IRRADIATION TREATMENT OPTIONS: SIZE MATTERS

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Overview

- Source of radiation
  - Isotope
  - E-beam
  - X-ray
- Size of irradiator
  - Large, medium, small
  - Technical objectives
  - Throughput requirements
  - Cost

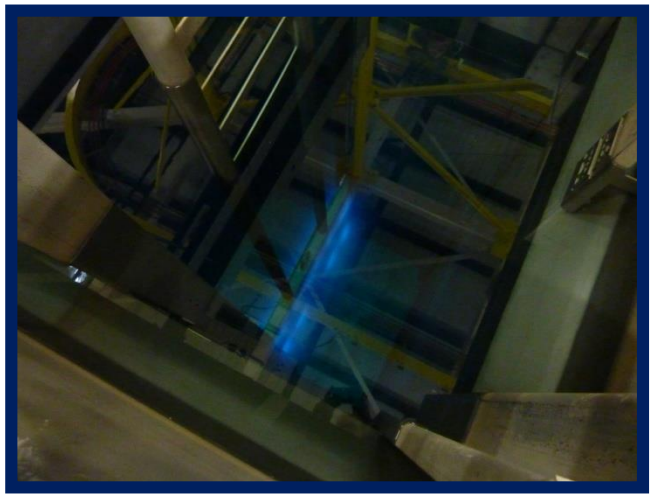
Definitions

Irradiation- The exposure of a substance to ionizing energy (radiation) for the purpose of achieving some desired technical benefit.

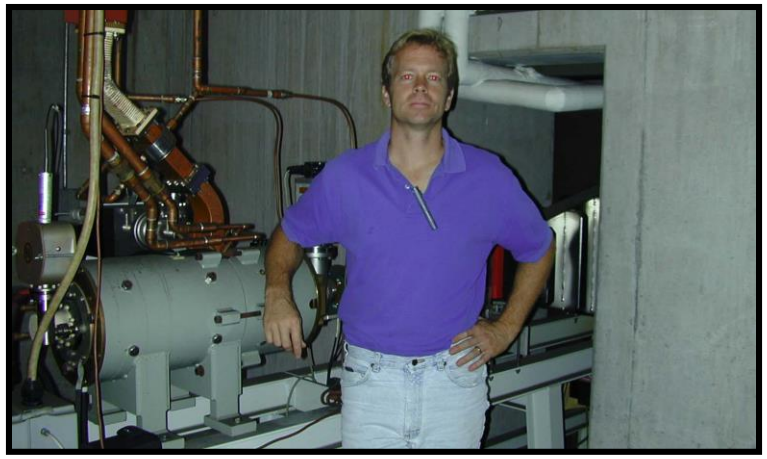
Gray (Gy) - a unit of absorbed dose where 1 Gy is equivalent to the absorption of 1 joule per kilogram of the specified material (1 Gy = 1 J/kg).

Dose uniformity ratio (DUR) – the ratio of the maximum to the minimum dose applied to the material

There are three approved radiation sources for phytosanitary treatment:



