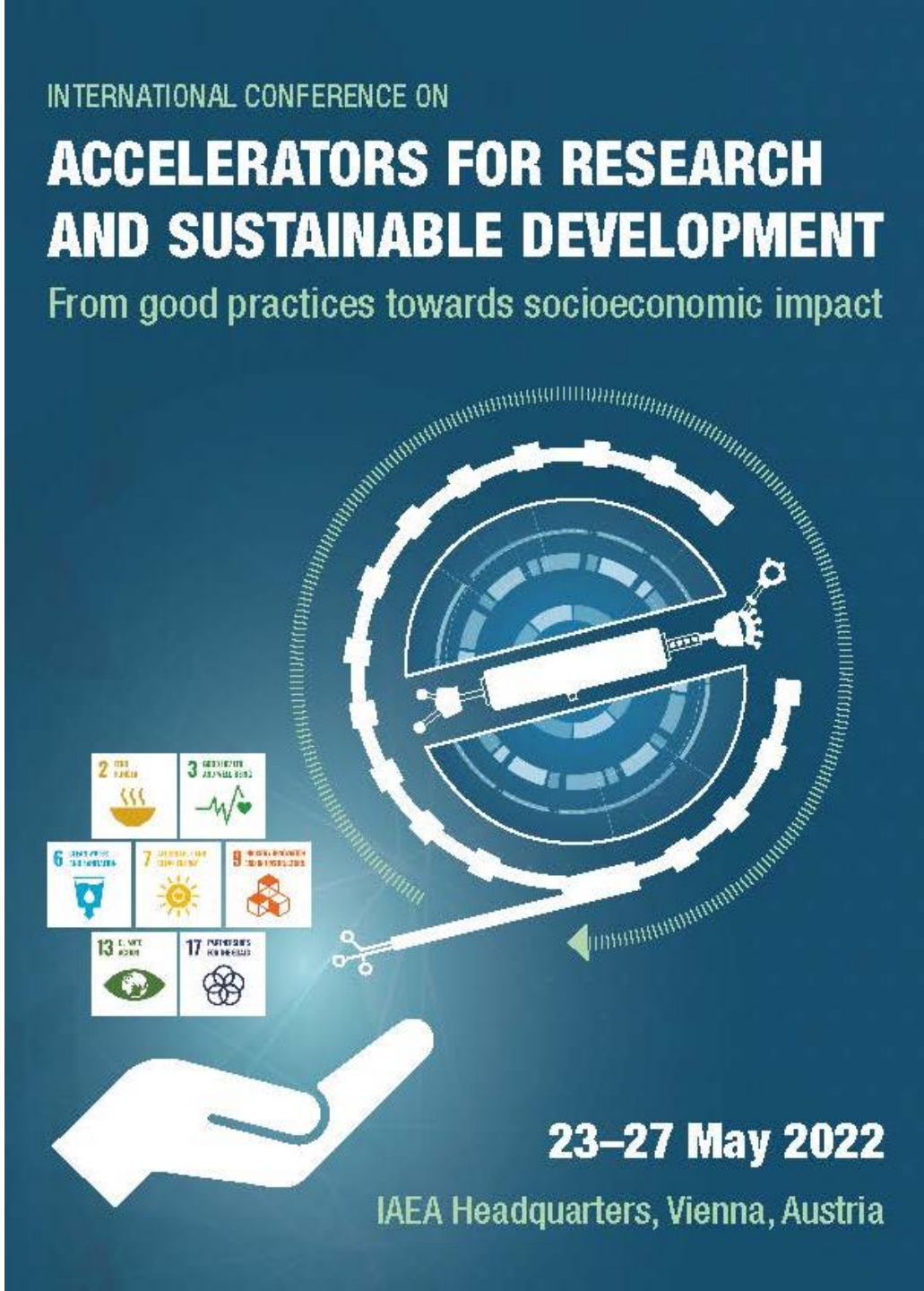

Outline

- Study Rationale and Background
- Experimental Design, Objectives, and Research Questions
- Methods & Results
- Conclusions

