Horticulture Innovation Australian Citrus Postharvest Science Program

Research update

John Golding. NSW Department of Primary Industries

Horticulture Innovation - Australian Citrus Postharvest Science Program (CT15010)

Focus - Development of a postharvest program for ultra-low chemical residues

Aims

- assess chemistry and other emerging technologies to address postharvest issues
- facilitate the adoption postharvest program with presentations across Australia
- keep industry informed with targeted communications using online platforms and other channels
- identify options to engage postharvest services on a fee-for-service basis for advice specific to their business

Postharvest decay control

Postharvest decay control must use a range of **complementary strategies**:

+ correct harvesting and handling

+ shed hygiene

+ correct use of sanitisers

+ use of fungicides

+ temperature management

+ monitoring inoculum levels and fungicide resistance

Fungicide resistance survey

Survey of resistance to postharvest fungicides in representative packingsheds across Australia from May to September 2018 (follow on from previous June/July 2017)

- New South Wales
- Queensland
- South Australia
- Victoria
- Western Australia

Test resistance to common postharvest fungicides (TBZ, imazalil and fludioxonil)

→ 3 locations in shed: (1) start of the line, (2) end of the line and (3) coolroom

2018 Fungicide sanitation and fungicide resistance survey results

Follow-up after sanitation and hygiene improvements

1. Initial reading
2. After cleaning

		Untreated				TBZ				Imazalil				Fludioxonil			
Shed	Time	S	E	C	T	S	E	C	T	S	E	C	T	S	E	C	T
A	1	3	3	4	10	1	4	3	8	1	1	1	3	1	1	1	3
A	2	3	1	1	5	1	1	1	3	1	1	1	3	1	1	1	3
B	1	4	4	2	10	4	4	3	11	1	1	1	3	1	1	1	3
B	2	4	3	1	8	4	4	1	9	1	1	1	3	1	1	1	3
C	1	4	3	2	9	4	4	4	12	1	1	1	3	1	1	1	3
C	2	1	1	1	3	2	2	3	7	1	1	1	3	1	1	1	3

Reducing fungicide resistance

Management of fungicide resistance requires an integrated approach:

1. Optimise fruit health
2. Use best hygiene practices
3. Optimise fungicide use
4. Optimise fungicide efficacy
5. Monitor fungicide resistance

Reducing fungicide resistance

3. Optimise fungicide use

→ rotate different fungicides with different actions

- Understand the class of fungicide you are using and limit the total number of fungicide applications of any one class.

= the continued use of the same fungicide class can cause selection pressures resulting in resistance

- Use rotations and mixtures or pre-mixtures whenever possible before resistance selection occurs

- Use the label rate for each fungicide - lower rates of fungicide can select for less sensitive spores in the population

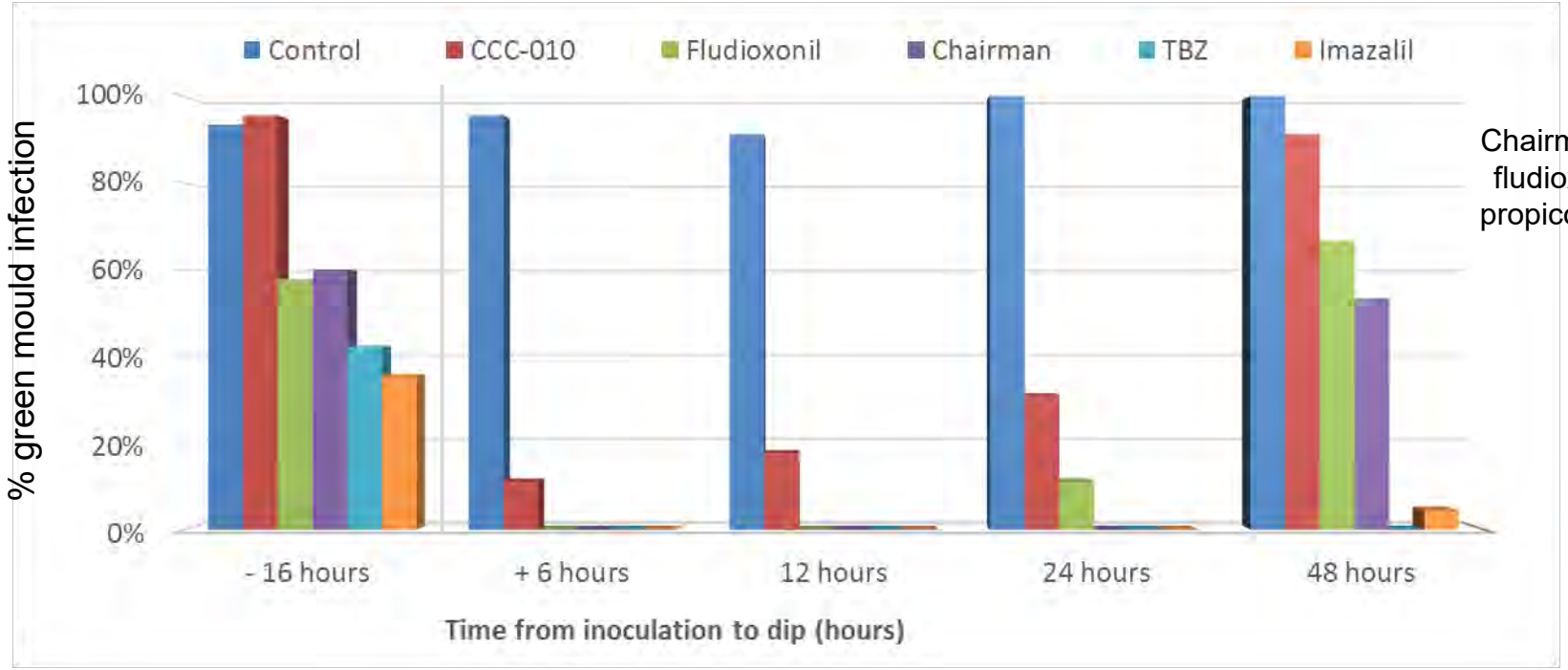
Reducing fungicide resistance

Thiabendazole (TBZ)	Vorlon®, Tecto® Benzimidazole Group *(activity also on* Stem End Rot, *Phomopsis citri*)	GROUP 1 FUNGICIDE
Imazalil	Magnate®, Fungaflor® DMI (Demethylation Inhibitors) (Imidazole)	GROUP 3 FUNGICIDE
Imazalil + Pyrimthanil	Philabuster® DMI and Anilinopyrimidine Group	GROUP 3 + 9 FUNGICIDE
Fludioxonil	Scholar® Phenylpyrrole Group *(activity also Diplodia Stem End Rot)*	GROUP 12 FUNGICIDE
Propiconazole + Fludioxonil	Chairman® DMI and Phenylpyrrole Group	GROUP 3 + 12 FUNGICIDE

Preventol® ON Fungicide *(controls blue mould only)*
(sodium ortho-phenylphenate)