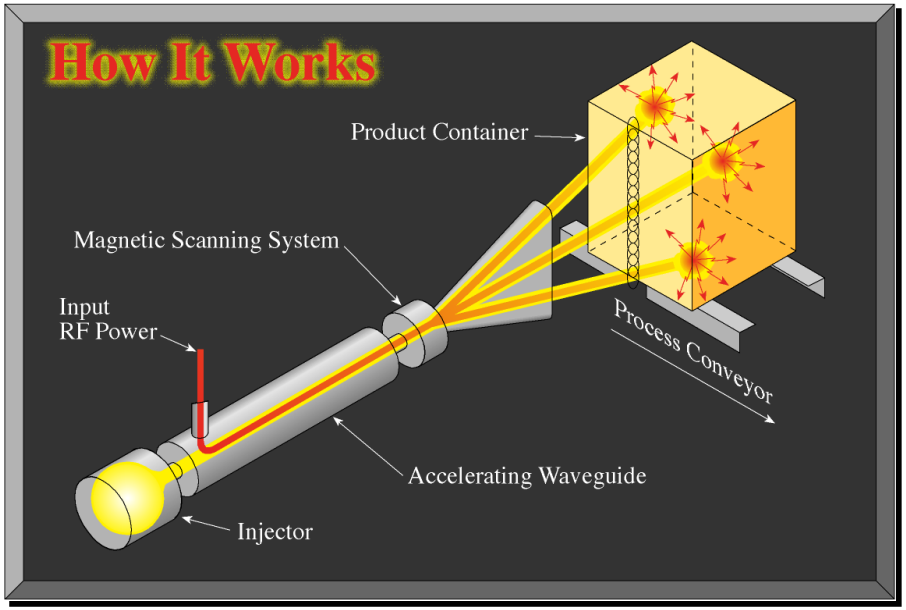
- **Gamma**: Cobalt-60 or Cesium-137 emits photons during decay

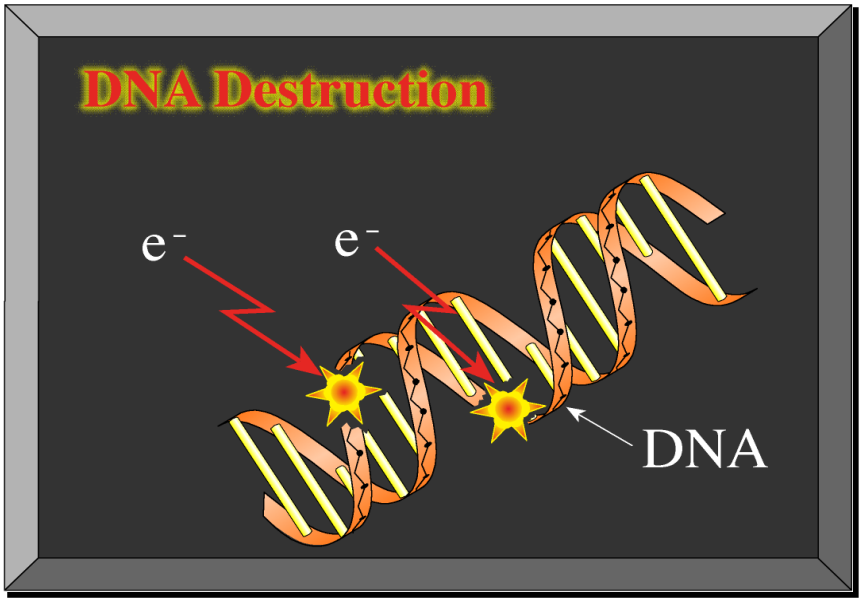


- **E-beam**: High energy electrons propelled (particle beam) from an electron gun
- **X-ray**: High energy electrons are converted to X-rays (photons)

The Technology

Irradiation technology
Gamma, e-beam, or x-ray





- Ionizing radiation breaks chemical bonds within DNA and other molecules, disrupting normal cellular function.
- Insect response varies with species and life stage.

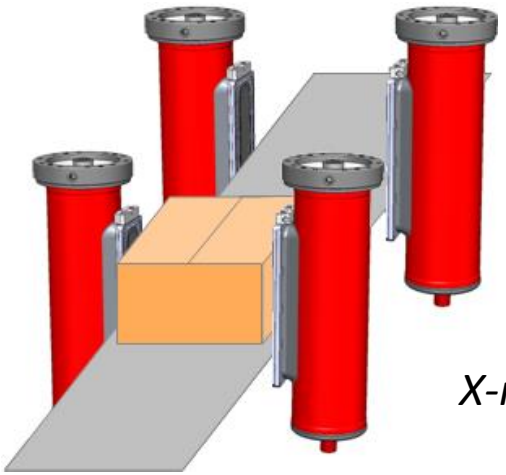
Dose Uniformity Ratio

Irradiation treatment efficiency

- US FDA approved irradiation doses up to 1000 Gy (1 kGy) for preservation and disinfestation.
- Maximum / minimum dose typically 1.5-3.0
- 400 Gy (generic dose) x 2.5 = 1000 Gy
- Advantageous to lower the dose:
  - Avoid problem of 1 kGy limit
  - Cost
  - Capacity
  - Quality

