USDA
United States Department of Agriculture

Phytosanitary Irradiation Research Needs

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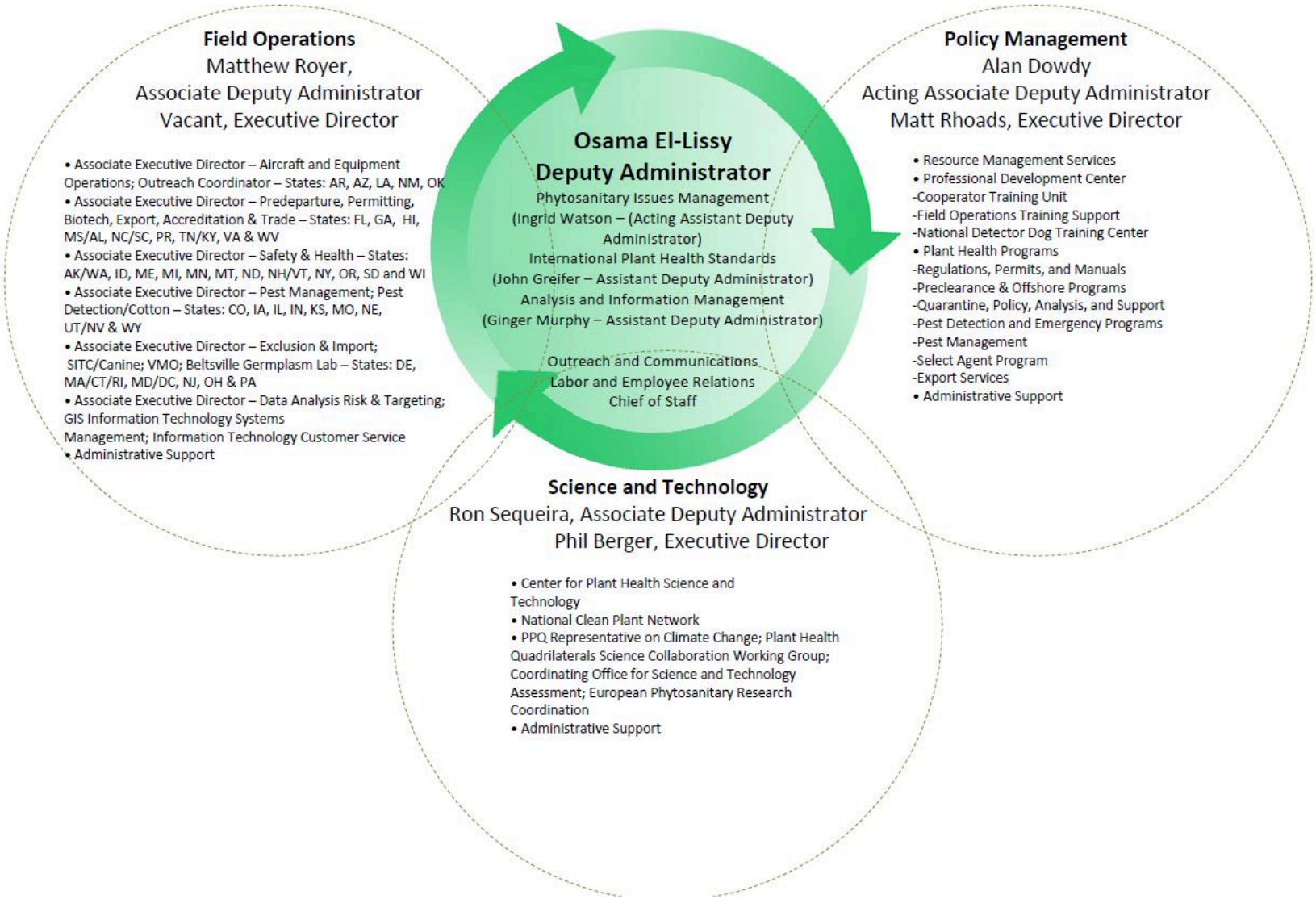
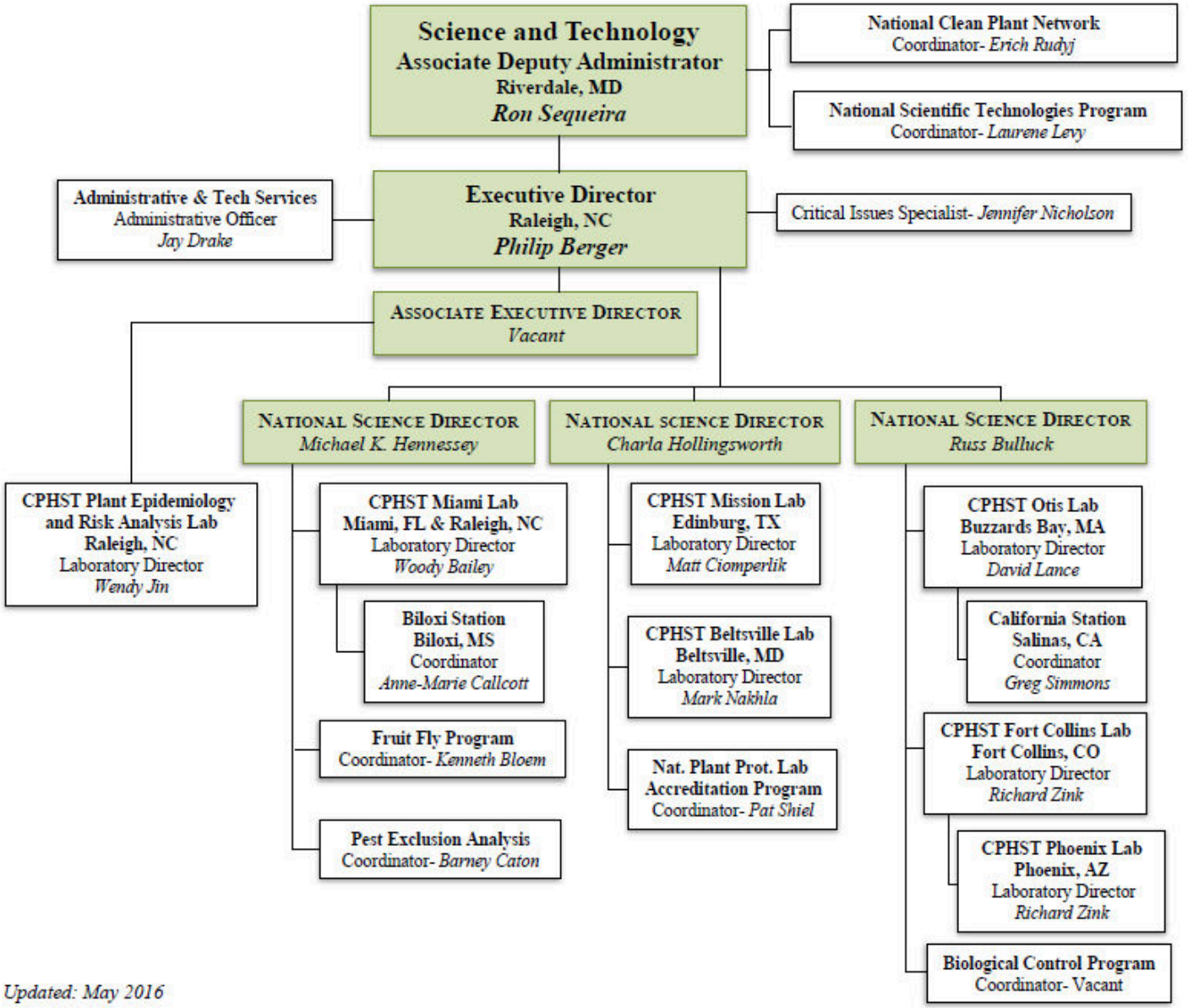
Science and Technology
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture

Plant Protection and Quarantine Organizational Structure

Current as of April 2016





Updated: May 2016

S&T Irradiation Efforts

- Facility, packaging and process configuration approval
- PPQ policy and standard development (CFWG)
- Research proposal review and/or development
- Cooperator research project management
- Irradiation database management and QA
- Field and hub staff training
- International and domestic outreach
- Methods development (quality, MAP, generic & specific pest doses)

Current Research Efforts

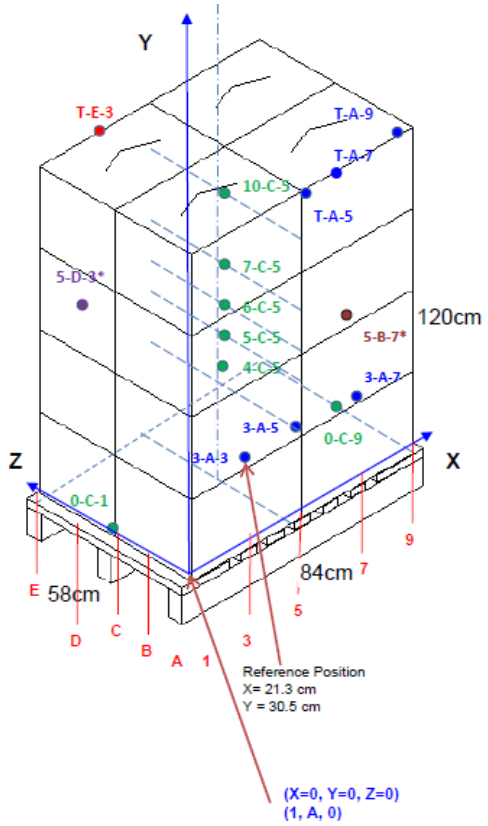
- Upon Arrival Process Configuration Approval
- Quality Studies
- Generic Doses
- Modified Atmosphere Packaging
- Treatment Verification Tool
- Odds n Ends

Dose Mapping

It is important to know what the absorbed dose range will be throughout the configuration

Dose mapping

- Identify areas of high and low absorbed dose
- Determine R_f (reference dose)



Process Configuration Testing

Packaging approval and process configuration testing and approval has to occur before commodity is shipped to the US from the country of origin

Issues with current process:

- Time consuming
- Cost prohibitive (destructive)
- Overly conservative
- Very difficult for Port of Entry Irradiation Program

Process configuration testing on Thai longan

Process Configuration Testing

Industry requested APHIS to help develop procedures:

- Non-destructive testing
- Immediate release of commodity

PPQ has validated industry proposals from 3 facilities

Benebion®

HIGH ENERGY PROCESSING CAPE (PTY) LTD
HEPRO
Established 1986

Genesis™

Process Configuration Testing

PPQ will work with previously-certified Co_{60} facilities to approve alternate methodologies

In the future, methods for process configuration testing will be addressed during approval/certification

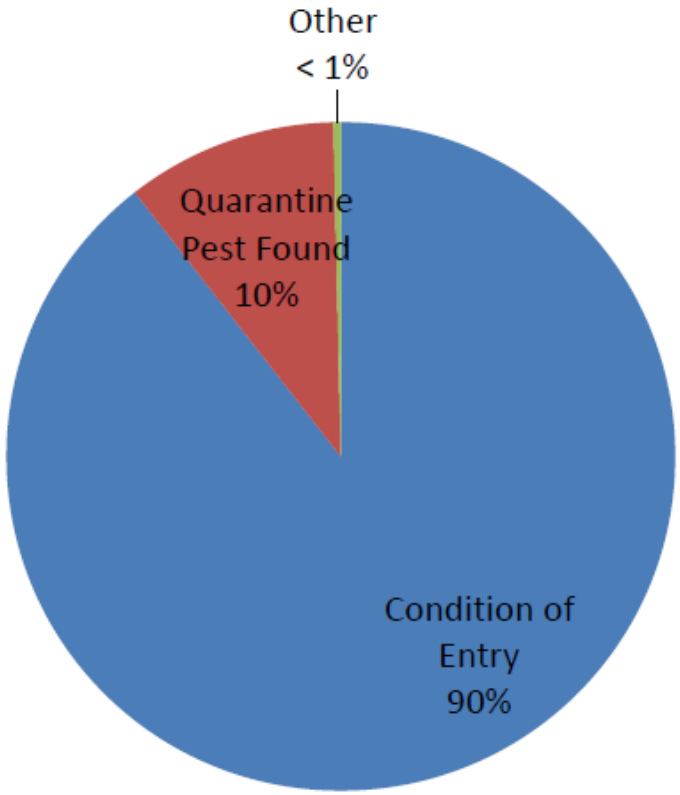
In addition to saving exporters and participating facilities considerable time and money, this is a large step towards using phytosanitary irradiation as a methyl bromide alternative for emergency actions (quarantine pest found on commodity)