Global citrus fruit production volume is ~31.2 million tons (Raimondo, et al 2018)

Waste occurs at a rate of ~30 – 60%

A large portion of waste is released into the environment

Environmental and human health implications

International Conference on Accelerators for Research and Sustainable Development
#Accelerators2022
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Phytosanitary Treatment

- **An official procedure for the killing, inactivation, sterilization, or removal of pests** (FAO 2009)

- Current phytosanitary treatments for tephritid fruit flies in or on citrus fruit (ISPM 18 and 28):
  - Holding fruit at 1℃ for 14 days, or
  - Irradiation at a minimum absorbed dose of 150 Gy (gamma-sourced)

- Current practices have issues involving fruit quality, costs, and the use of radioactive substances

Objectives

- To evaluate the effects of this proposed phytosanitary treatment on **selected quality attributes** of mandarin oranges
  - Color & visual appearance
  - Percent weight loss & extractable juice volume
  - pH
  - Vitamin C content

- Determine maturity stages of the samples

Research Questions

1. What are the quality effects on mandarins when treated with the current phytosanitary dose of 150 Gy?

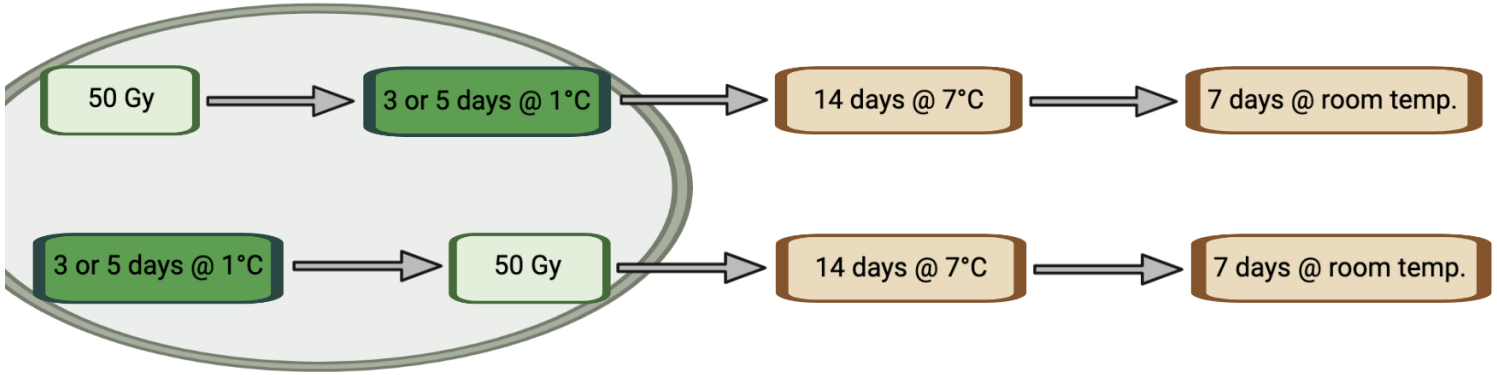
2. Can a less harsh cold storage period + lower eBeam doses hinder quality degradation?

   Is cold storage **before or after** eBeam treatment, for **3 or 5 days**, more effective?