Commercial irradiator - *Requirements*

- Good penetration
  - Fruit boxes or pallets
  - Single layer of fruit
- Good dose uniformity ratio
  - Especially if 400 Gy, then $\leq$ 1 kGy maximum
- Sufficient throughput
- Acceptable cost
- Reliable during continuous use



X-ray emitter

Irradiator Size Matters

Small	Medium	Large
• Boxes	• Carrier	• Pallet
• DUR	• DUR	• DUR
1.5	1.5-2.0	2.5- 3.0
• Throughput	• Throughput	• Throughput
100s lbs/hr	1000s lbs/hr	10,000s lbs/h
• Cost	• Cost	• Cost
$1 million	$3-10 million	$10-30 million

Large multipurpose irradiator

Why might you be interested?

- Isotope, e-beam, x-ray
- Existing facilities can provide service
- High dose rate and throughput
- Versatile, larger products e.g. pallets
- Sterilization capability

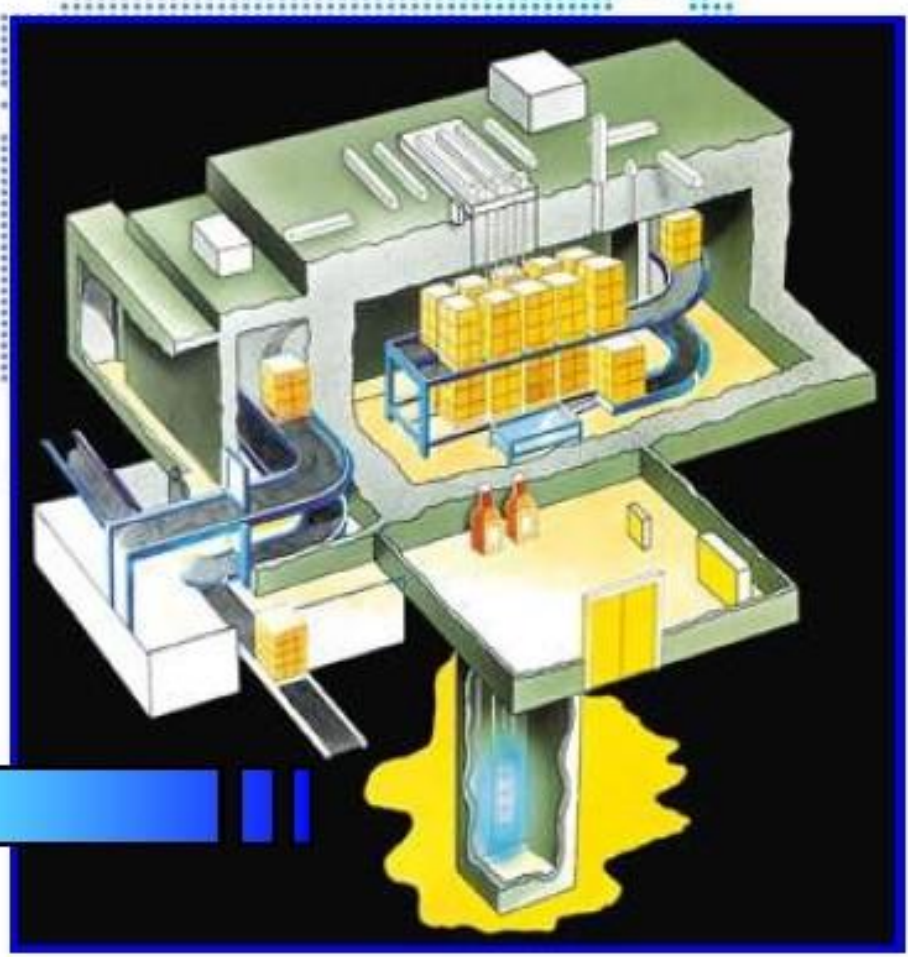
But…

- Transportation
- Availability
- Dose uniformity issues
- If building your own:
  - High initial cost
  - Slow start up

Large multi-purpose pallet irradiator

Synergy Health (Thailand) Ltd.