Methyl Bromide Alternative

Condition of Entry Treatment

↓

Emergency Action at Port of Entry



US Imports: 2013 MB Usage

Quality Work

PPQ Irradiation Programs

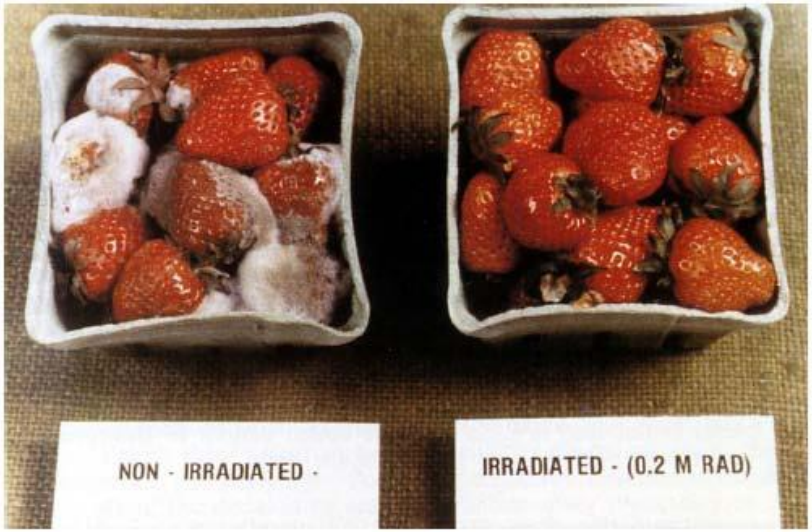
Preclearance
- Offshore irradiation of U.S. imports