Fungicide best practice application

Effect of time of fungicide dipping time on decay development

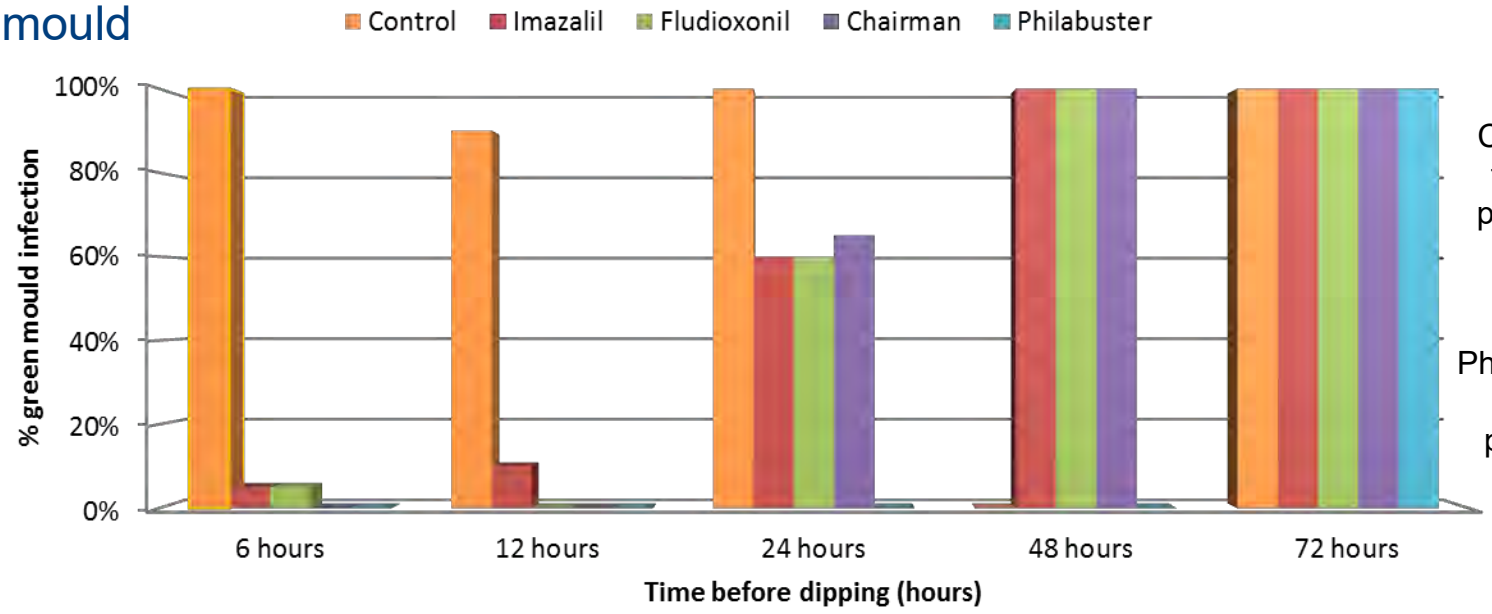


Chairman™ = fludioxonil + propiconazole

Fungicide best practice application

Effect of time of fungicide dipping time on decay development

Green mould



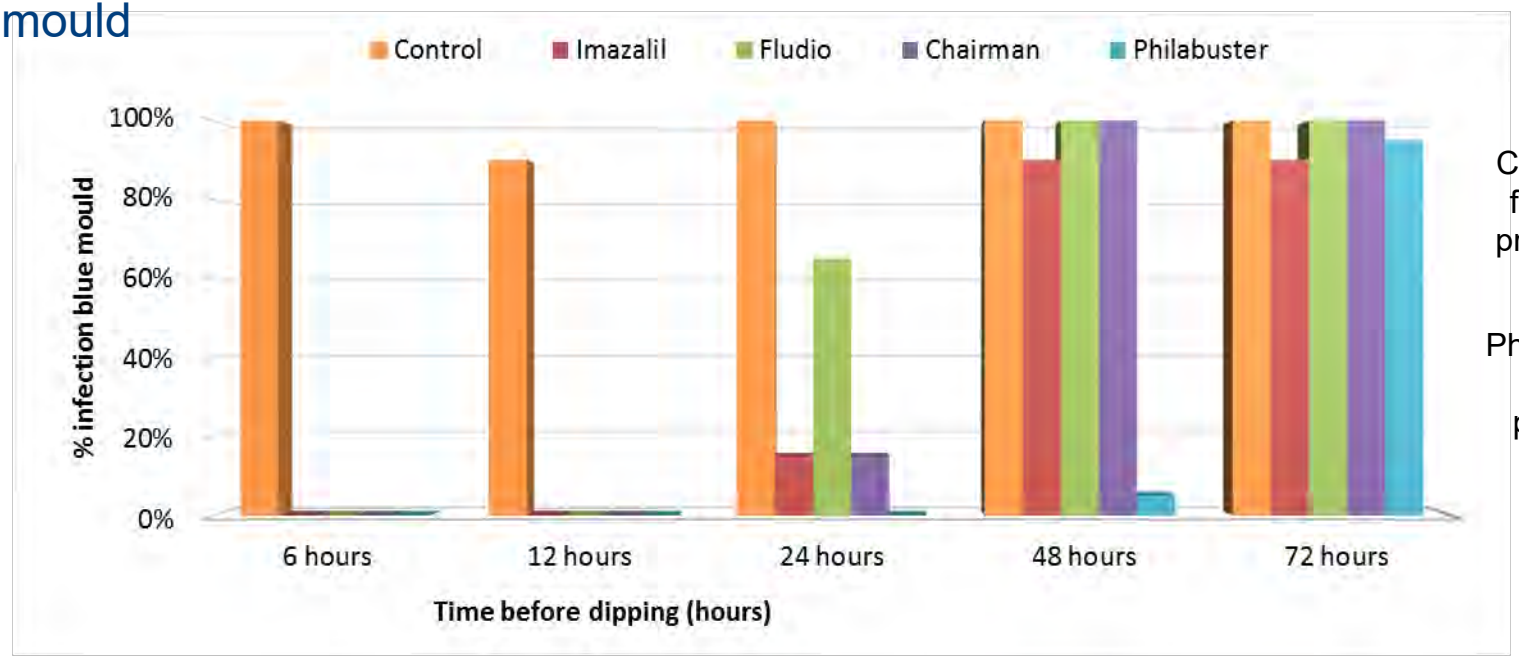
Chairman™ = fludioxonil + propiconazole

Philabuster™ = imazalil + pyrimethanil

Fungicide best practice application

Effect of time of fungicide dipping time on decay development

Blue mould

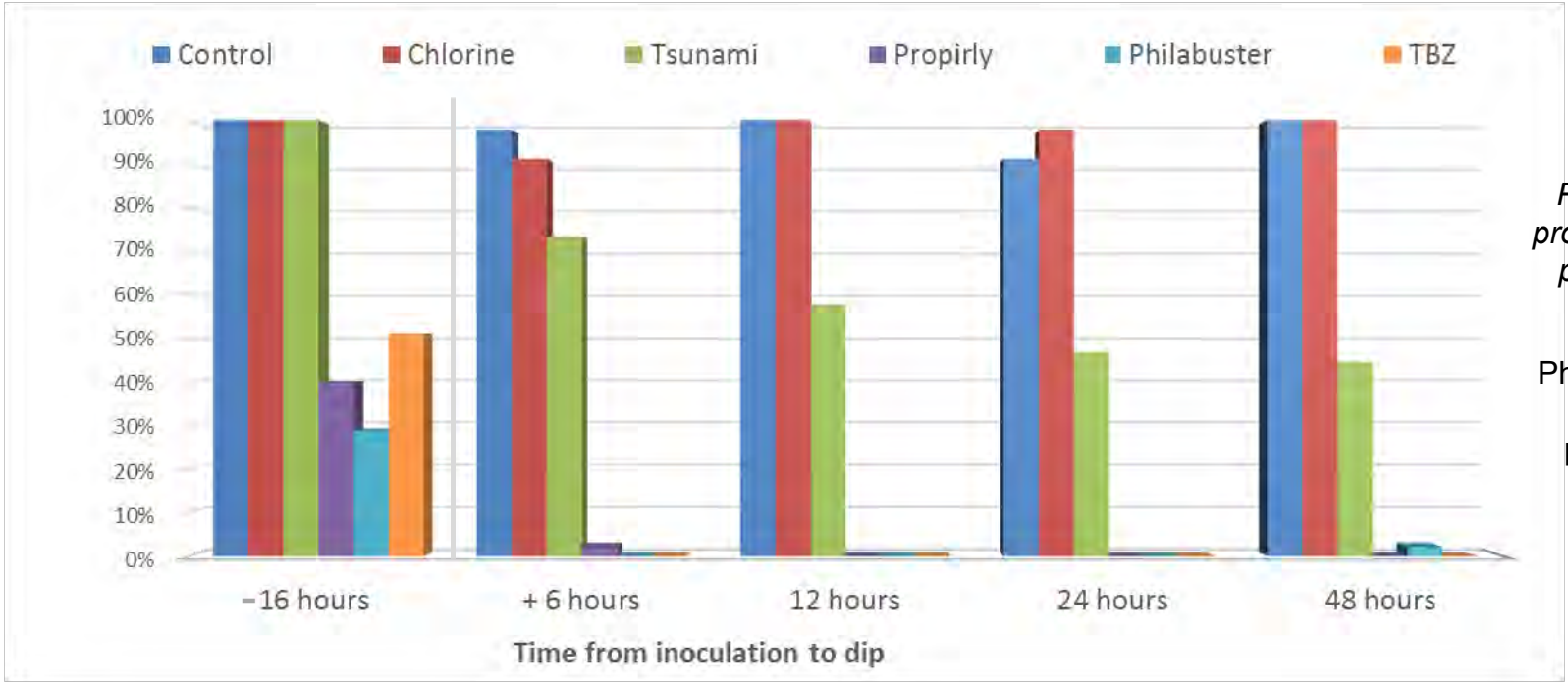


Chairman™ = fludioxonil + propiconazole