Disposable medical devices – 70%
Food, fruit – 5%



Pallet irradiation of longan

If they treated only fruit: potential throughput of 17,500 lbs/hour

Medium scale irradiator

Why might you be interested?

- Isotope, e-beam, x-ray
- Lower initial cost
- Lower operating cost
- Smaller footprint
- Dedicated to one or a few products
- For fruit with no other treatment or sensitive to other treatments

But…

- Lower throughput

Hawaii examples:

- Hawaii Pride (x-ray)
- Pa'ina Hawaii (cobalt)

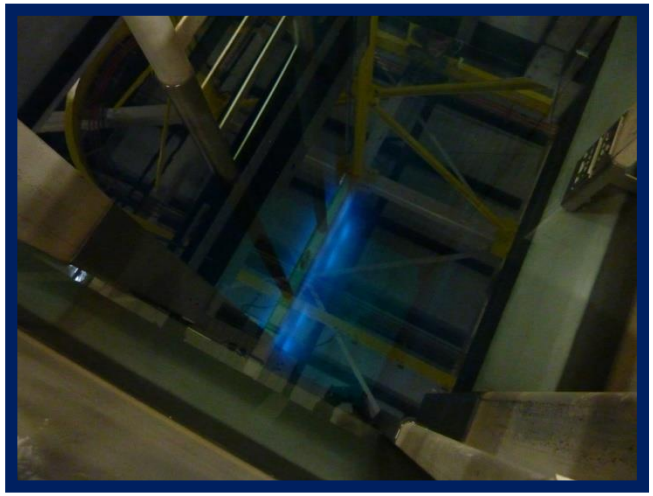
Hawaii's commercial irradiators

< Hawaii Pride

- E-beam/X-ray source
- Started 2000
- Designed for fresh produce
- Expensive
- DUR = 1.4