Port of Entry
- Domestic irradiation of U.S. imports

Domestic Quarantine
- Treatment for domestic movement

Exports
- Domestic irradiation of U.S. exports

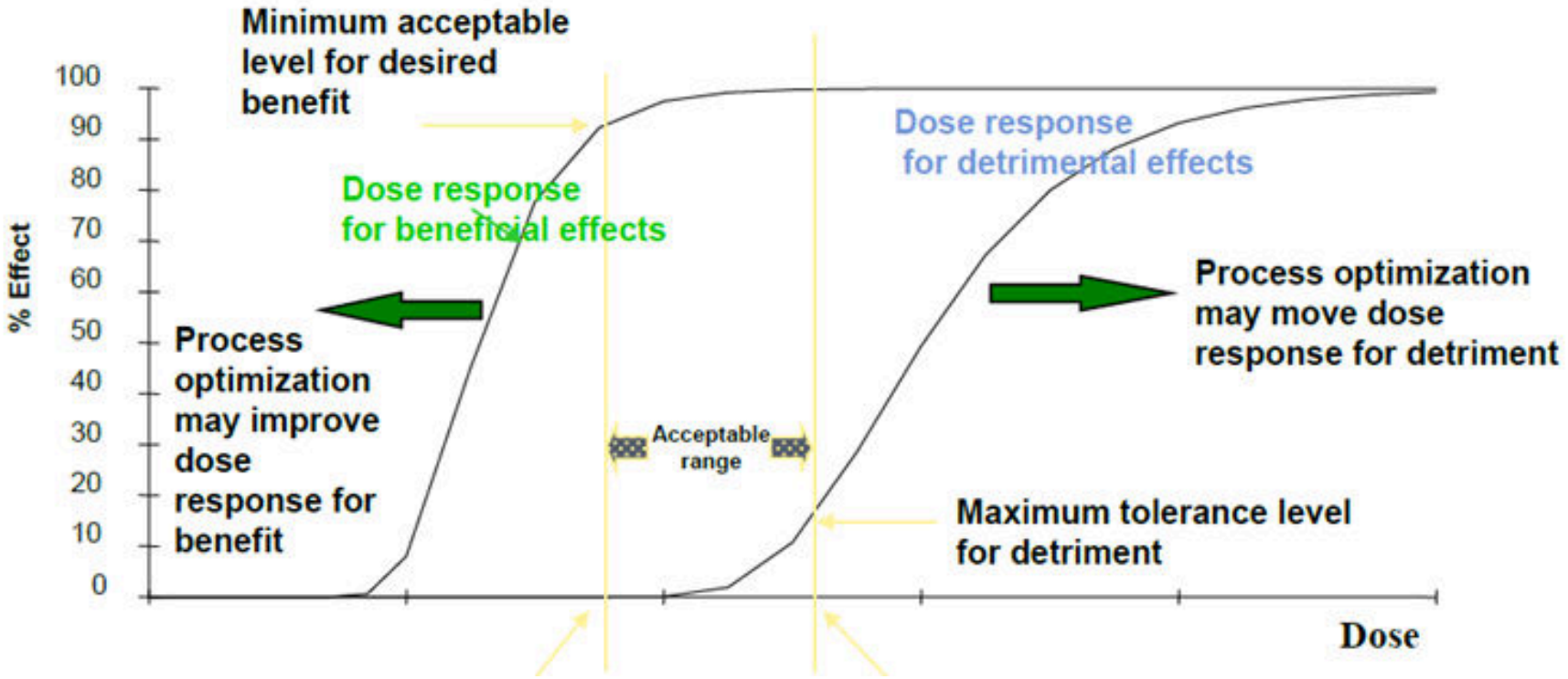
Quality Work



Most fruit can be irradiated with 150-600 Gray with no adverse effects

- Increased shelf life
- Improved quality

Quality Work



Joseph Borsa, MDS Nordion

Quality Work - Peaches

Joint Project (Chapman University, FTSI, and PPQ)

- Peaches irradiated 250, 400, 700, and 1000 Gy
- Analysis performed 1,7,and 14 days after treatment
- Shelf life, pH, Brix, and weight loss

Quality Work

Appearance	Aroma	Texture	Flavor
Smoothness	Overall Peach Aroma	Firmness Whole	Overall Peach Flavor
Bruising		Firmness Cut	Sweet
Flesh Color		Skin Firmness	Tart
		Mealiness	
		Ripeness	
		Juiciness	

Quality Work

Irradiation positively affected the liking/acceptability of all peach varieties tested

Shelf life, pH, Brix, and weight loss were not negatively affected by irradiation (variety and age play a bigger role)

Quality Work

Effect of phytosanitary irradiation on the quality and shelf-life of citrus

- Determine whether or not phytosanitary irradiation is a feasible treatment for Chinese citrus imports

Quality Work - Citrus

Joint Project (Chapman University, PPQ)

- Kishu mandarin and Chandler pummelos
- Irradiated 150, 400, and 1000 Gy
- Analysis performed 2, 21,and 28 days after treatment
- Shelf life, titratable acidity, firmness, organic acids

Quality Work

Kishu mandarin did not tolerate irradiation

- Dark coloration on peel 2 days after irradiation at 400 and 1000 Gy

Chandler pummelos

- No change in color, pH, sugars, juice content
- Quality compromised at 1000 Gy, but acceptable at 150 Gy

Generic Absorbed Doses

Table 5-2-12 Pest-Specific Minimum absorbed dose (Gy)

Scientific Name	Common Name	Minimum Absorbed Dose (Gy)
Cryptophlebia illepida	Koa seedworm	250
Cylas formicarius elegantulus	Sweet potato weevil	150
Cydia pomonella	Codling moth	200
Euscepes postfasciatus	West Indian sweet potato weevil	150
Grapholita molesta	Oriental fruit moth	200
Omphisa anastomosalis	Sweet potato vine borer	150
Pseudaulacaspis pentagona	White peach scale	150
Rhagoletis pomonella	Apple maggot	60
Sternochetus mangiferae	Mango seed weevil	300
	All other fruit flies of the family Tephritidae which are **not** listed above	150
	Plant pests of the class Insecta **not** listed above, except pupae and adults of the order Lepidoptera	400