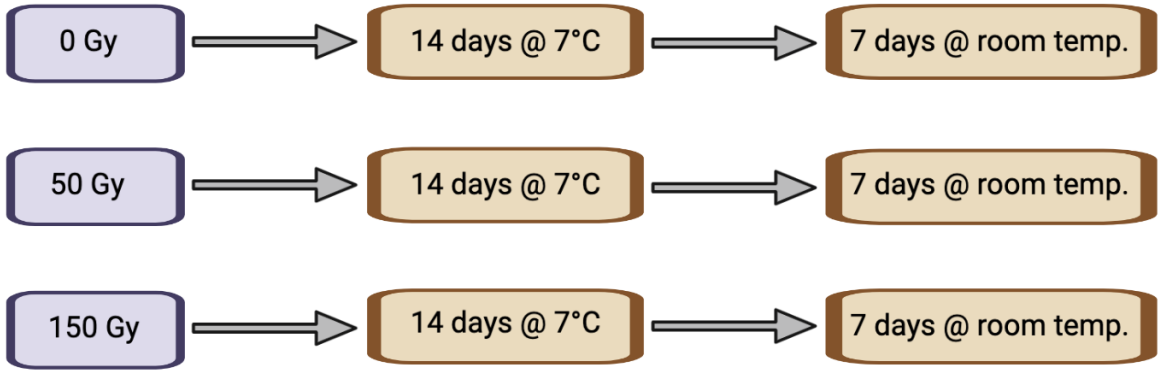
3. Does quality impact differ between Californian and Chilean mandarins?

Experimental Design

- Rationale: Simulate commercial conditions experienced by citrus



- Experimental hypothesis: A lower irradiation dose (50 Gy) coupled with a shorter cold storage period (3 or 5 days) will impart less quality damage



Treatment Designations

Treatment	Designation
0 Gy Control	0Gy
50 Gy Control	50Gy
150 Gy Control	150Gy
50 Gy, followed by 3 days of storage at 1°C	50Gy3D
50 Gy, followed by 5 days of storage at 1°C	50Gy5D
3 days of storage at 1°C, followed by 50 Gy	3D50Gy
5 days of storage at 1°C, followed by 50 Gy	5D50Gy

Methods and Results

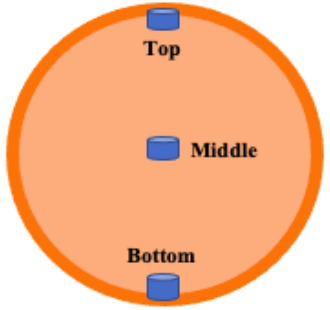
eBeam Treatment

- 10 MeV, 15 kW linear accelerator
- **Attenuation** needed to reduce the number of electrons entering the fruit in order to achieve low target doses

Attenuated

Dosimetry

- Dose mapping helps ensure that the entire product receives the necessary dose
- Measured using L-α-alanine dosimeters



Dosimeter placement

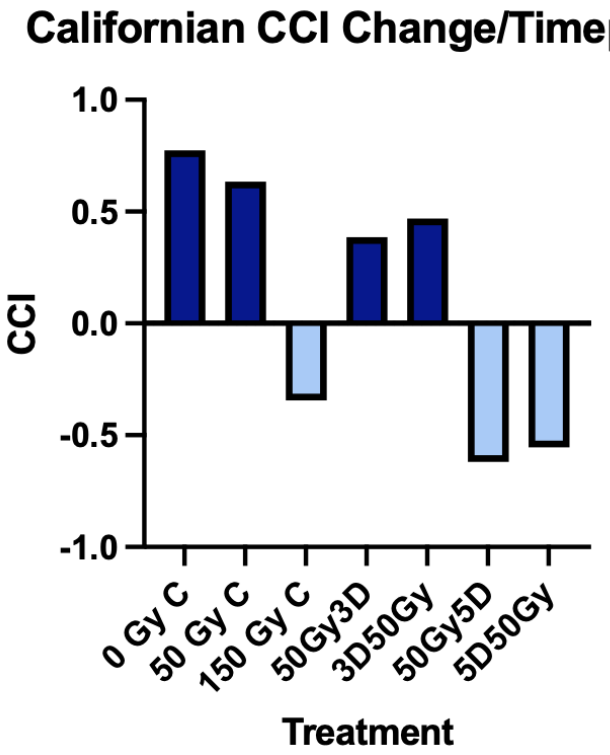
Target Dose (Gy)	Location	Absorbed Dose (Gy)	DUR*
50	Top	58.33 ± 24.85	1.76
	Middle	49.00 ± 13.89	
	Bottom	86.33 ± 49.80	
150	Top	186.33 ± 61.09	1.16
	Middle	161.33 ± 70.21	
	Bottom	161.00 ± 42.15	
50	Top	50.00 ± 2.65	1.11
	Middle	45.00 ± 1.00	
	Bottom	49.00 ± 2.00	
50	Top	208.33 ± 267.32	1.62
	Middle	218.33 ± 295.89	
	Bottom	135.00 ± 137.71	