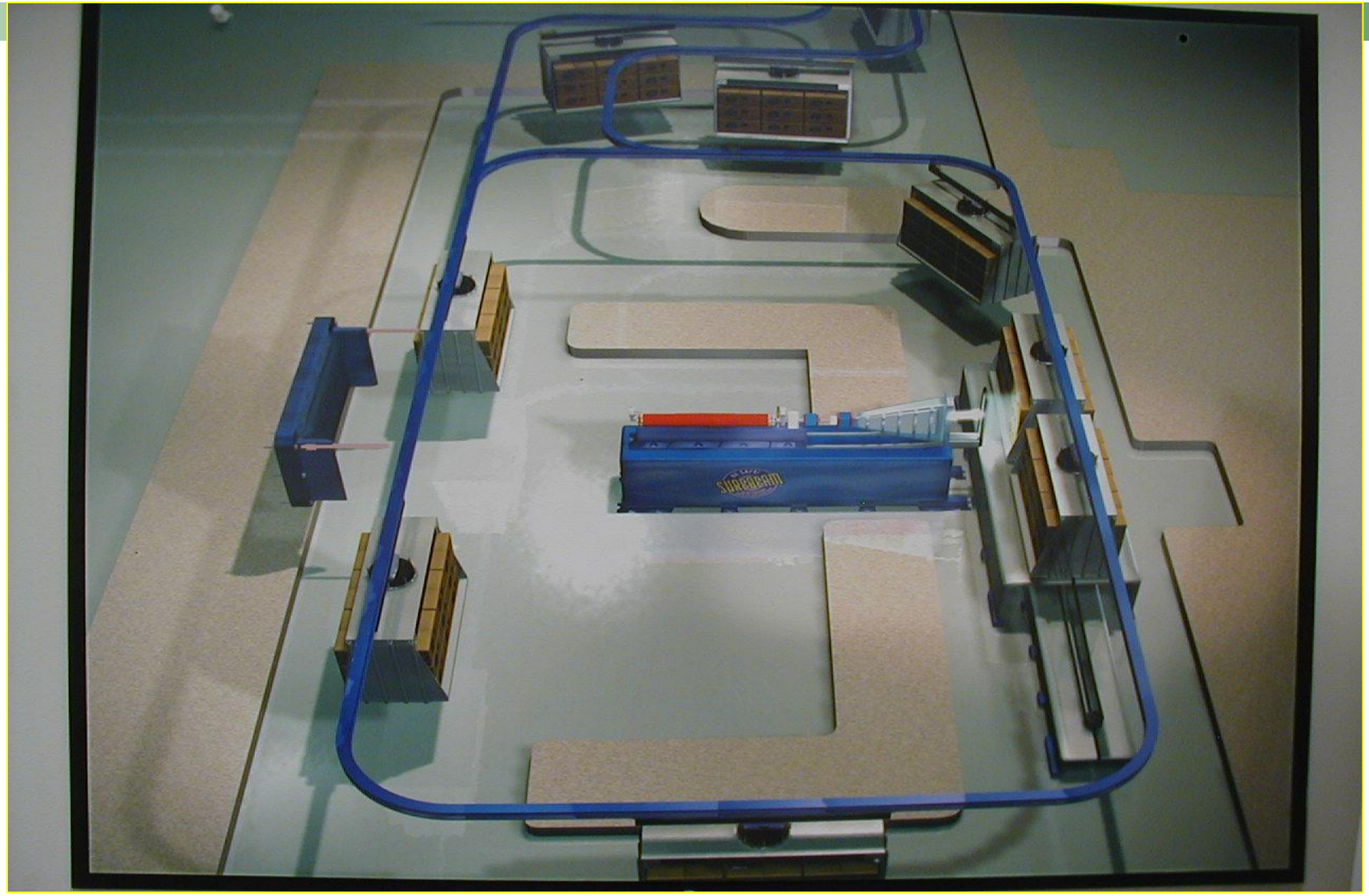
Pa'ina Hawaii >

- Underwater cobalt source
- Started 2013
- Designed for fresh produce
- Relatively inexpensive
- DUR = 2.5, 1200 lbs/h



Medium-size x-ray irradiator for fruit

Hawaii Pride (Hawaii)



Medium-size cobalt Irradiator

Pa’ina Hawaii

Small cabinet x-ray irradiators

Why might growers be interested?

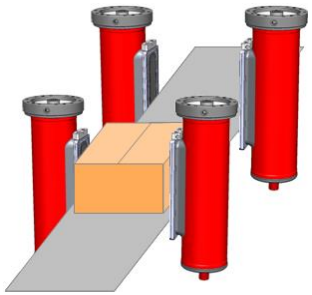
- Costs a fraction of a stand alone facility (<$1 million)
- Treat fruit the same day it's packed – no transportation
- Moveable - ready-made for domestic quarantines
- Under grower's control

- Methyl bromide alter.
- Can treat fruit cold
- Simple solution

Potential application:

- Sweet cherries to Australia and Mexico

  (80 Gy for SWD)

