Industry Innovation in Fresh-cut Processing: The Fresh Appeal System *

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Process Water Sanitation

Center for Produce Safety Key Learning #6:

'Even properly managed wash systems do not sanitize the surface of fruits and vegetables ... **Washing is not a kill step'.**

Combinations of treatments may offer better control over microorganisms in wash water.

http://www.centerforproducesafety.org/amass/documents/document/210/CPS%20Key%20Learnings%20May%202014_FINAL2.pdf

Hurdle technology

Hurdle technology is a preventive control program used for managing safety in whole and fresh-cut produce by utilizing individual **sub lethal** physical, chemical, and biological stressors in a **sequential** application with a **cumulative** inhibitory effect on the microbiological load (*Tapia & Welti-Chanes, 2012).*

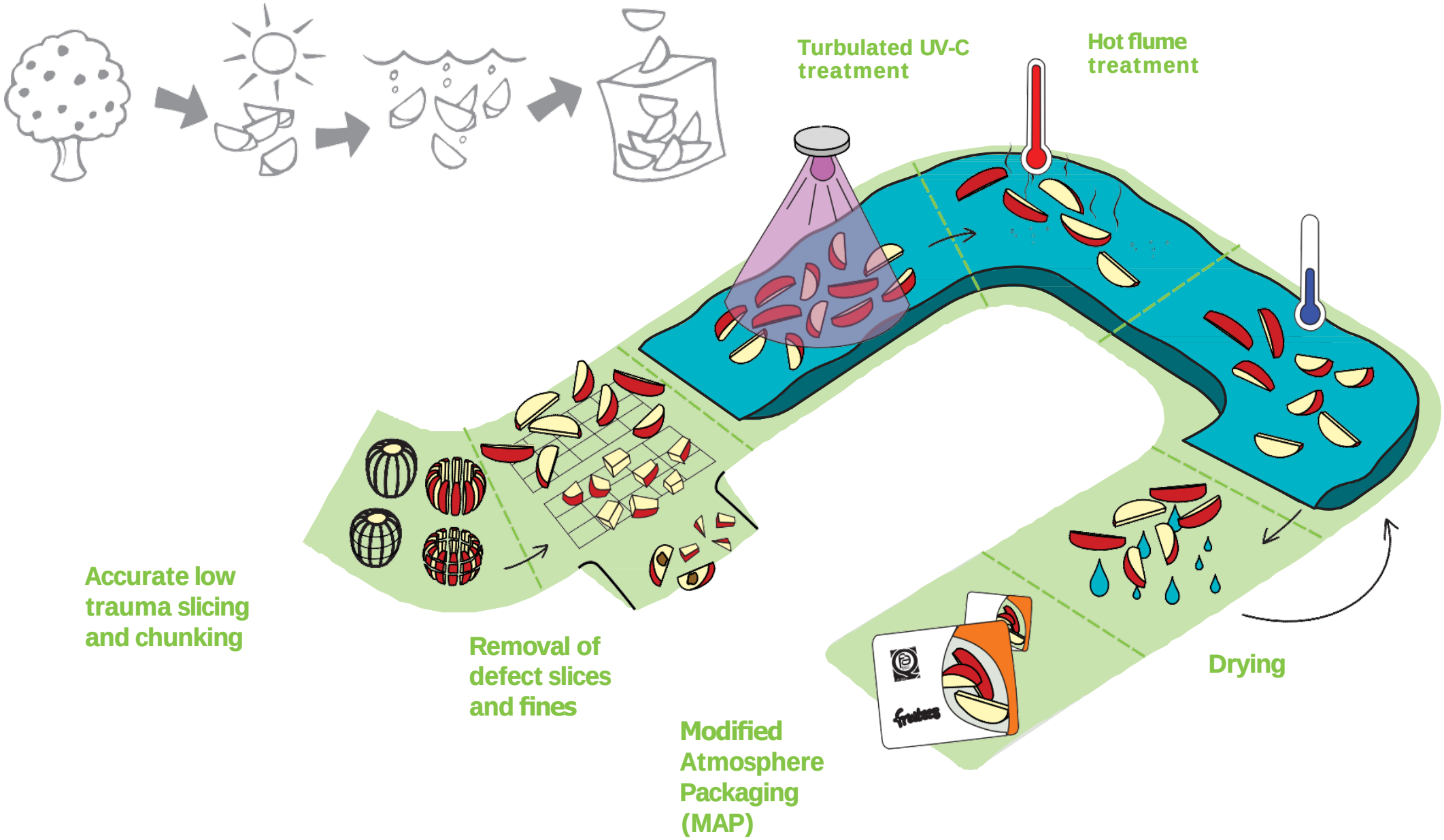
Chemical: Wash water sanitizer, e.g. PAA

Physical: UV-C treatment

Physical: Mild heat treatment

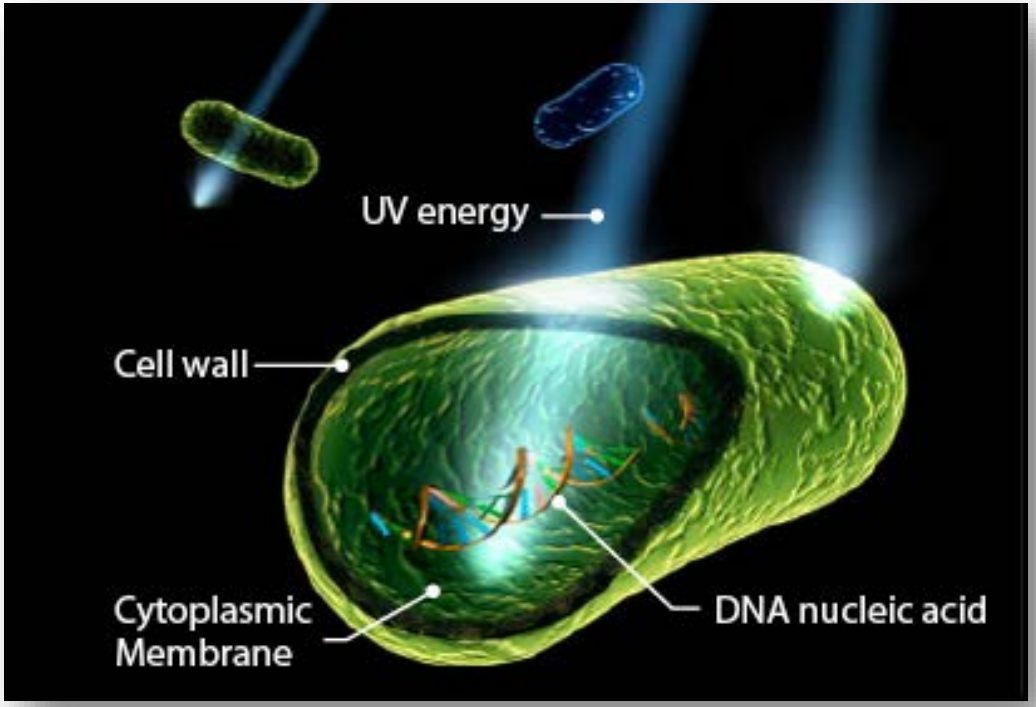
Physical: Rapid recooling after heat.

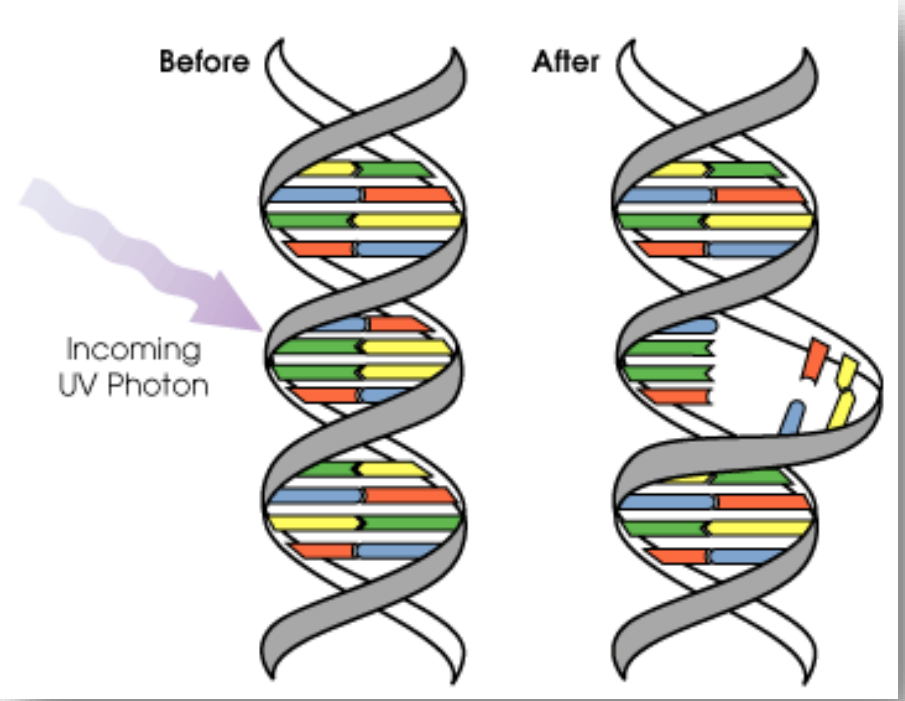
Overview


Turbulated UV-C treatment
Hot flume treatment
Accurate low trauma slicing and chunking
Removal of defect slices and fines
Modified Atmosphere Packaging (MAP)
Drying