Philabuster™ = imazalil + pyrimethanil

Fungicide best practice application

Effect of time of sanitisers and fungicide dipping time on decay development

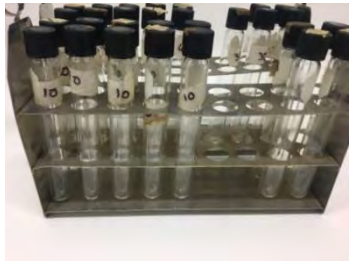


Propirly™ = propiconazole + pyrimethanil

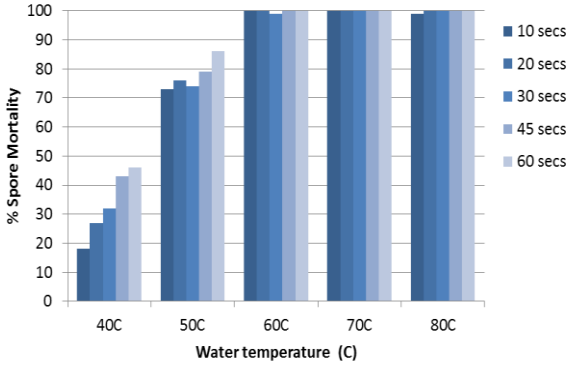
Philabuster™ = imazalil + pyrimethanil

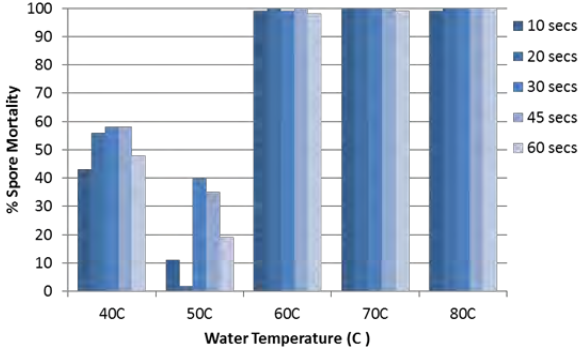
Non-chemical decay control

Effect of hot water on spore mortality



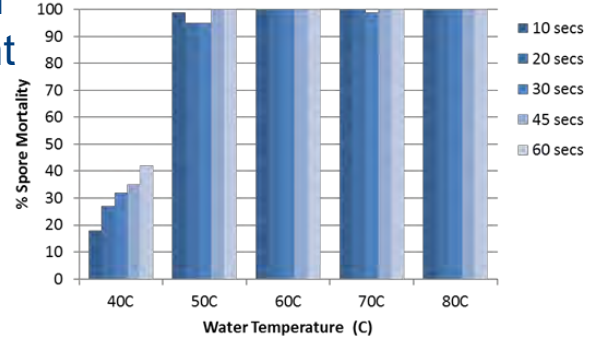
Green mould (sensitive strain)

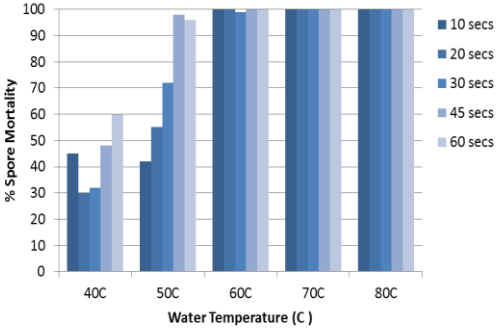




Blue mould (sensitive strain)

Green mould (TBZ resistant strain)