Pest-Specific Absorbed Doses

Generic Absorbed Doses

Generic Absorbed Doses

Generic Absorbed Doses Facilitate Trade

If a risk analysis of a new commodity demonstrates that no pupae or adult Lepidoptera follow a pathway, then export approval can happen without further research.

Generic Absorbed Doses

- Develop doses for quarantine Lepidoptera (adults and pupae) not covered by the generic treatment
- Develop generic dose for mites (not included in generic 400 Gy dose)
- Reduction of dose levels for specific pests and commodities to shorten treatment time and minimize deleterious effects
- Development of generic doses below 400 Gy for important groups of quarantine arthropods (other than fruit fly)
- IAEA Working Group

The Evolution of Pest Proof Packaging

Modified Atmosphere Packaging

MAP is a process that alters the gas composition surrounding a commodity.

- prolongs the shelf-life of perishable goods
- slows the speed of aerobic microorganisms

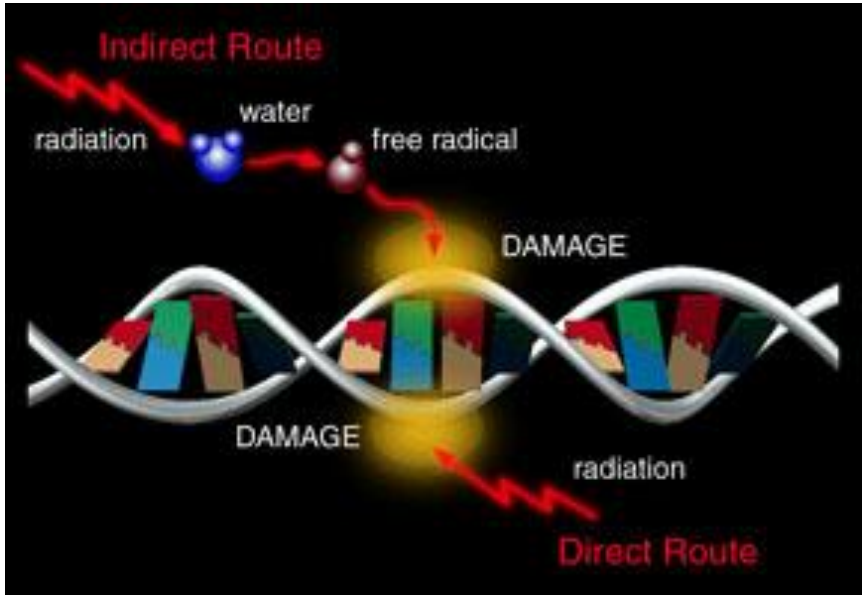
In the past few years, requests to use MAP for phytosanitary treatments have dramatically increased.

Modified Atmosphere Packaging

Commodity	Temperature [°C]	Humidity [%]	Modified atmosphere % O_2	CO_2
Fruit				
Apricot	0-5	90	2-3	2-3
Orange	3-9	90-95	5-10	0-5
Banana	13-15	90-95	2-5	2-5
Persimmon	0-5	90-95	3-5	5-8
Cherry, sweet	0-5	90-95	3-10	10-15
Strawberry	0-5	90-95	4-10	15-20
Apple	0-5	90	1-3	1-3
Blueberry	0-5	90-95	5-10	15-20
Peach	0-5	90-95	1-2	3-5
Pear	0-5	90-95	2-3	0-1
Vegetables				
Asparagus	0-5	95-100	aria	5-10
Broccoli	0-5	95-100	1-2	5-10
Cauliflower	0-5	95-98	2-5	2-5
Cucumber	8-12	90-95	3-5	0
Lettuce	0-5	95-100	1-5	0
Corn, sweet	0-5	95-98	2-4	10-180
Green pepper	8-12	90-95	3-5	2-8
Tomato, partly	8-12	90-95	3-5	0-3
Spinach	0-5	95-98	7-10	5-10