Mode of action of UV-C

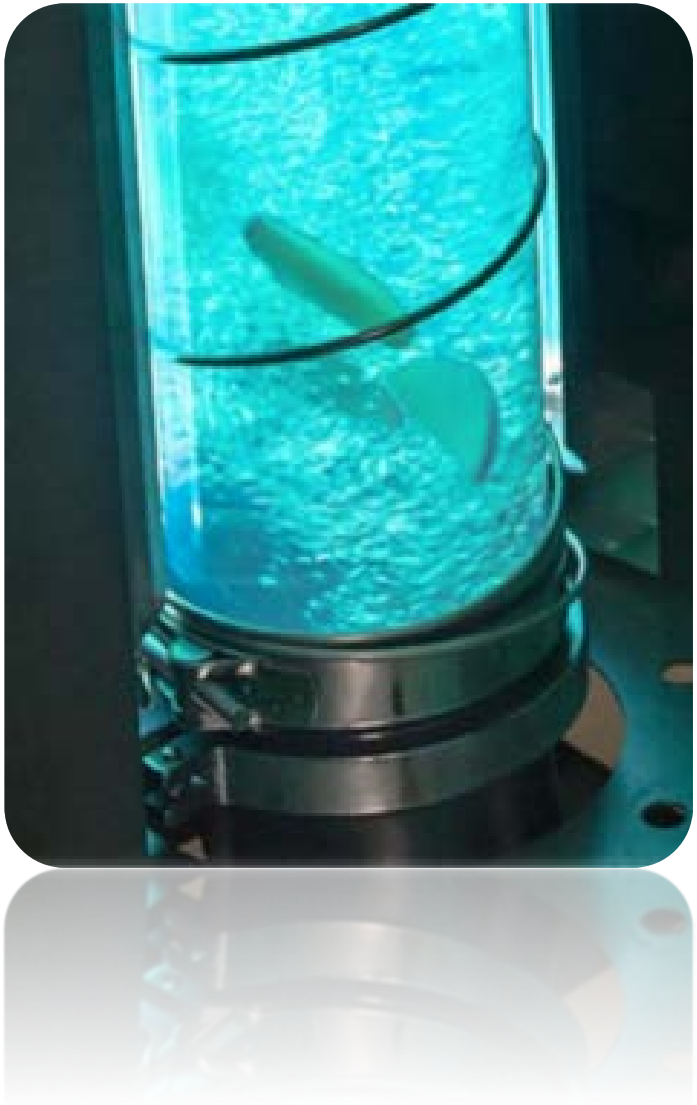
UV-C (wavelength 254 nm) permanently damages the DNA of microorganisms resulting in death.





UV-C causes cross-linking between thiamine and cytosine blocking DNA transcription and replication

‘The Turbulator’



Factors affecting efficacy of UV-C

Factors
Dose
Dwell time
UV transmittance
Temperature of lamps
Age of lamps
Exposure

The ‘Turbulator’

Non-ionizing UV-C radiation is delivered through a column of circulating (turbulated), pasteurized water.

Benefits :

- **Full coverage - minimal ‘shadowing’**
- **Spinning motion detaches some microorganisms**
- **UV disinfection in water – no desiccation**
- **Recontamination eliminated**
- **Continuous monitoring of transmissivity**
- **Fresh water replacement.**

UVsensor

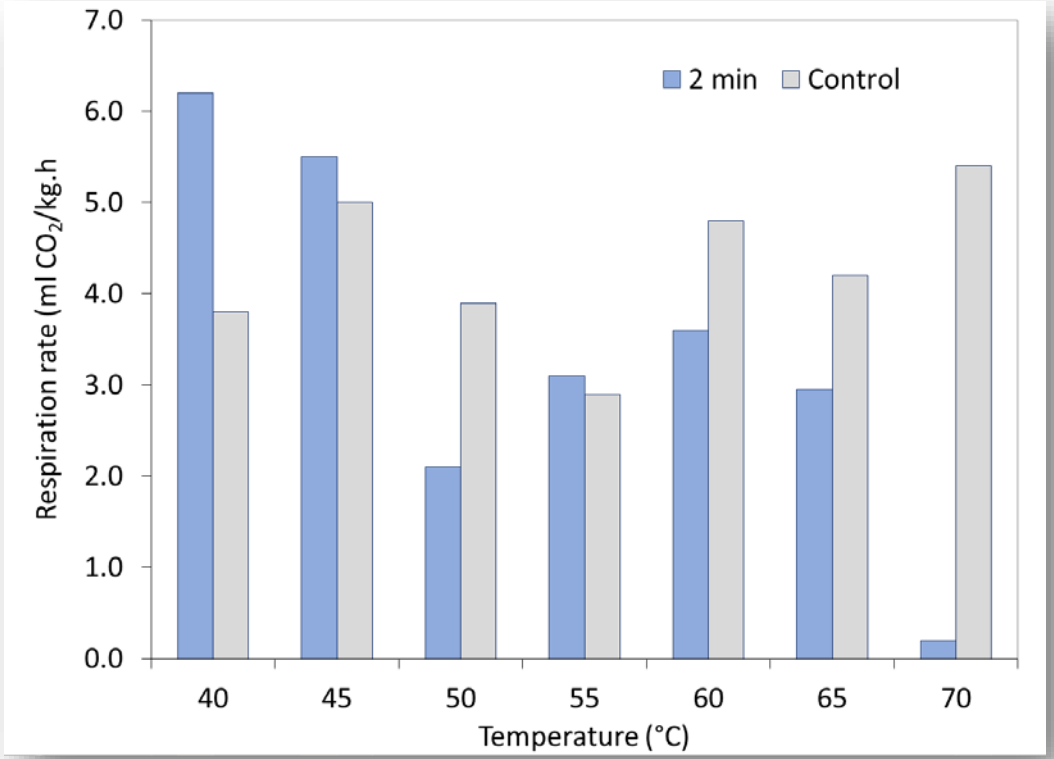
Mild Heat Treatment

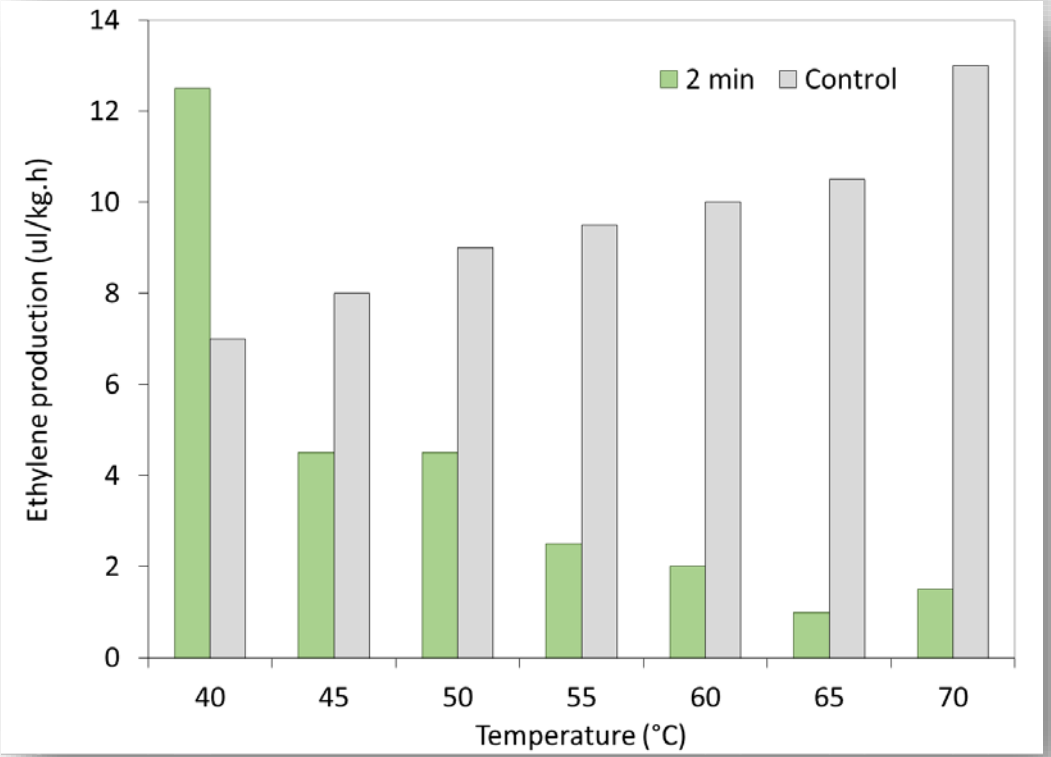
Reduce or delay:

- Decay/fungal infection,
- Microbial loads,
- Ethylene synthesis and action,
- Respiration
- Ripening including fruit softening,
- Sensitivity to chilling injury (HSP),
- Enzymatic browning (affects PPO enzyme),
- Synthesis of phenols (affects PAL)

Apples Slices: Respiration and Ethylene

Respiration rate and ethylene production were reduced by heat >45-50°C





Woolf et al., 2007.
Plant and Food Research, NZ

Cooling (and antioxidant application)

Fresh Appeal's Cold Treatment:

- Removes heat
- Ensures cold product is packaged
- Delivers the antioxidant
- Maximizes antioxidant uptake – temp and pressure
- Maintains antioxidant close to 0°C - minimizes the growth of microorganisms.

Effect on organoleptic and microbial quality

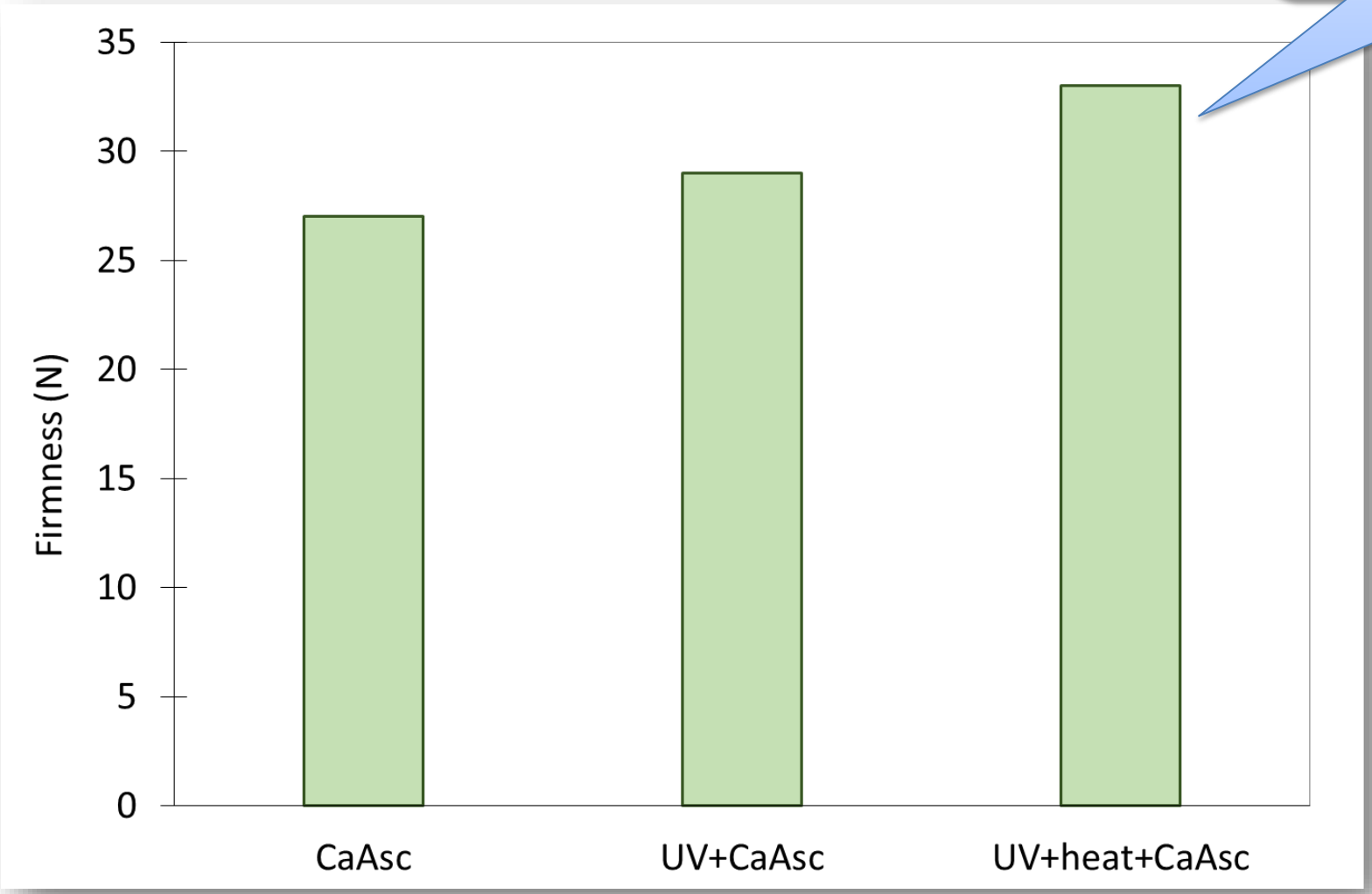
1. Sliced apples
2. Pomegranate arils
3. Blueberries

Apple slices: Firmness

'Royal Gala' apple slices after 21 days at 4°C where:

- CaAsc = 6% calcium ascorbate
- Heat = 60 secs at 52°C
- UV = turbulator

Firmest fruit with UV+Heat+CaAsc: Δ= 6 N or 1.3 lbf



Woolf et al., 2007. Plant and Food Research, NZ

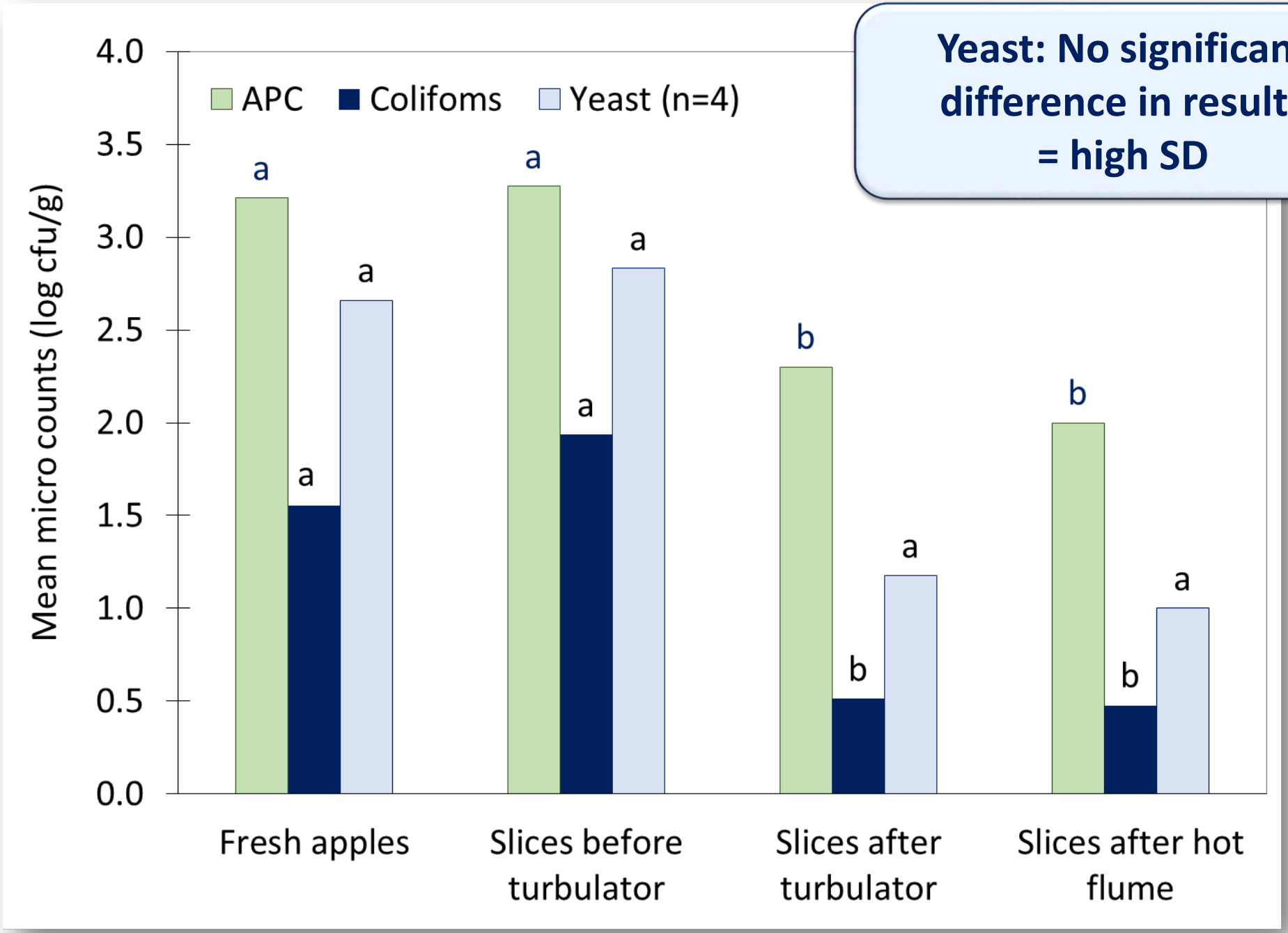
Apple slices: Inoculation

Microbial counts on apple slices inoculated with *Lactobacillus* in a simulation study.

Sample stage	*Lactobacillus* (log CFU/g)
Before turbulator	4.3 - 4.7
After turbulator	2.0 - 2.8

Woolf et al., 2007. Plant and Food Research, NZ

Apples samples from a processor:



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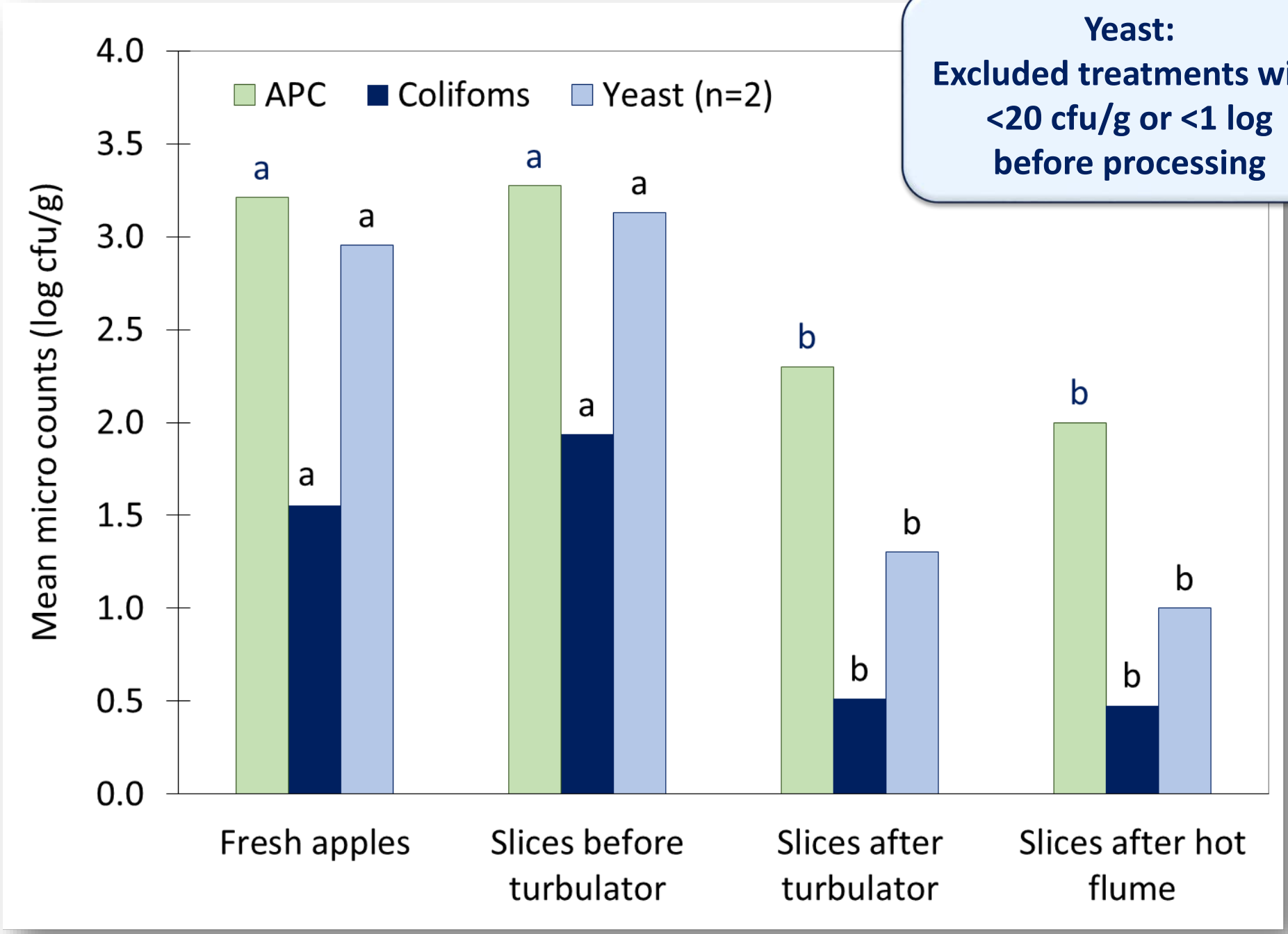


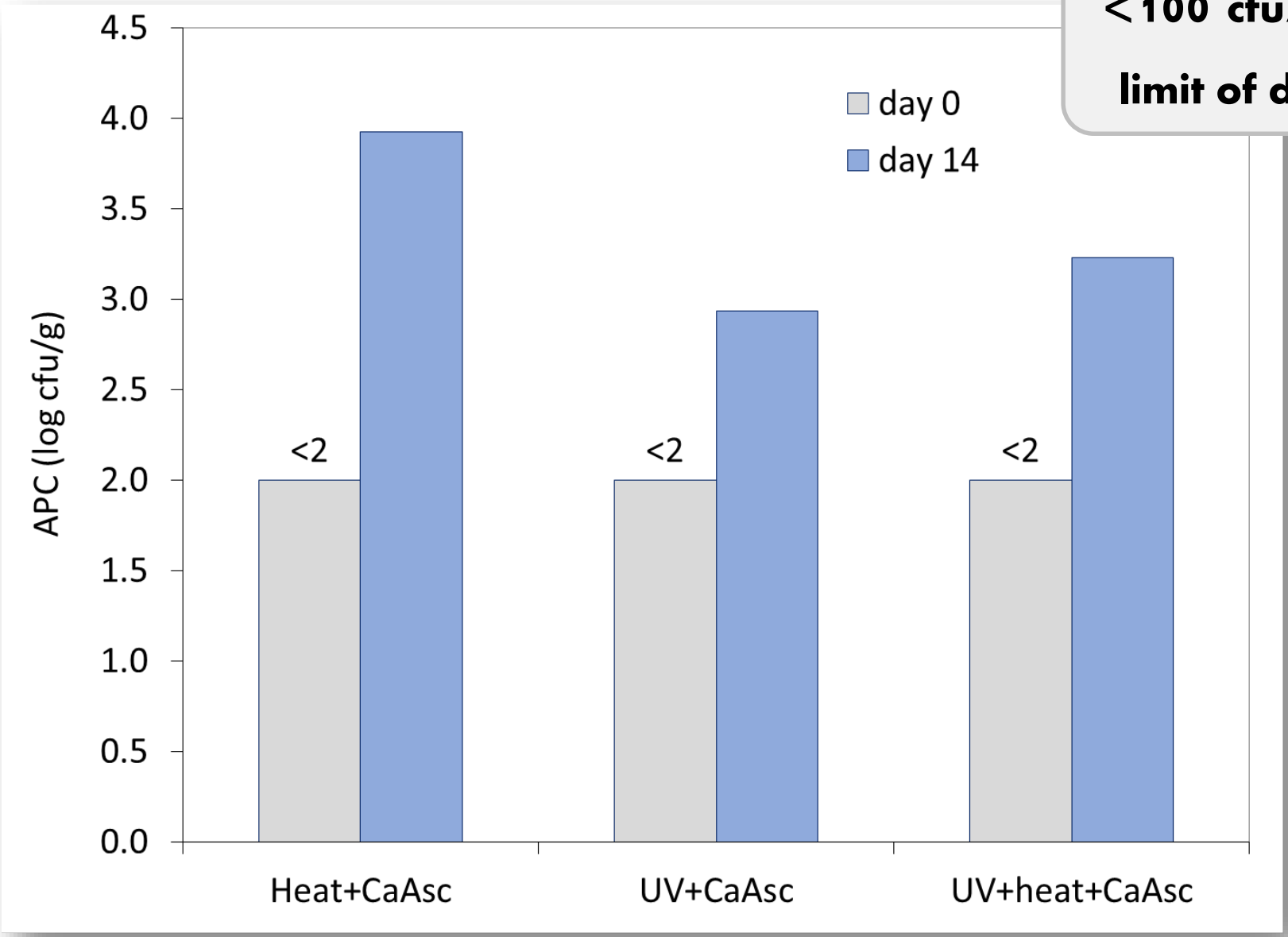
Commercial fresh-cut apple slices

Sliced apple products were purchased from local stores and analyzed on their 'Use By' dates