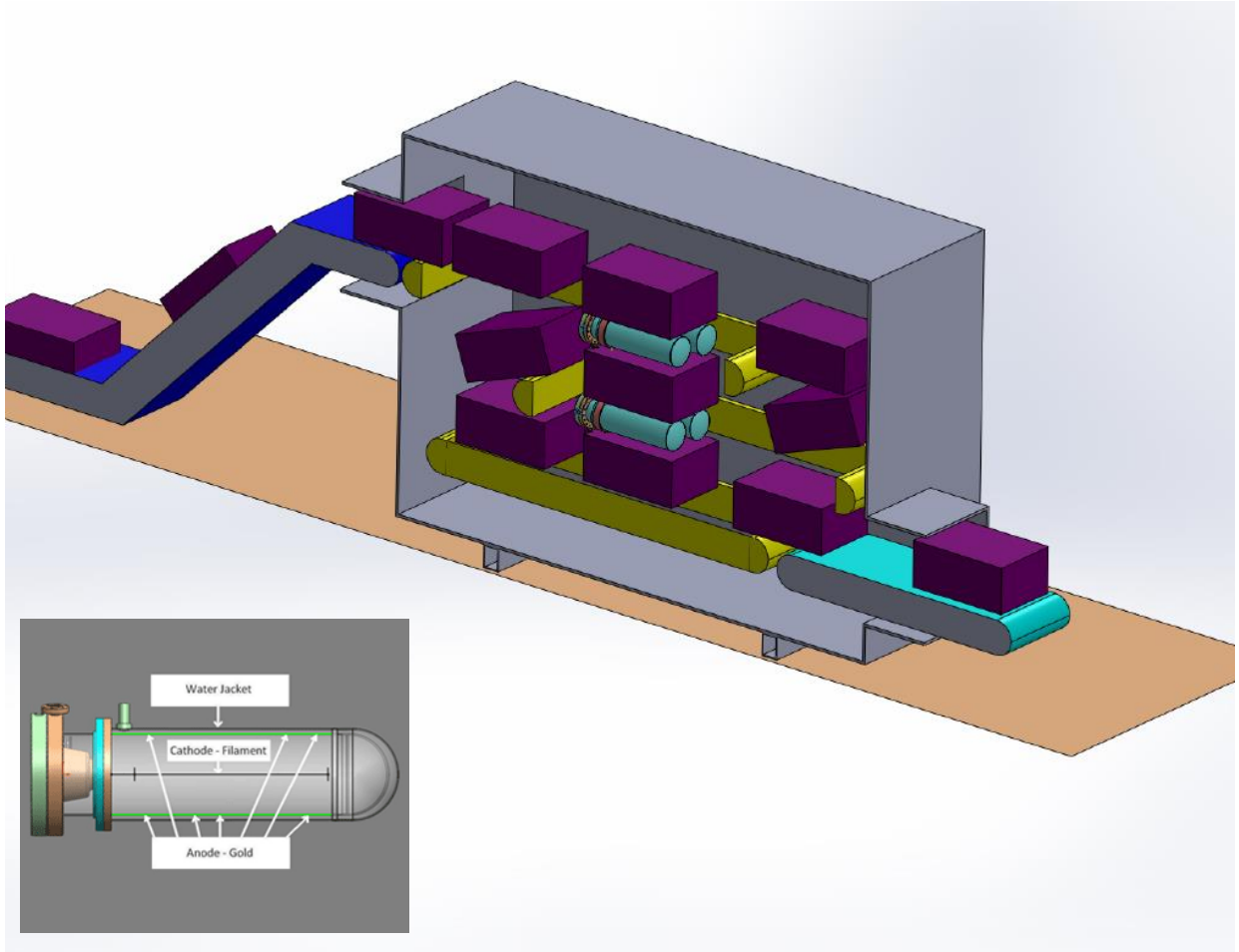


Small-scale cabinet x-ray irradiator

Sweet cherries

Designer:
Randy Kirk

Applied Energy Devices



4-pi X-ray tube

Sweet cherry quality after x-ray

Demonstration tests

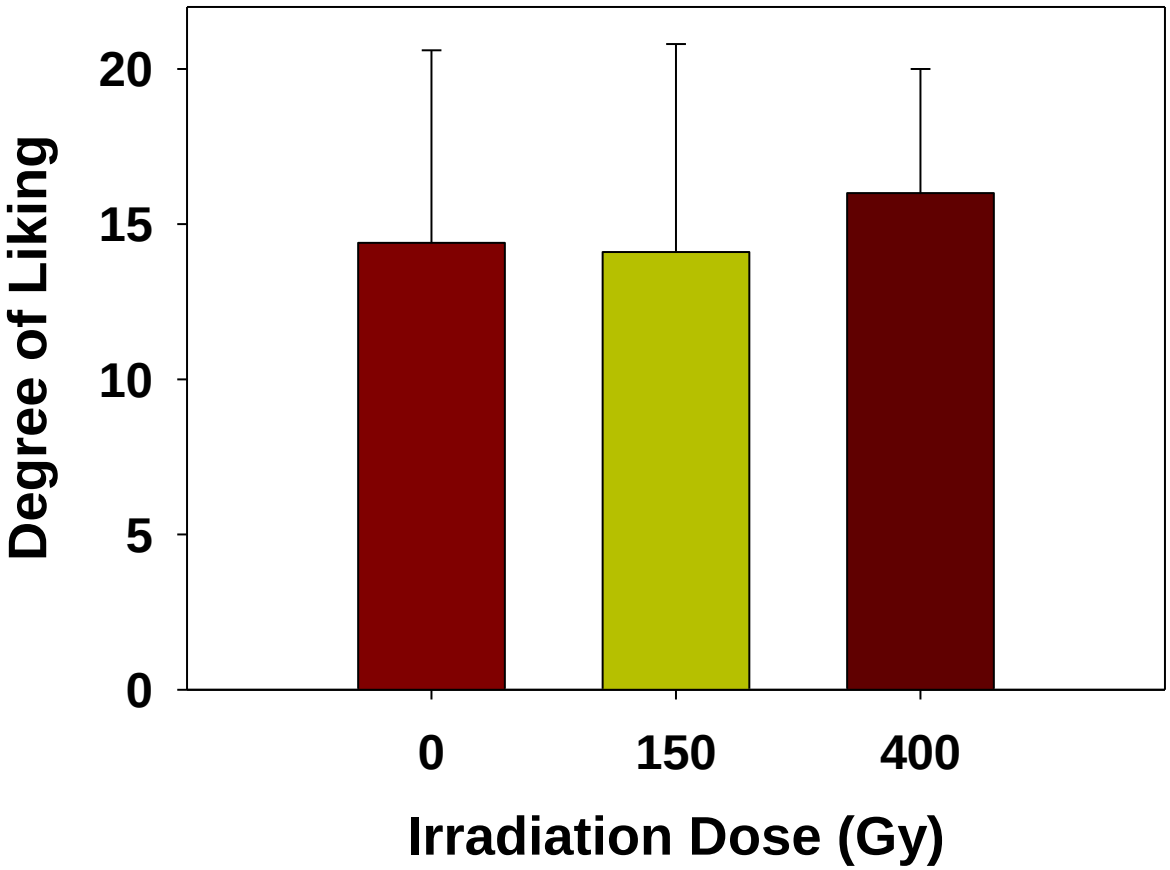
- Rad Source (Atlanta)

  Nutek (Hayward)
- Unique 4-Pi x-ray tube
- California 'Bing'

  Oregon 'Skeena'
- Irradiation at:
  - 0 (control)
  - 150 Gy