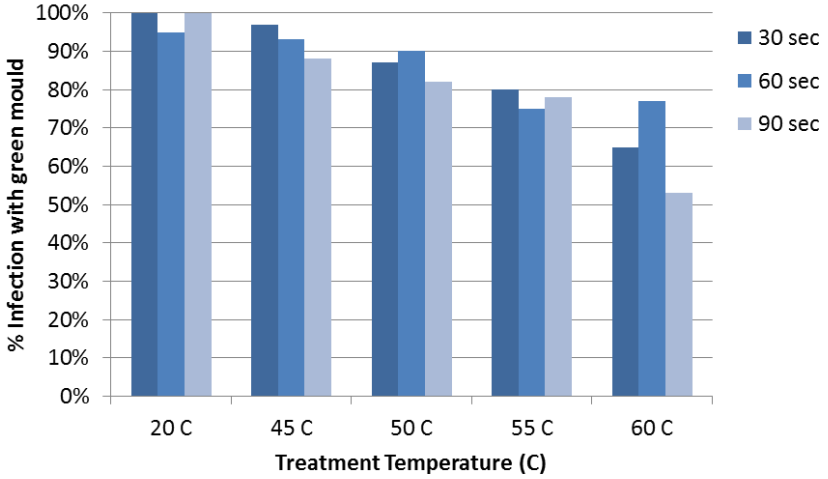


Sour rot

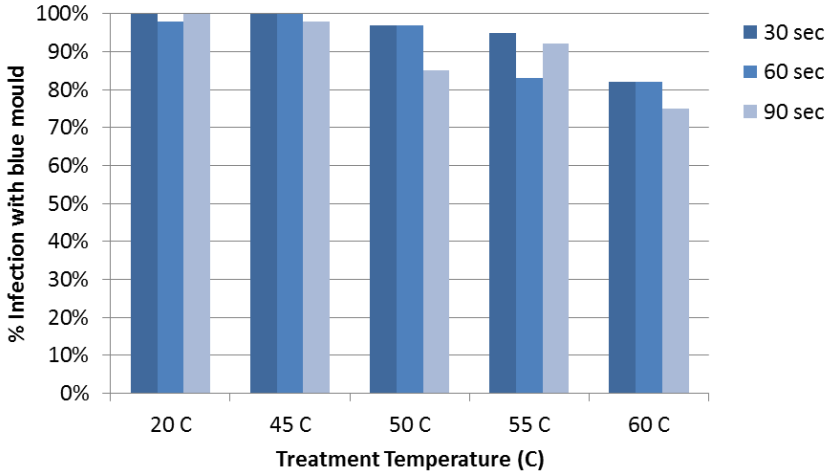
Non-chemical decay control

Effect of hot water on decay development in oranges

Green mould



Blue mould

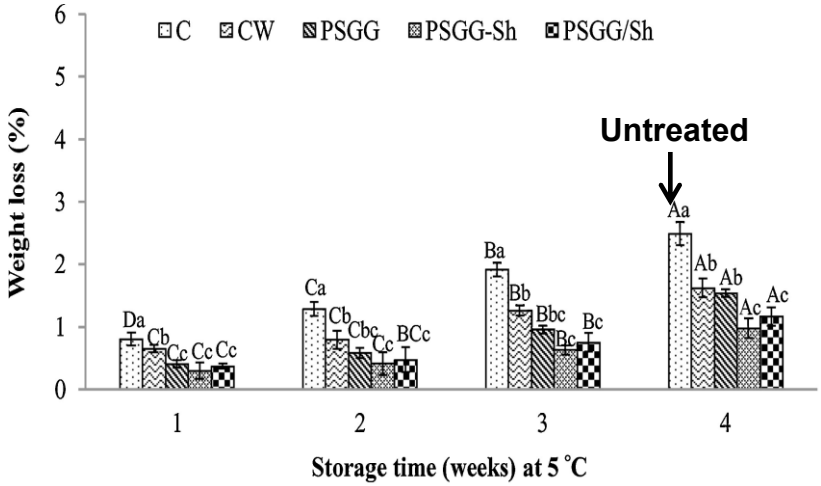


Alternative postharvest treatments

Development and assessment of new citrus fruit coatings

Bahareh Saberi, John Golding and Penta Pristijono – see poster

Alternative edible coatings (eg starch and guar gum based coatings) assessed during storage and shelf life



Pea starch and guar gum (PSGG)-based edible coatings could be a beneficial substitute to commercial waxes

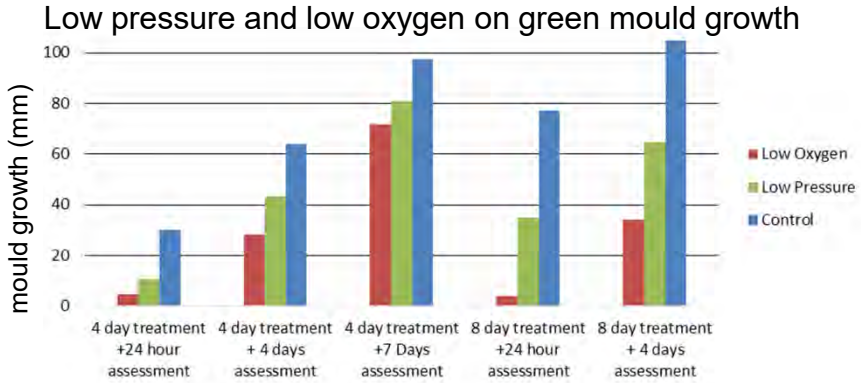
Non-chemical decay control

Low oxygen and low pressure on decay development in oranges

John Archer, Penta Pristijono, Quan Vuong, Lluis Palou, John Golding

Low oxygen treatment (1% O_2) + low pressure (7 kPa)

Both treatments reduced the growth of green mould



Hort Innovation Strategic levy investment
CITRUS FUND
Australian Citrus Postharvest Science Program (CT15010)
NSW GOVERNMENT Primary Industries

Reducing fungicide resistance

2. Use best hygiene practices

→ good postharvest hygiene

Reduce numbers of decay-causing spores in the shed, cool room and on the fruit = reduced risks

- Remove all culled and especially decaying fruit from the shed
- Regular sanitation of equipment (including picking bins), cool rooms and packing line
- Ideal to have a separate area of receivals of fruit to the packing line
- Good shed hygiene

Assessing new sanitation methods

ChillSafe® is a sachet which slowly releases hydrogen peroxide gas into the coolroom