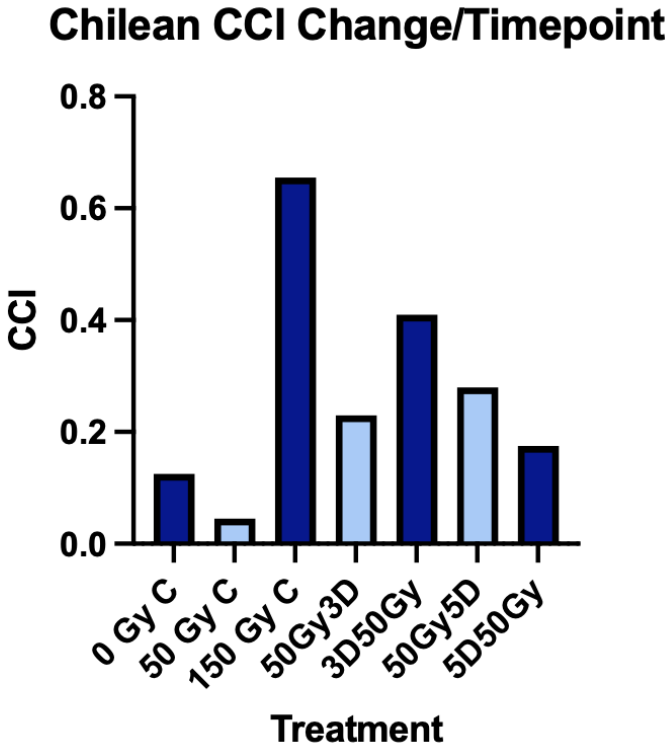
Color

- 20 mandarins held throughout storage
- Citrus Color Index (CCI) value

$$CCI = (\frac{a^*}{L^* \times b^*}) \times 1000$$

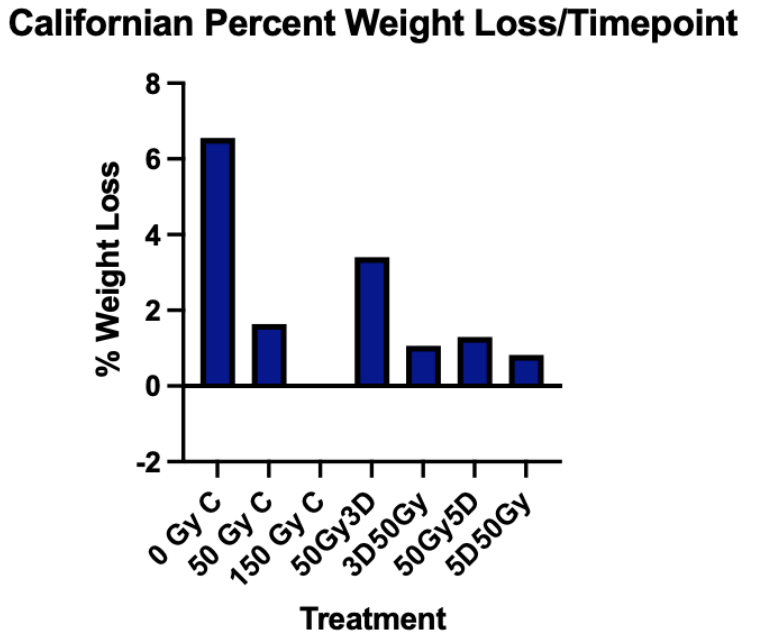
- No significant differences between treatment groups