  - 400 Gy

Taste Test – Sambado's

- 15 panelists
- 'Skeena'
- 1-day after treatment
- Could not detect treatment differences
- 1 week later – same result



In-line irradiation
E-beam option

Cherry irradiation

Prima Frutta, Linden, Calif.

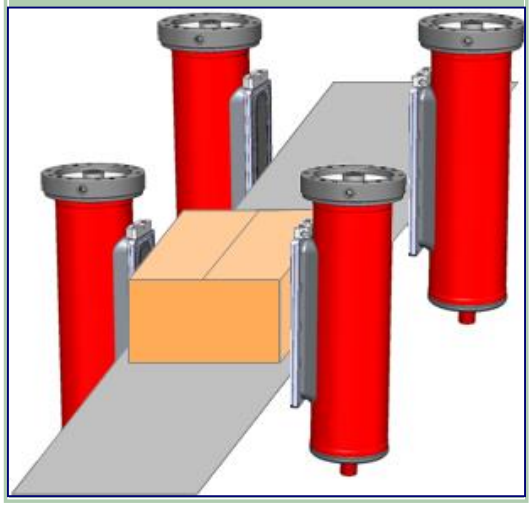
- High volume
  - 15,000 boxes per day
  - 1 box per 4 sec
- Keep fruit cold
- Short harvest
  - 2 months
  - Continuous use