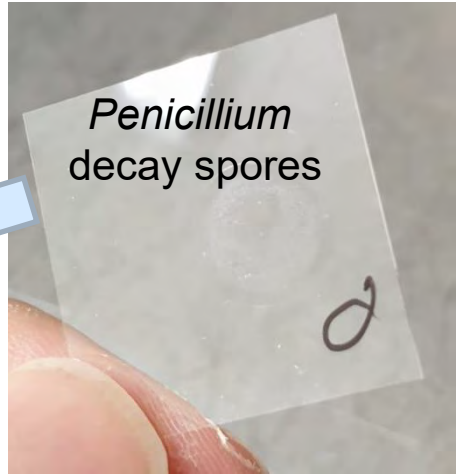
Hydrogen peroxide is an unstable gas which kills mould spores (and also oxidises ethylene - *degreening)

https://coolsan.com.au

Assessing new sanitation methods

ChillSafe® - impact on *Penicillium* spores

Treatment of decay spores



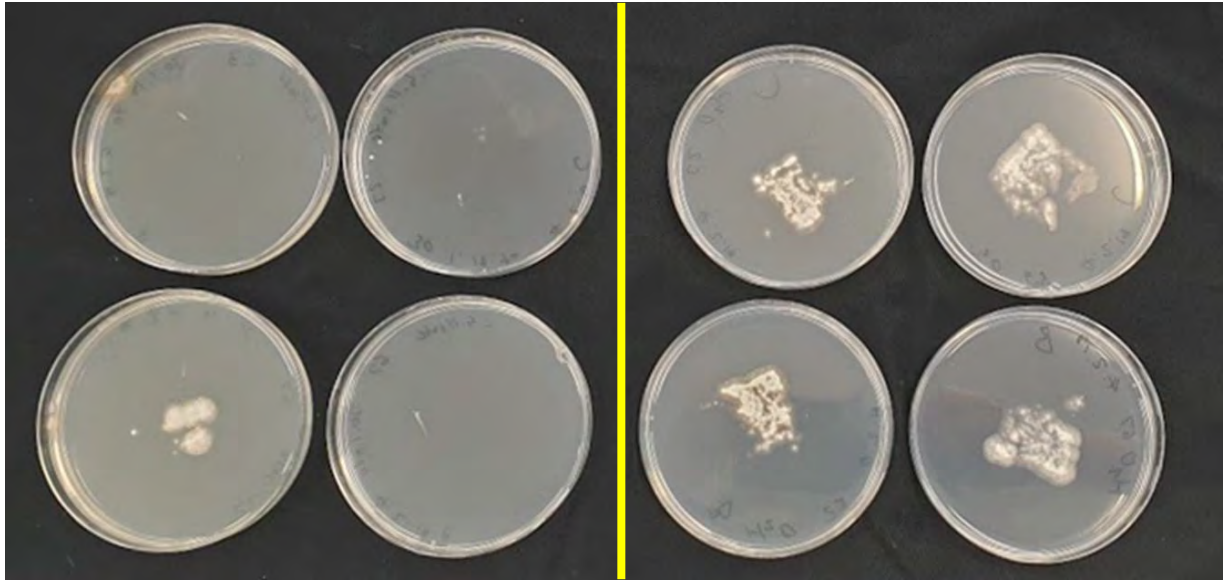
+ 'ChillSafe®' active ingredient in sealed container

Assessing new sanitation methods

+ 4 days

active ingredient (a.i.) (6 x 10^4 spores were exposed to a.i. for 4 days at 20˚C)

+ ChillSafe® a.i. | No treatment



green mould | blue mould | green mould | blue mould

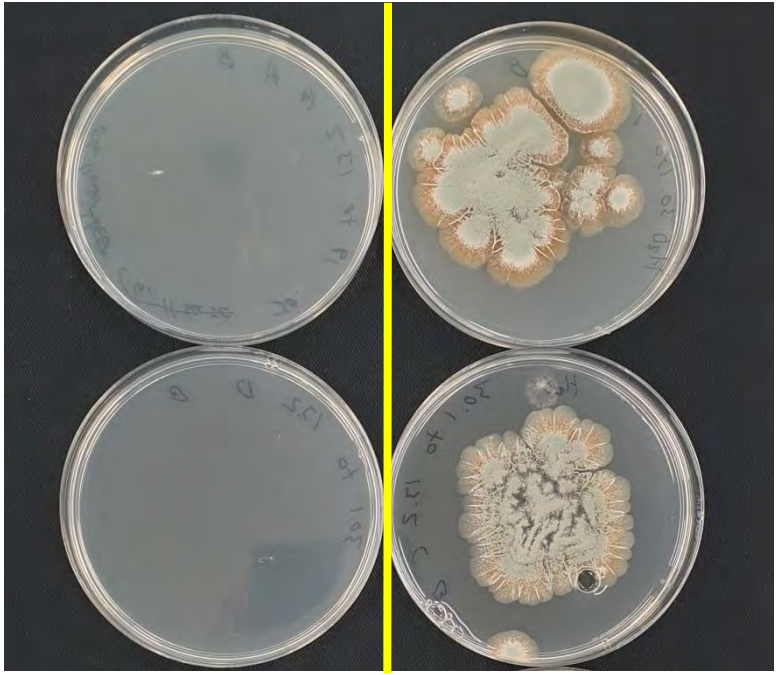
Assessing new sanitation methods

+ 14 days

Blue mould growth on agar plate

active ingredient (a.i.) (6 x 10^4 spores were exposed to a.i. for 14 days at 20˚C)

+ ChillSafe® a.i. No treatment



Assessing new sanitation methods

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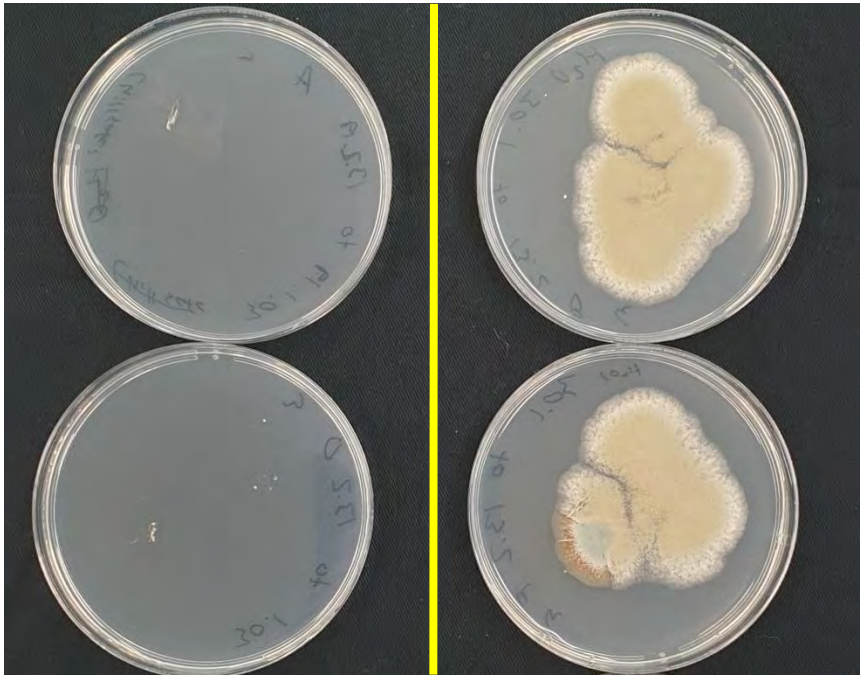
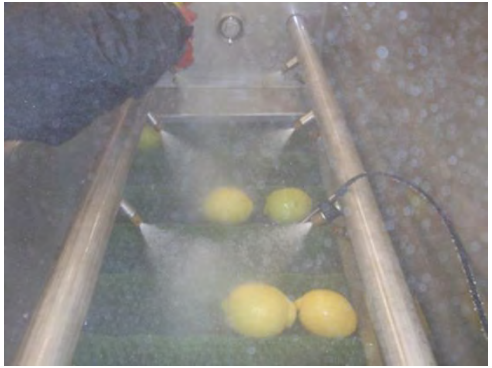