Sample	Use by	Log_{10} cfu/g		
		APC	Yeast	Mold
Red 14 oz	10/21	6.2	6.0	3.8
Red 14 oz	10/29	5.3	5.2	<1.0
Red 14 oz	10/28	5.8	**4.6**	1.8
Red, 6x2 oz bags	10/28	5.8	5.3	1.9
Mixed red and green, 14 oz	10/31	6.2	**4.5**	1.3
Mixed red and green, 14 oz	10/29	5.9	6.3	<1.0
Mixed red and green, 14 oz	10/28	5.8	5.1	1.8
Red, 5x2 oz bags	10/28	>4.4	5.2	2.2
Red, 5x2 oz bags	10/18	6.3	5.8	3.8
Mixed snack pack	10/23	5.5	**4.4**	<1.0

70% of the samples >5 log (150,000) cfu/g yeast

Apple slices: log APC



<100 cfu/g (2 log)

limit of detection

Woolf et al., 2007. Plant and Food Research, NZ

Commercial fresh-cut apple slices

Treatment	Yeast (log cfu/g)	
	Day 7	Day 15
Without turbulator	3.2	5.1
With turbulator	1.8	3.2
Log reduction	**1.4**	**1.9**

Pomegranate Experiment

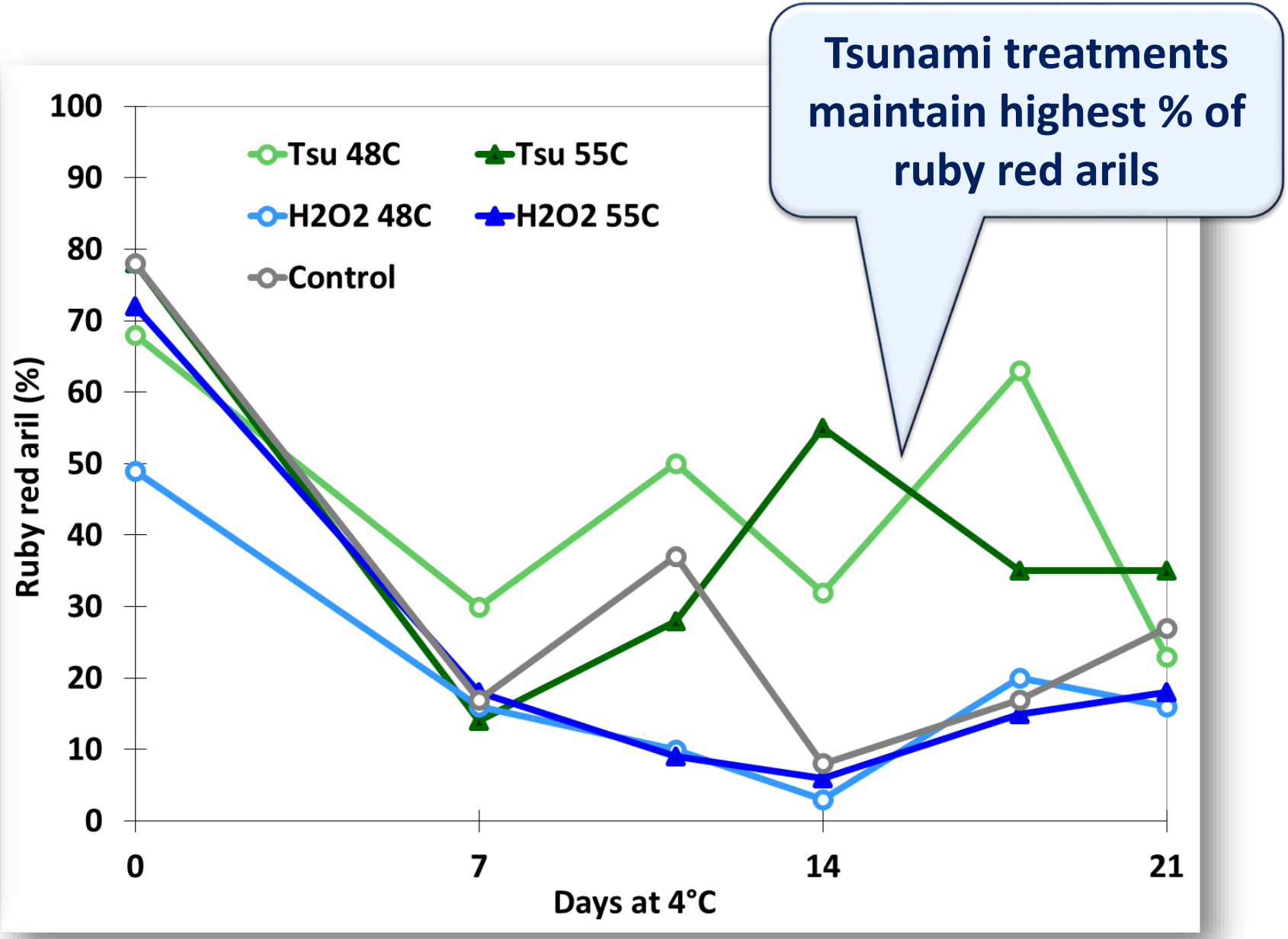
- 'Wonderful' pomegranate after 6 months storage
- Arils extracted and subjected to:

Treatments	1. Prewash	2. UV (7 s)	3. Hot water (30 s)	4. Cooling (2°C 60 s)
Control	Water	No	Ambient	Water
Tsu100 48C	80 ppm PAA	Yes	48°C	80 ppm PAA
Tsu100 55C	80 ppm PAA	Yes	55°C	80 ppm PAA
H_2O_2 48C	1.5% H_2O_2	Yes	48°C	1.5% H_2O_2
H_2O_2 55C	1.5% H_2O_2	Yes	55°C	1.5% H_2O_2

- Dried in UV sanitized air
- Packed in modified atmospheres in sealed cups (122 g)
- Store at 4°C for 21 days