Customize for packing line

Small-scale cabinet x-ray irradiator

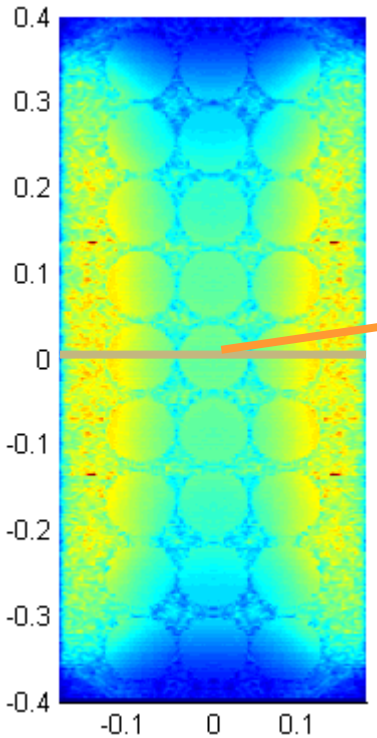
Papayas

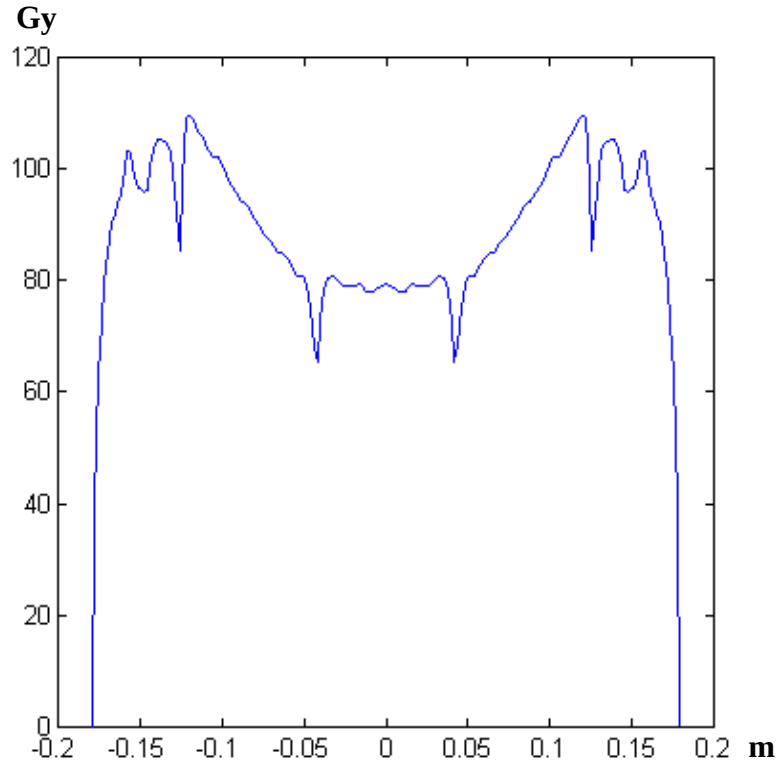
Comet AG Flamatt, Switzerland



X- ray emitter

Papaya box *Dr. Dominique Cloetta (Comet)*





At 180kV, 4.5kW and 10cm/min conveyor speed:
Min. dose: **78Gy**, max. dose: **109Gy**
DUR: **1.4**

- at **5cm/min**: Min. dose: **156Gy**, max. dose: 218Gy
- at **1.95cm/min**: Min. dose: **400Gy**, max. dose: 559Gy
- → at **1.09cm/min**: Min. dose: 716Gy, max. dose: **1000Gy**

Questions?

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