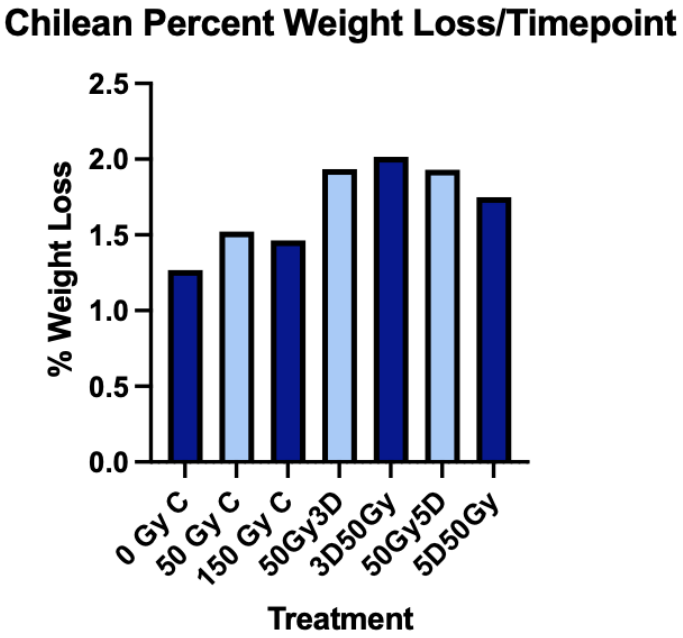




Percent Weight Loss

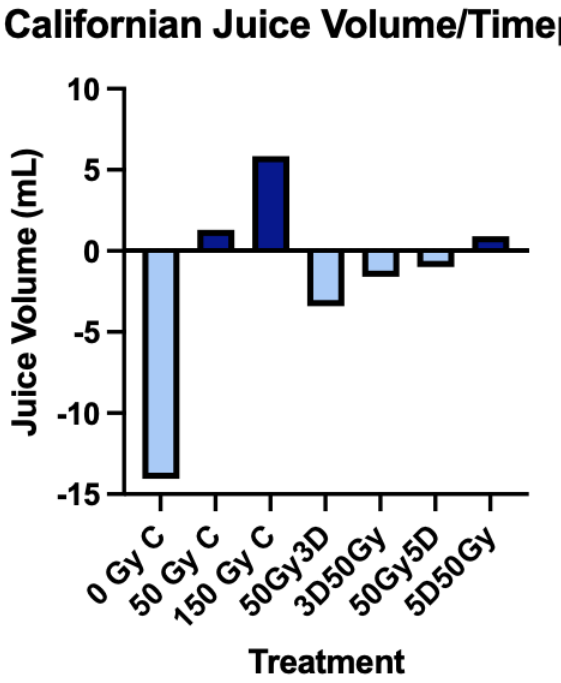
- 20 mandarins held throughout storage
- Reported as percentage of weight loss
- No significant differences between treatment groups