Table 8: MAP recommended conditions for fresh fruit and vegetable

Modified Atmosphere Packaging

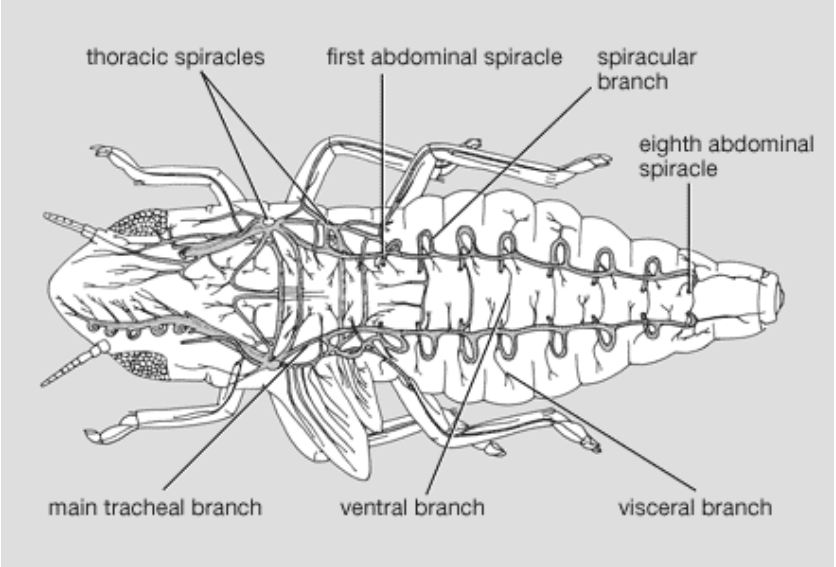


The generation of free radicals from oxygen and water cause tissue damage.

Modified Atmosphere Packaging

Most MAP creates a low O_2 environment.

Insect respiration slows, resulting in reduced O_2 concentrations in the hemolymph.



In hypoxic environments, higher absorbed doses may be necessary to achieve same physiological effects.

Modified Atmosphere Packaging

Anoxic environment reduce efficacy of irradiation treatments

In hypoxic environments, higher absorbed doses may be necessary to achieve same physiological effects

Current policy requires a minimum concentration of 18% O_2 in MAP (very conservative)

APHIS

Modified Atmosphere Packaging

Mexican Guava

- No irradiation
- Simulate treatment facility conditions
- Record the O_2 concentrations before and after “treatment”