Fletcher et al., 2015. Plant and Food Research, NZ

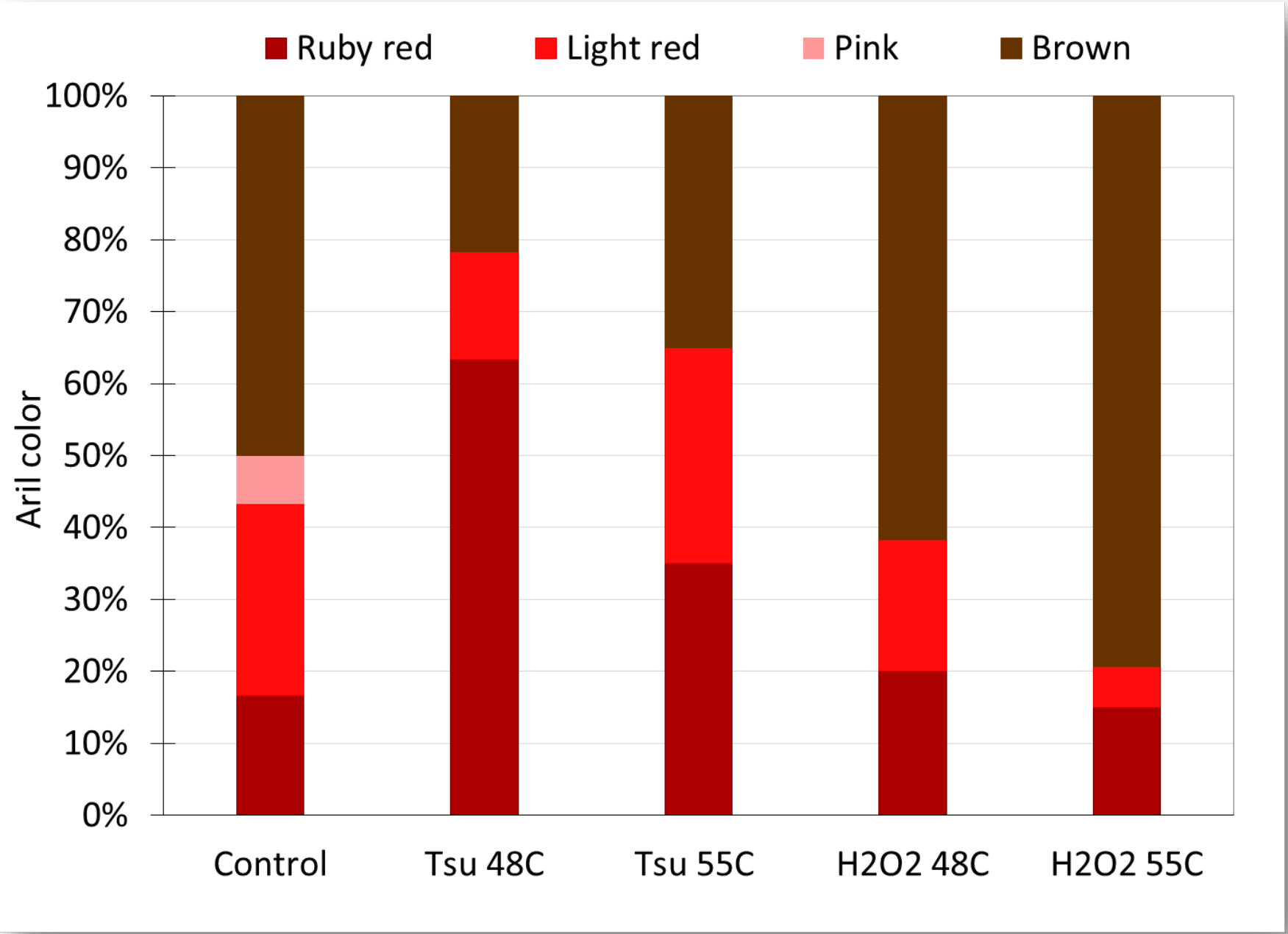
Pomegranate: Aril color



Tsunami treatments maintain highest % of ruby red arils

Fletcher et al., 2015. Plant and Food Research, NZ

Aril color distribution: 18 days at 4°C



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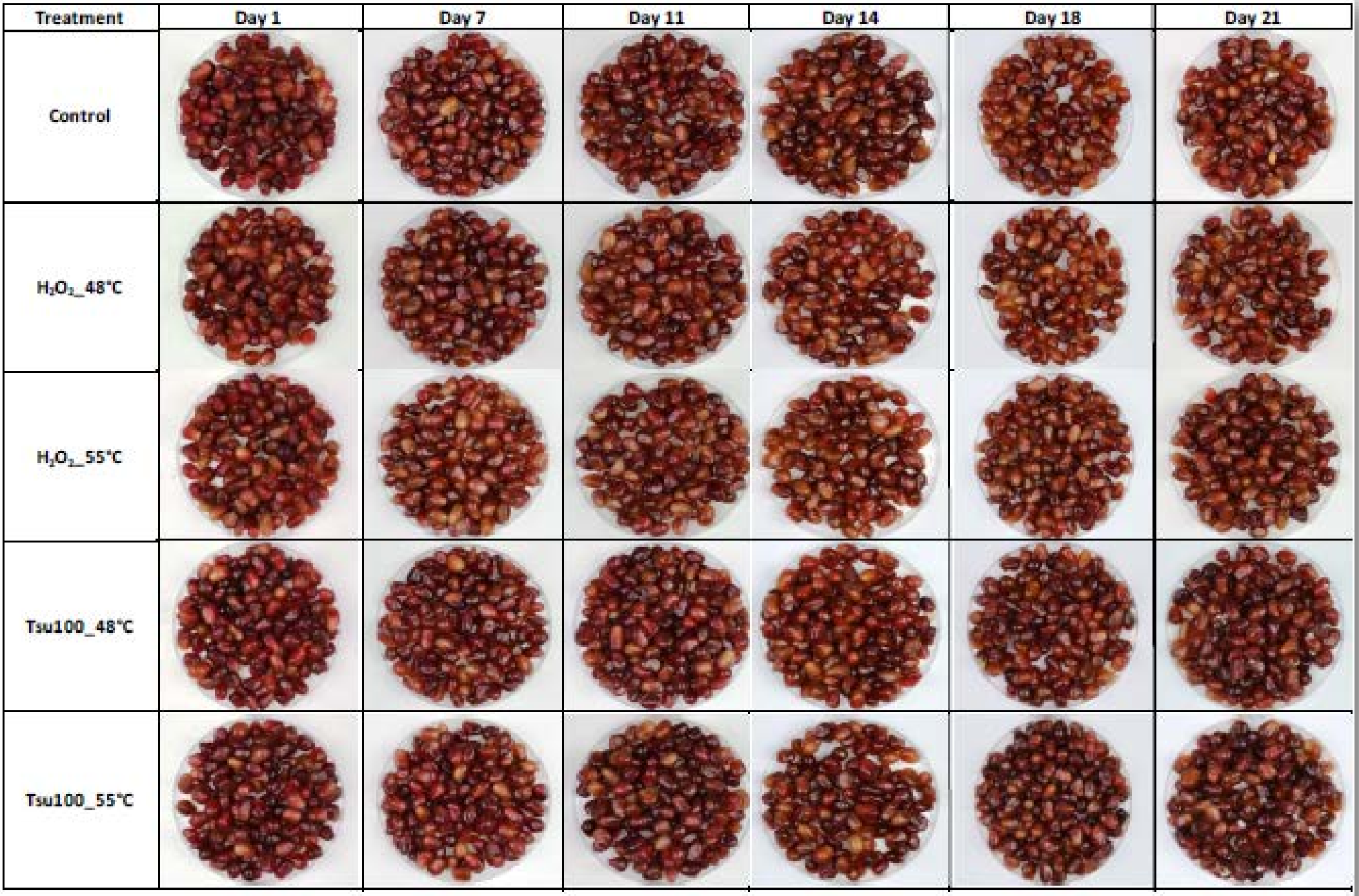