→ Coolrooms…

Managing chemical residues

Effect of postharvest washing on dithiocarbamate residues in lemons

Treatment	Concentration (mg/kg)
cold chlorine	0.643 a
hot PAA	0.712 a
hot water only	0.775 a
cold water only	0.810 a
cold PAA	0.817 a
hot PAA – stored	1.027 a
no treatment	**2.933 b**



Postharvest washing can reduce dithiocarbamate residues in lemons

However ALL efforts should be undertaken to reduce the risk of chemical contamination

- see poster

Long term storage

Effect of ethylene in storage coolroom on fruit quality

- Nasiru Alhassan see poster

Effect of storage temperatures and ethylene levels on button browning of 'Afourer' mandarins after 4 weeks storage

	Storage temperature		
Ethylene ($\mu L.L^{-1}$)	5°C	10°C	20°C
<0.001	2.6	2.9	4.0
0.01	2.8	3.0	4.3
0.1	2.9	3.2	4.4
1.0	3.4	3.6	4.8

Button score rating.
2 = slightly yellow,
3 = moderate yellow,
4 = totally yellow,
5 = brown

→ **Low temperature and low ethylene maintain fruit quality during long term storage**

Supervision – Penta Pristijono, Prof. Ron Wills, Michael Bowyer, John Golding

Australian Citrus Postharvest Science Program (CT15010)

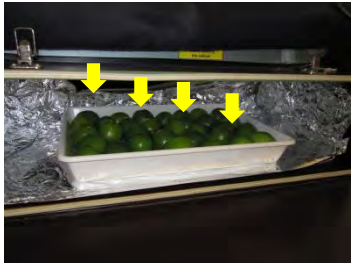
Long term storage

Maintaining lime fruit quality during storage

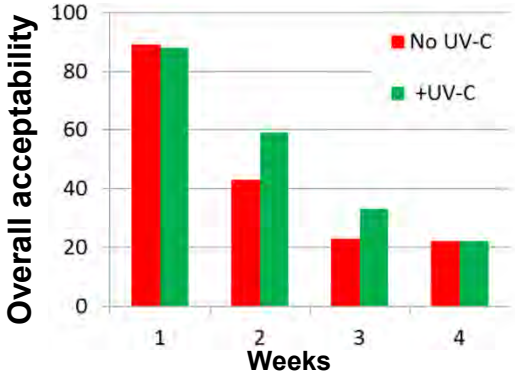
- Penta Pristijono and John Golding – see poster

Effect of UV-C treatment on lime fruit quality

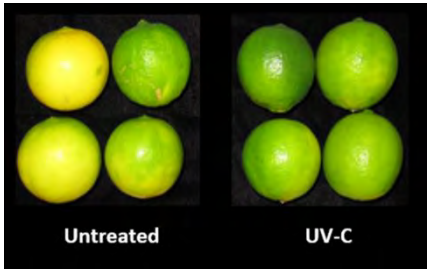
UV-C light = 100-280 nm



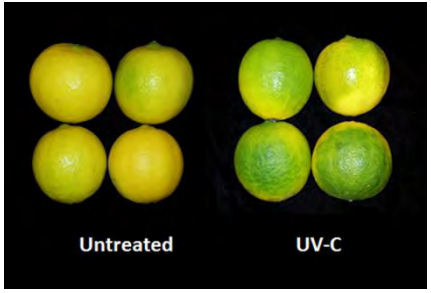
UV-C treatment delayed yellowing and no effect on other quality



2 weeks



3 weeks



4 weeks

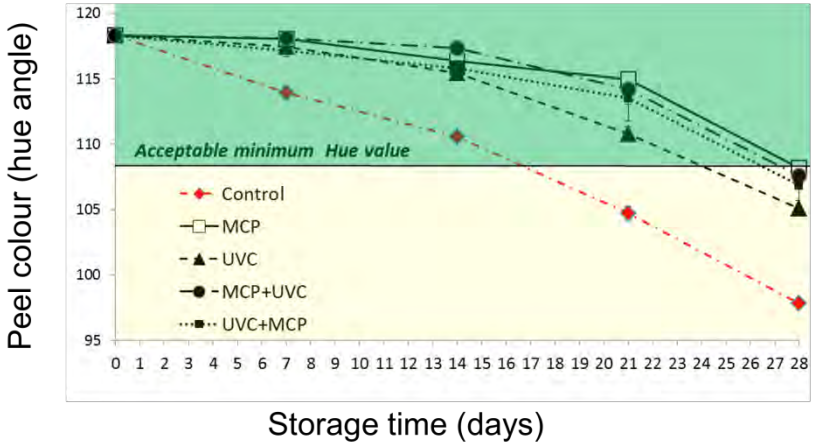
Long term storage

Maintaining lime fruit quality during storage

- Penta Pristijono and John Golding – see poster

Effect of UV-C treatment and 1-MCP on lime fruit quality

1-MCP 'SmartFresh®' stops ethylene action



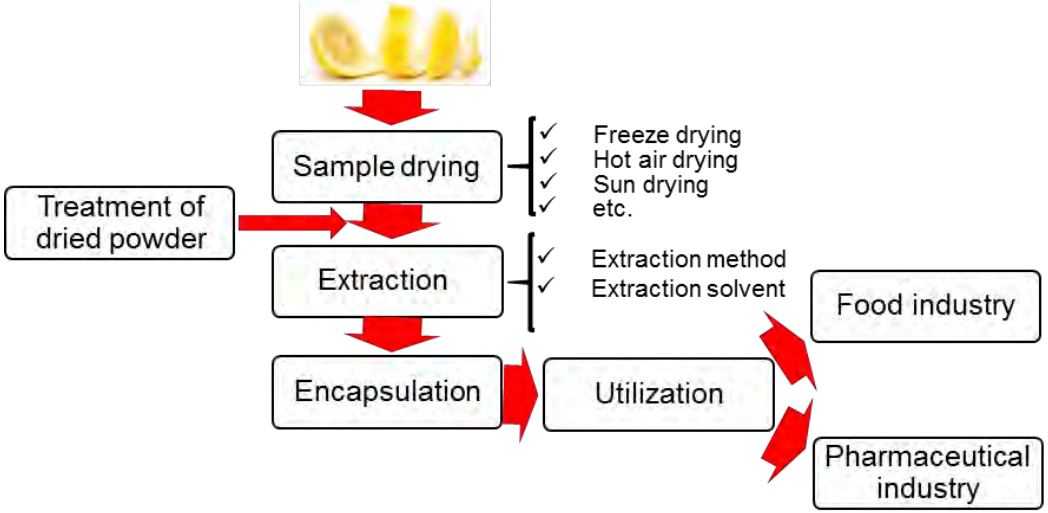
4 weeks at 20C

UV-C and 1-MCP further maintained quality (yellowing) and no effect on other quality