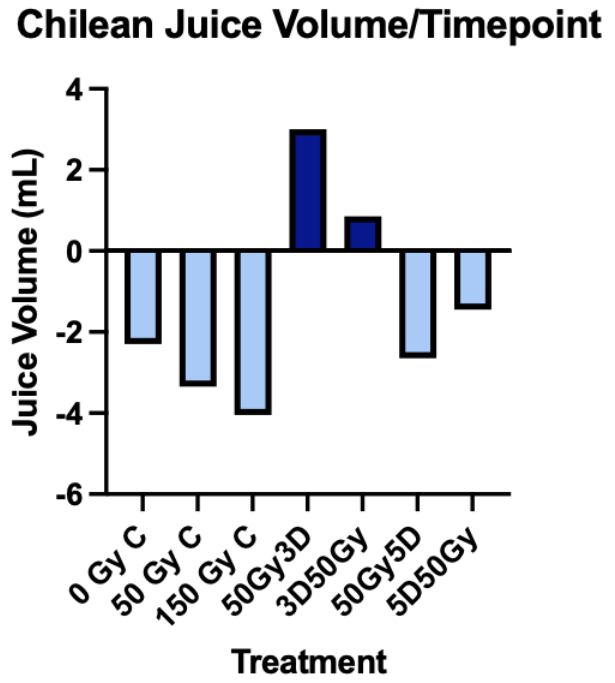




Extractable Juice Volume

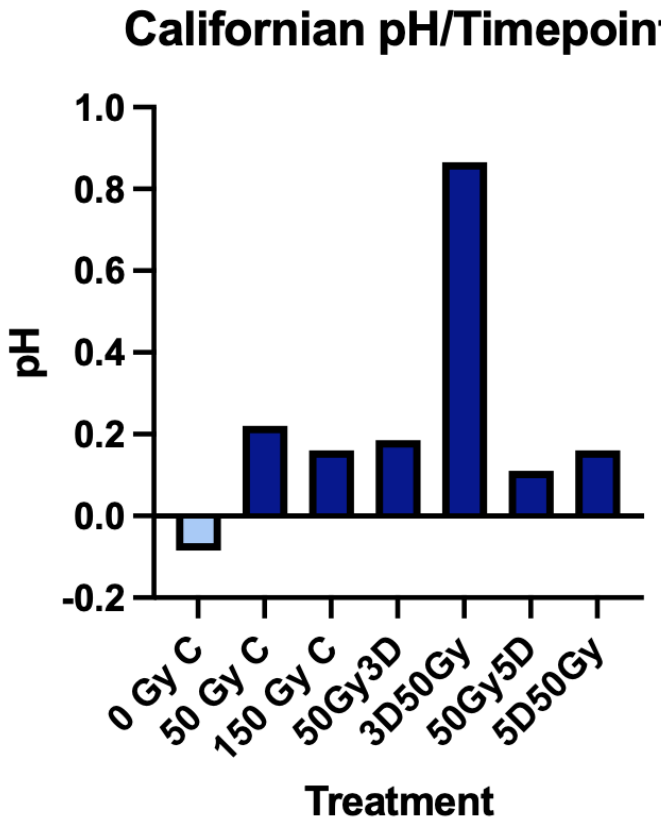
- Mandarins were juiced using a commercially available juicer
- No significant differences between treatment groups

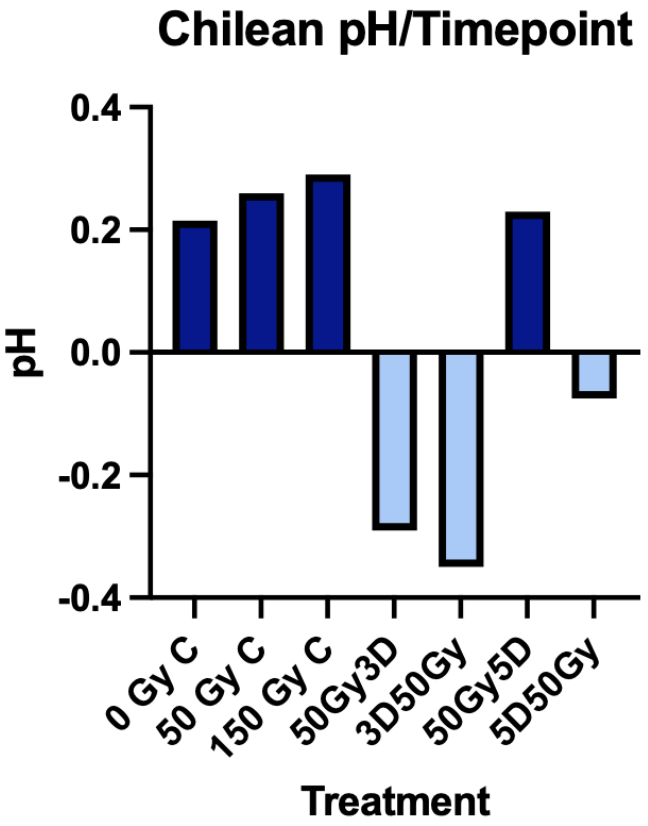




pH and Titratable Acidity (TA)