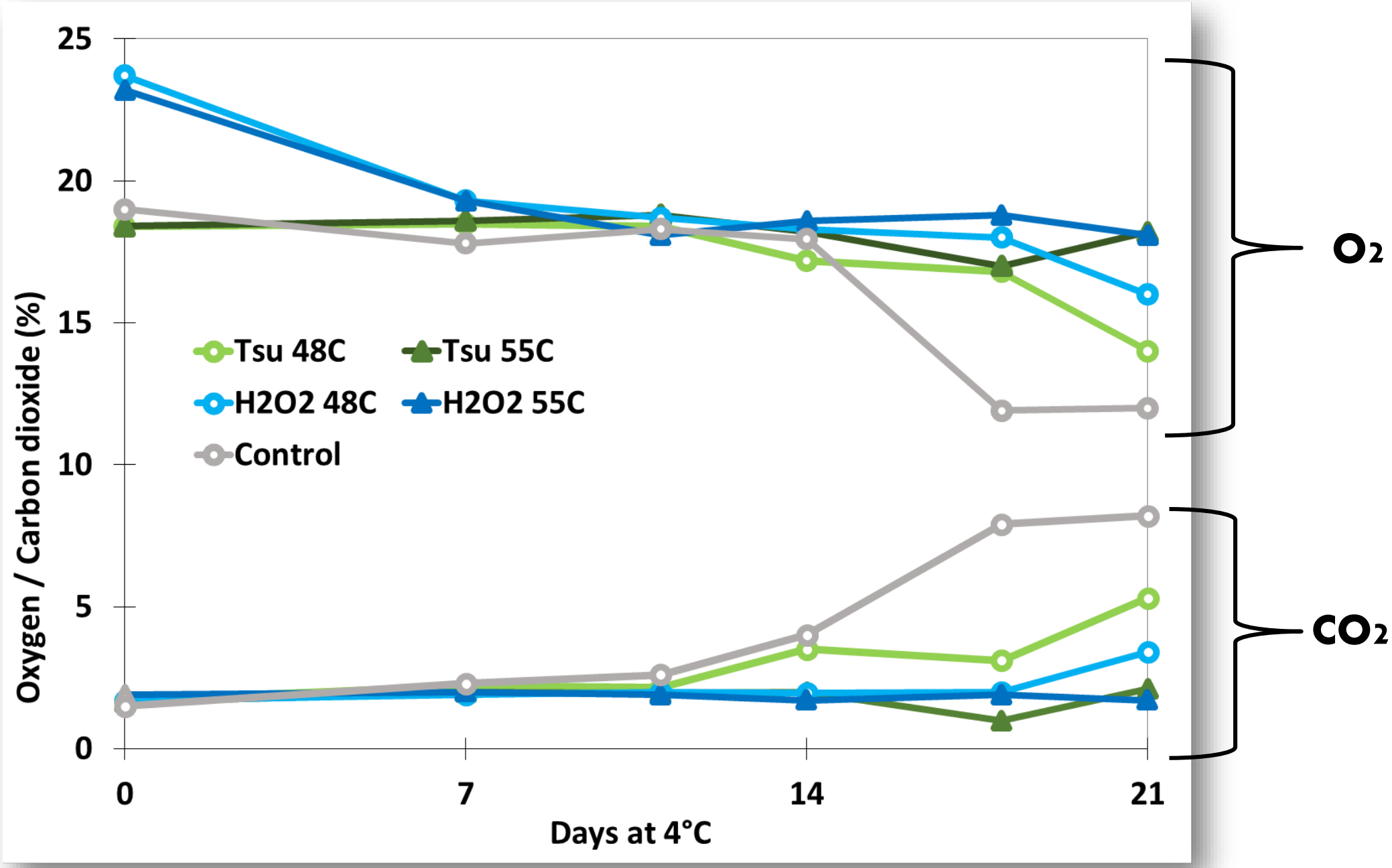
Fletcher et al., 2015. Plant and Food Research, NZ

Pomegranate: Quality

Treatment	Mold	Purge (ml)	Firmness
Control	Visible white mold	1-2 ml	Firm
Tsunami 48°C	Visible white mold	2-5 ml	Firm
Tsunami 55°C	NO visible mold	3-5 ml	Firm
H_2O_2 48°C	Visible white mold	3-5 ml	Firm
H_2O_2 55°C	NO visible mold	3-5 ml	Firm

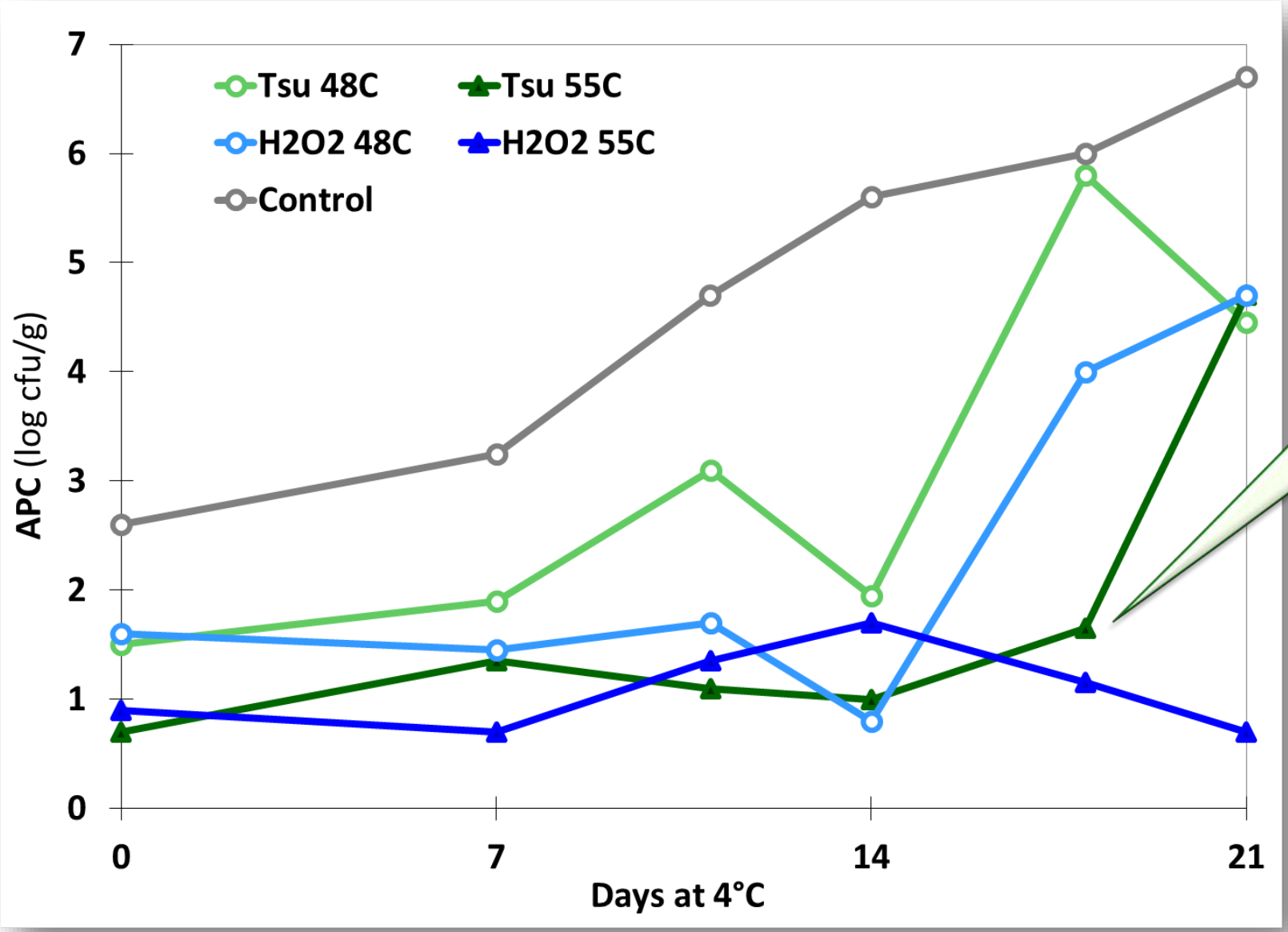
Fletcher et al., 2015. Plant and Food Research, NZ