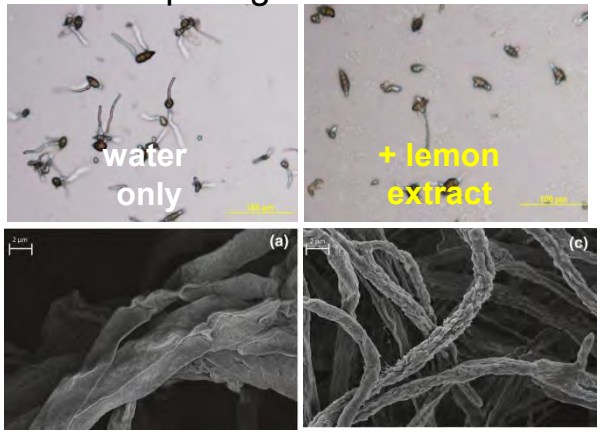
Adding value

Adding value to citrus pomace

Kostas Papoutsis. University of Newcastle



Spore germination



Fungus growth

Optimise extraction and preparation methods
- see poster

Market access

Irradiation

Benefits

- important tool in market access toolbox efficacious and accepted
- short term treatment with high volumes and speed
- no cold treatment – no potential chilling injury
- no packaging issues
- no chemicals

STERITECH
Protecting what matters

Issues

- not accepted by many importing countries, but still some good markets in SE Asia (such as Vietnam, Indonesia)

  But perhaps new markets coming
- potential consumer acceptance issues*
- potential fruit quality issues*
- limitation of treatment facilities – Steritech in Brisbane (and Melbourne - 2019)

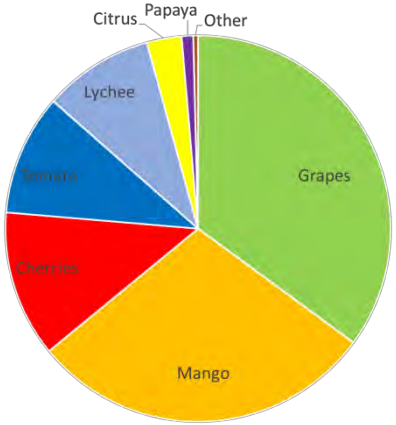
Steritech – Construction of Melbourne X-ray Facility

Market access

STERITECH
Protecting what matters

Irradiation

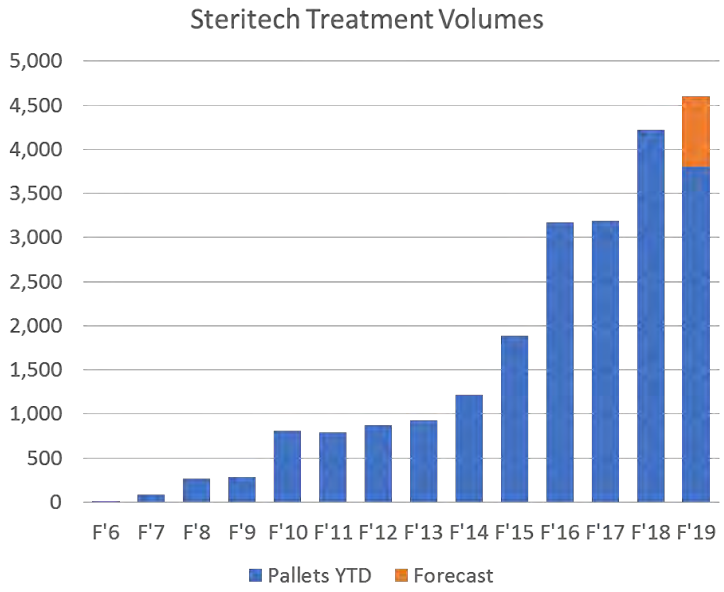
Growing markets and treatment



Australian grapes to Vietnam

Y1 800 pallets
Y2 1200 pallets
Y3 1800 pallets
Y4 tracking for + 2000 pallets
All air freight and
all trucked to Brisbane

Data from Steritech – Ben Reilly (Feb 2019)



Citrus

2018 - 150 pallets for Vietnam (double 2017 volumes)

Approximately 50% mandarins + 50% oranges (2017 - 70% mandarins, 30% oranges)

Market access

Irradiation – Review of potential fruit quality issues

No Chilling Injury

Few consistent negative effects of irradiation

Some reports of surface damage (such as pitting) can occur in some types of different citrus
- In literature

Lane Late navel oranges
(McDonald et al., 2013)

Chandler pummelo
(Jain et al., 2017)

Kishu mandarins
(Ornelas-Paz et al., 2017)

Market access

STERITECH
Protecting what matters

Irradiation – Commercial treatment

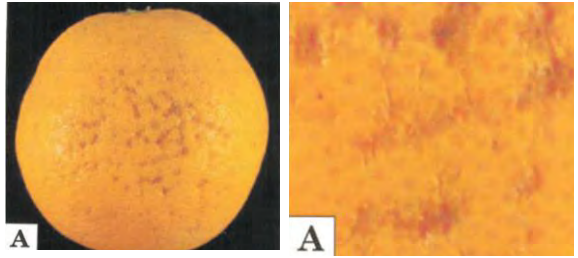
Steritech

2018 - treated 150 pallets citrus

Data from Steritech – Ben Reilly (Feb 2019)

Market access

Chilling Injury



Storage disorder following low temperature storage

→ shallow pitting of the peel, browning of the albedo

Symptoms not always develop, but severity = storage temperature x time
(more chilling with lower storage temperatures and treatment times)

Injury to the peel occurs at low temperature but symptoms often appear after fruit is removed from storage

Cause and prediction of chilling injury is <u>not known</u>

Market access

Chilling Injury – Preharvest factors

- **citrus type and cultivar**

In general: grapefruit > lemon / limes > oranges / mandarins

Navel oranges
'Navelate' and 'Roberts' > 'Thomson' > 'Navelina'

Katina Lindhout (2007)

- **orchard conditions**

preharvest orchard temperatures, harvest times, growing locations etc.

Earlier and later harvest fruit > mid-season fruit
= but this does not always hold in different seasons and growing conditions

→ *we still do not know what causes chilling injury and its contributing factors*

Market access

Postharvest treatments to reduce chilling injury

Temperature treatments. Short term high temperature treatments / conditioning (hot water dips, hot water brushing, curing or conditioning with hot humid air)

Fungicides. Thiabendazole (TBZ) and warm TBZ (40°C)

Waxes. Different outcomes with different wax and fruit types

Modified atmospheres. MA and high relative humidity

Others *… Plant growth regulators such as jasmonic acid and salicylic acid*

Market access

Postharvest treatments to reduce chilling injury

Effects of ethylene levels on chilling injury after 1°C storage and shelf life (5 days at 20°C) in Navel oranges

Ethylene level (ppm)	1 week	3 weeks	5 weeks
<0.001	0.9	1.8	3.0
0.1	0.6	1.1	2.0
1	0.3	0.7	1.2