Modified Atmosphere Packaging

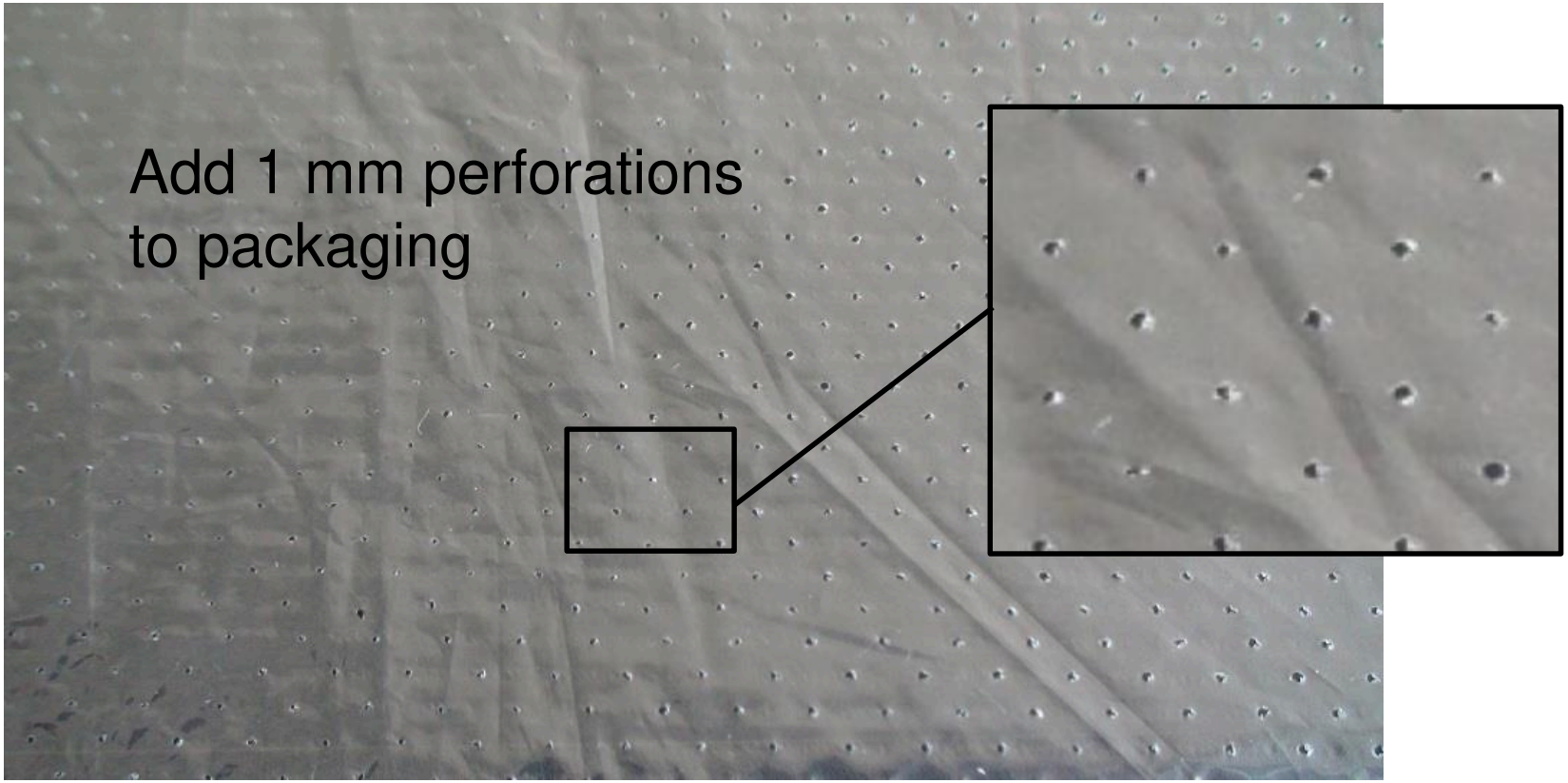
Before Treatment

19.8%

After Treatment

5.6%

Modified Atmosphere Packaging



Modified Atmosphere Packaging

Before Treatment

20.9%

After Treatment

20.9%

Modified Atmosphere Packaging

Requires insect proof packaging

Modified Atmosphere Packaging

CPHST is funding University of Florida research to characterize the effects of modified atmospheres on irradiation treatments.

- Determine whether irradiation in modified atmospheres affects survival or fertility (Lepidopteran pests)

APHIS

UF UNIVERSITY of FLORIDA

Treatment Verification Tool

In the event that CBP intercepts a live pest within the pest proof packaging, PPQ needs a tool to verify that an irradiation treatment has occurred.

Ideally, the Treatment Verification Tool Would:

- Provide Immediate Y/N answer
- Be Inexpensive
- Be Easy to Use
- Not Require Hazardous Reagents
- Have Low-Maintenance Storage Requirements
- Work for Multiple Insect Families

Treatment Verification Tool

CPHST is working with the University of Florida to develop a diagnostic assay to verify that a phytosanitary irradiation treatment was performed.

APHIS

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Incremental Dosing

CPHST is working with facilities to show that it is possible to achieve required minimum doses using incremental doses

CPHST is working with facilities to allow program commodities to run through the irradiation cell in immediate succession

Reworking Procedures

CPHST is working with facilities to develop procedures to re-treat under-dosed commodity

Cobalt Reloading

CPHST is working with facilities to develop procedures to confirm the validity of previously-approved process configurations after reloading

Final Thoughts & Questions