Headspace Oxygen and Carbon dioxide



Fletcher et al., 2015. Plant and Food Research, NZ

Pomegranate: Log APC

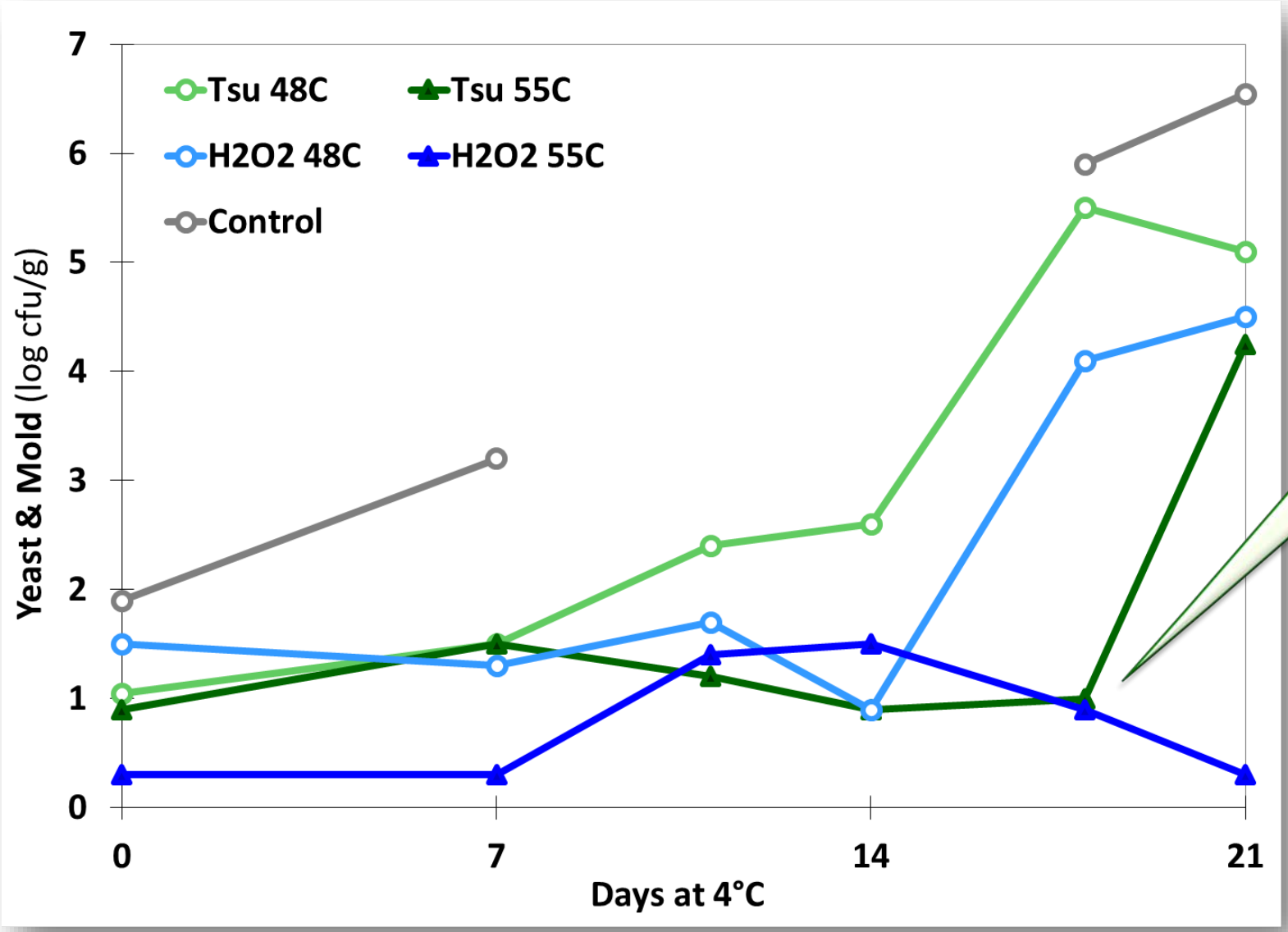


Tsunami 55C was an effective sanitizer for up to 18 days

H_2O_2 55C was an effective sanitizer but aril color was poor

Fletcher et al., 2015. Plant and Food Research, NZ

Pomegranate: Log Yeast + Mold



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Fletcher et al., 2015. Plant and Food Research, NZ

Blueberry

Blueberry trials tested several variables in 4 exps

Recommended treatment:

- UV-C
- Heat: 52.5-55°C for 30-60 sec + 1% $CaCl_2$
- CA: 1-2% cold calcium ascorbate
- MAP

Requejo-Jackman et al., 2012. Plant and Food Research, NZ

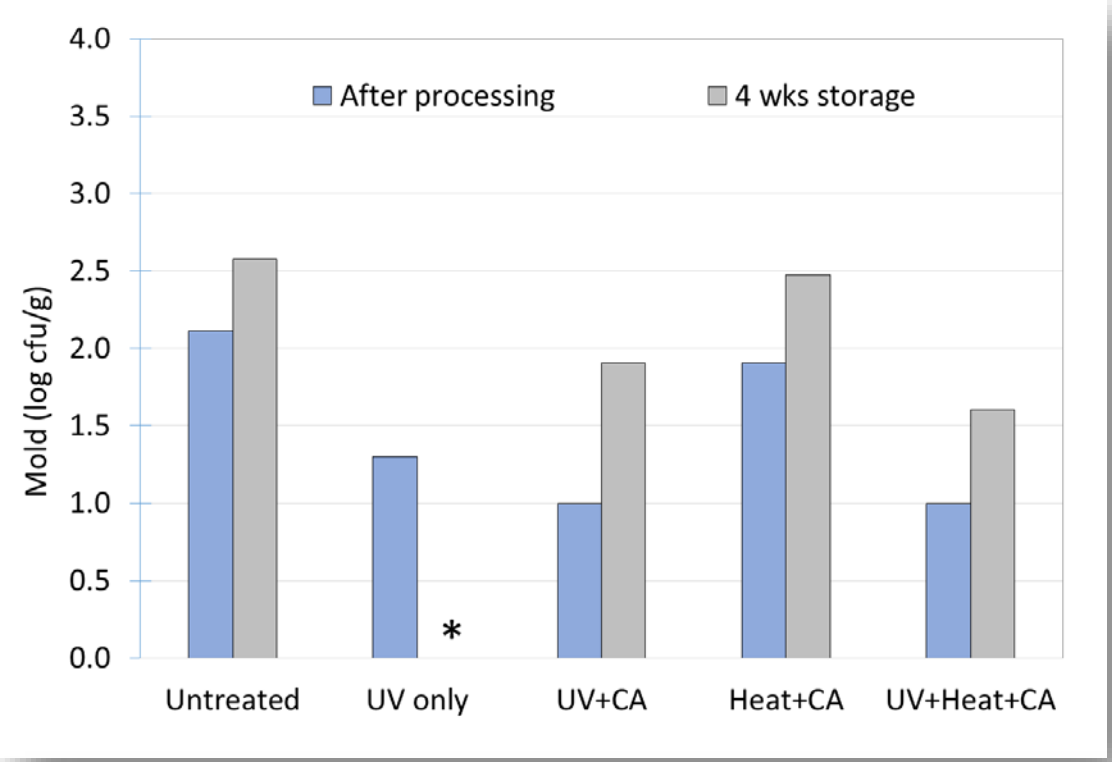
** Data not recorded*

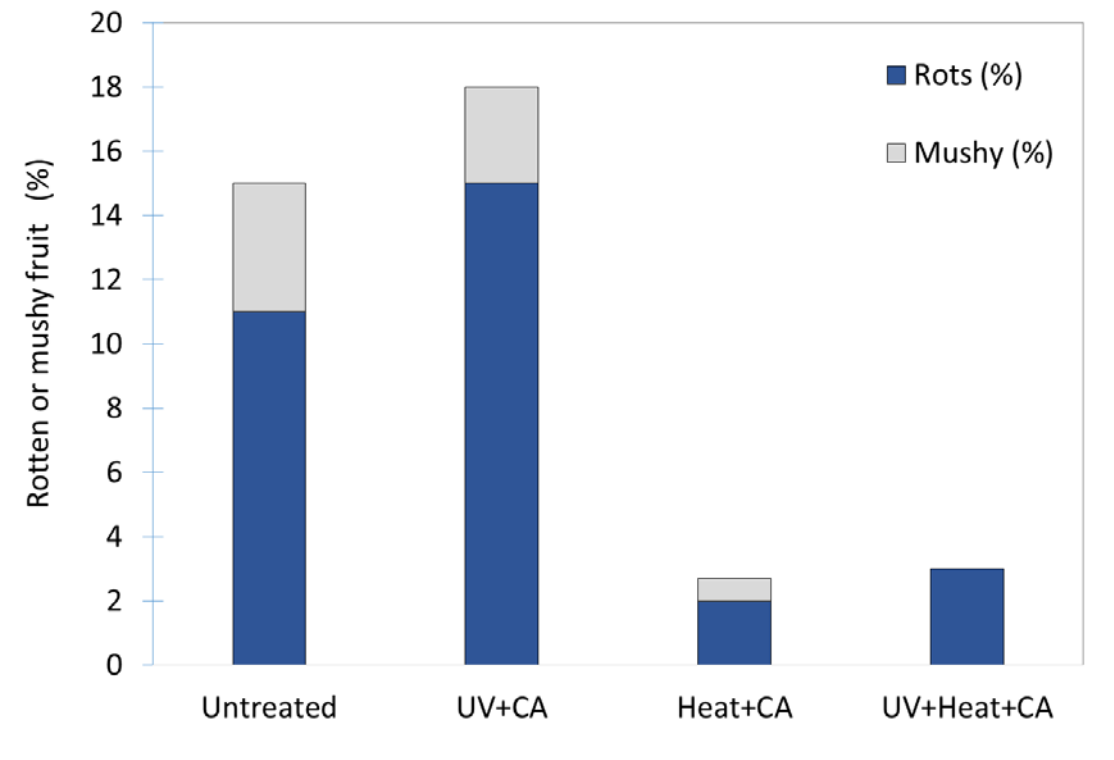
Blueberry results

** Data not recorded*

Mold counts were higher on untreated control fruit than UV treated fruit.

Incidence of rotten and mushy/soft fruit (%) tended to be higher in treatments without heat.





Requejo-Jackman et al., 2012.
Plant and Food Research, NZ

Fresh Appeal's patented system is the first system that includes sequential applications of several sanitation hurdles.

freshappeal