Nasiru Alhassan. University of Newcastle

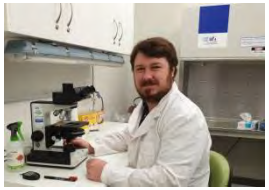
+ ethylene reduced chilling injury

Collaboration and training

University of Newcastle

Current students:

- Hort Innovation PhD training - John Archer – *Alternative decay control methods*
- Mizan Rahman – *Utilising citrus pomace to control postharvest decay*
- Nasiru Alhassan - *Maintaining the quality of citrus fruits for long term storage*



University of Newcastle staff – Prof. Ron Wills, Dr. Penta Pristijono,
Dr. Michael Bowyer, Dr. Quan Vuong

Previous PhD students with citrus-related projects:

- Kostas Papoutsis, Bahareh Saberi

Institut Valencià d'Investigacions Agràries (IVIA) (Spain)

- Prof. Lluis Palou

More information

- Exposure to low ethylene and storage temperatures delays button (calyx) aging and maintains ‘Afourer’ mandarins and Navel oranges quality
- Evaluating the effects of plastic film packaging on postharvest quality of Navel oranges
- Development and assessment of new citrus fruit coatings
- Effects of temperature and time on postharvest fungicide efficacy
- Alternative decay control strategies using citrus essential oils
- Effect of postharvest washing on residues of preharvest sprays in lemons

Australian Citrus Postharvest Science Program (CT15

Hort Innovation Strategic levy investment | CITRUS FUND

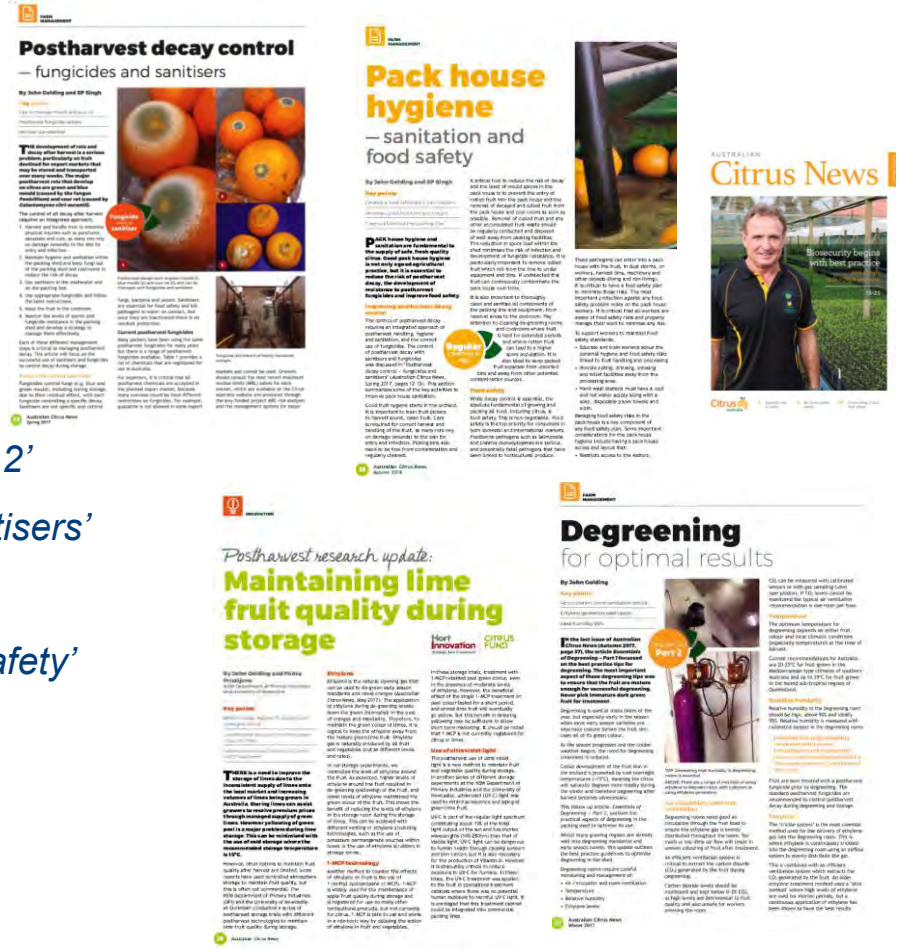
More information

- Antifungal activity of citrus by-product aqueous extracts against *Alternaria*
- Assessment of postharvest UV-C treatments to maintain quality of limes
- Combined postharvest treatments of UV-C and 1-methylcyclopropene (1-MCP) to maintain the quality of limes
- Effect of postharvest UV-C light on postharvest decay and Navel orange fruit quality
- Evaluating the effects of low pressure and low oxygen on the postharvest growth of green mould

More information

Regular articles in
Australian Citrus News

- *'The Essentials of Degreening. Part 1'*
- *'Degreening for optimal results. Degreening Part 2'*
- *'Postharvest decay control – fungicides and sanitisers'*
- *'Preventing postharvest fungicide resistance'*
- *'Packinghouse Hygiene - Sanitation and Food Safety'*
- *'Maintaining lime fruit quality during storage'*
- *'Food safety is everyone's responsibility'*
- *'Management change can reduce fruit decay'*



Australian Citrus Postharvest Science Program (CT15010)

More information

On-line You tube video clips

Degreening citrus

Promoting colour development in mature citrus

www.citrusaustralia.com.au
www.dpi.nsw.gov.au/agriculture/horticulture/citrus

3 minutes

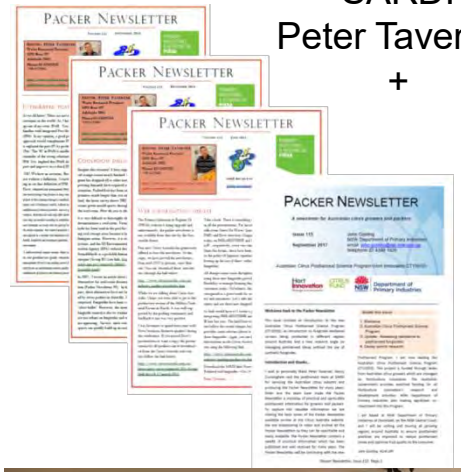
More information

Hort Innovation Strategic levy investment | CITRUS FUND

SARDI
Peter Taverner
+

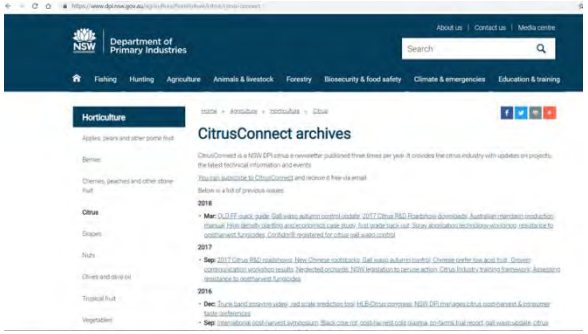
Regular updates in:

Australian Citrus News
Citrus E-news
You tube clips
– degreening citrus



Packer Newsletter

NSW DPI – Citrus Connect



Workshops

Packinghouse visits

Australian Citrus Postharvest Science Program (CT15010)

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