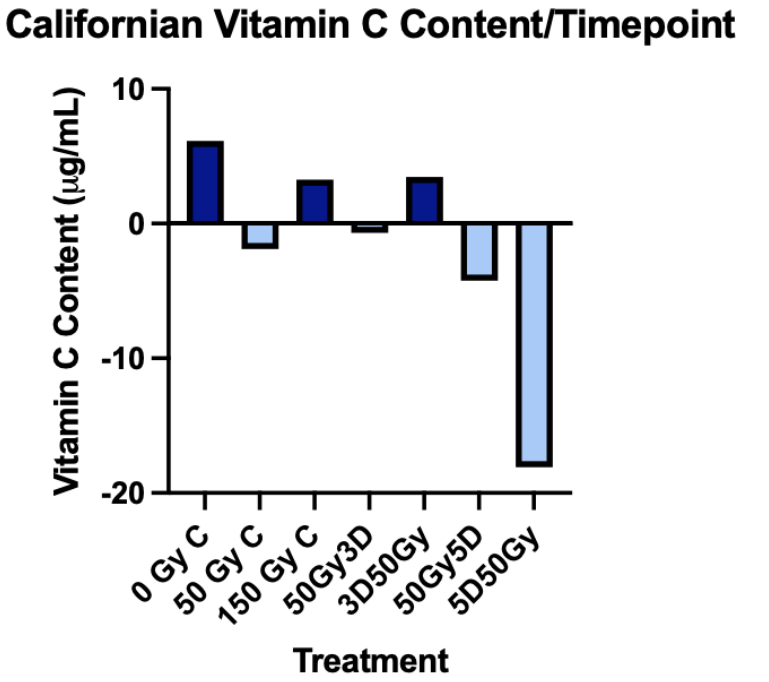
- 20 mL of fruit juice and an automatic titrator used to measure pH and TA
- TA used in maturity index calculation
- No significant differences seen between treatment groups

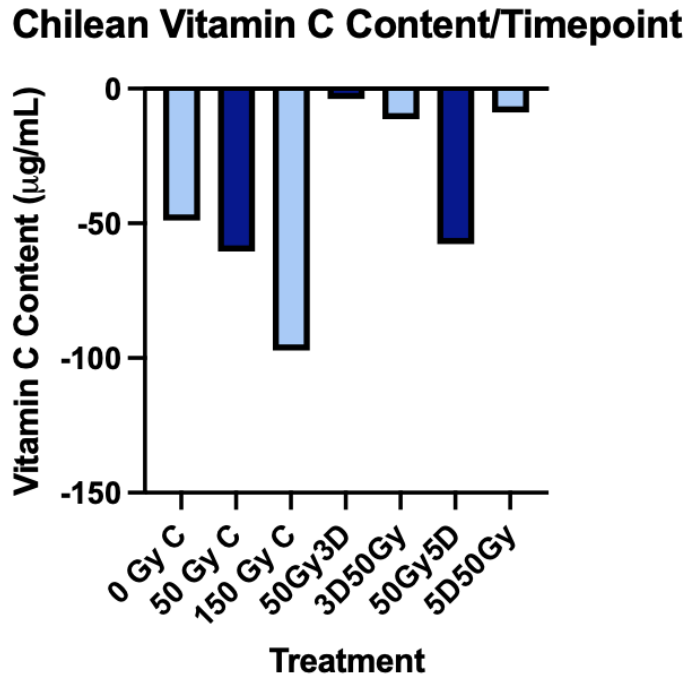




Vitamin C Content

- Performed by the Integrated Metabolomics Analysis Core (IMAC) at Texas A&M University
- Performed using targeted liquid chromatography (LC-QQQ)
- No significant differences between treatment groups



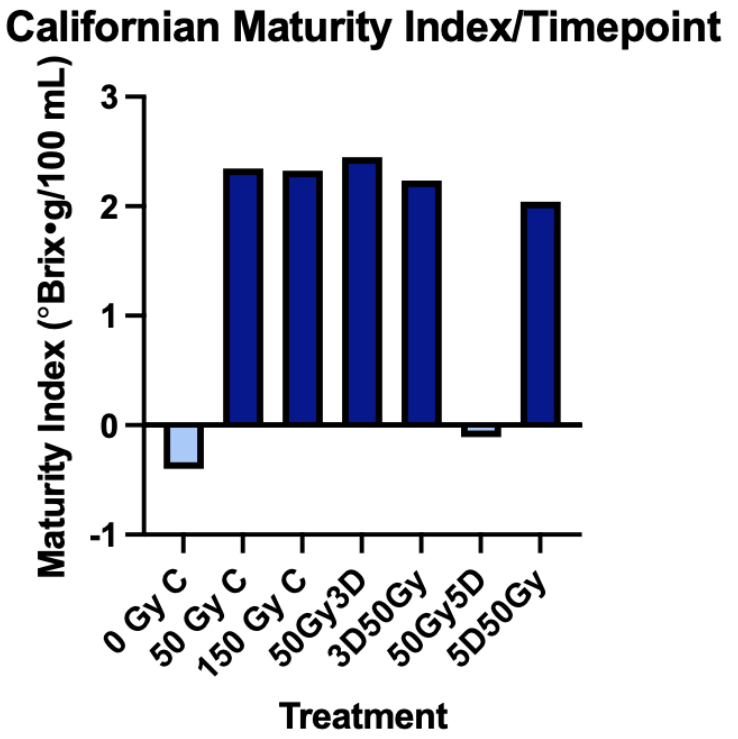


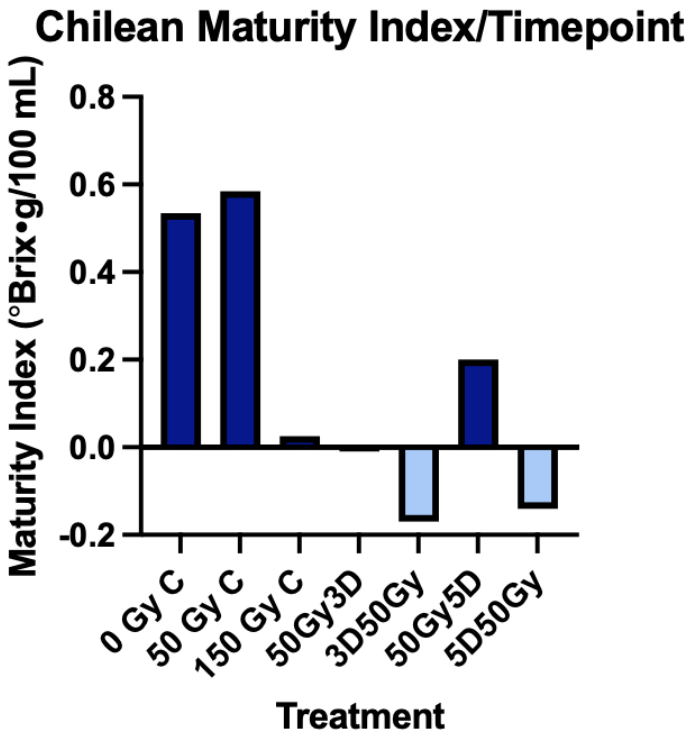
Maturity Index

- TA measurements were obtained in previous step
- Total Soluble Solids (TSS) (ºBrix) were determined using a digital refractometer

$$Maturity\ index = \frac{°Brix}{TA}$$

- No significant differences between treatment groups





Visual Appearance

Californian mandarins

Chilean mandarins

Conclusions

- 50 Gy eBeam dose + 3 days of storage at 1℃ best maintained visual quality and overall appearance
- Treatment at 150 Gy alone lead to the most visual deterioration
- Chile-harvested mandarins may be more susceptible to visual quality deterioration as a result of eBeam treatment

Thank you! Questions?

Acknowledgements

- Halos – The Wonderful Company
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