Hot water treatment (HWT) of fresh produce to prolong shelf life and reduce losses and waste

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At harvest **During storage/shelf life**

Gloeosporium rot *(Neofabraea* spp.)

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Optimizing Water Use in the Supply Chain of Fresh Produce

Why is there a growing interest for HWT?

- HWT can reduce food losses and waste
- HWT is an eco-friendly and safe alternative to synthetic fungicides
- A good alternative for organic products
- No residues on the treated product
- There is no human health risks with HWT
- Accepted by consumers

Photo: Connie Krogh Damgaard

Agenda

- The history of hot water treatment (HWT)
- HWT of fresh produce for disease control
- The mechanisms behind HWT
- Examples with HWT of apples and pears
- The future for HWT

The history of hot water treatment (HWT)

There are basically two treatment strategies:

- Immersion / dipping between 43 and 53 °C for several minutes up to 2 h
- Showering / rinsing between 48 and 63 °C for 10 – 30 s

During treatment:

- Heat is efficiently transferred from the water to the produce
- Operation times are short
- Water (> 50 °C) can be recycled /reused

The history of hot water treatment (HWT)

Hot water treatment has been used for:

- Postharvest disease control
- Insect disinfection
- Inhibit ripening, sprouting, geotropic curvature
- Induce resistance to chilling injury

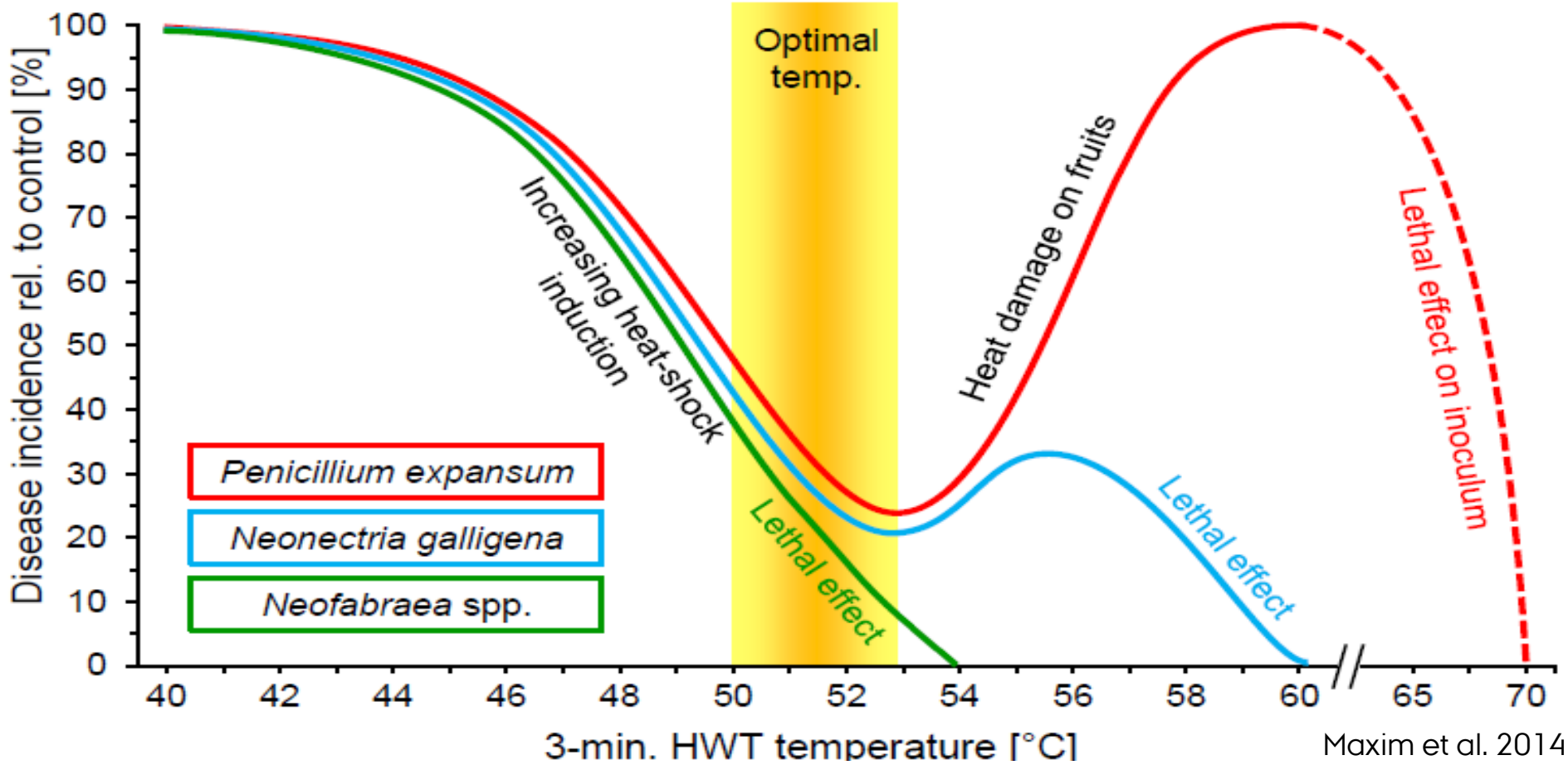
Examples of disease control:

- Brown rot in citrus fruits (Fawcett, 1922)
- Gloeosporium / Bull's eye rot (*Neofabraea* spp.) in apples (Burchill, 1964)
- Grey mold in kiwifruit (Cheah et al., 1992)
- Green and blue mold in oranges (Strano et al., 2014)

Examples of treated horticultural crops

- Apples, pears, peach, nectarine, plum
- Banana, mango, papaya, litchi, kiwifruit
- Clementine, grapefruit, lemon, mandarin, orange, tangerine
- Melon, muskmelon, strawberry
- Avocado, potato, tomato, pepper

The mechanisms behind hot water treatment



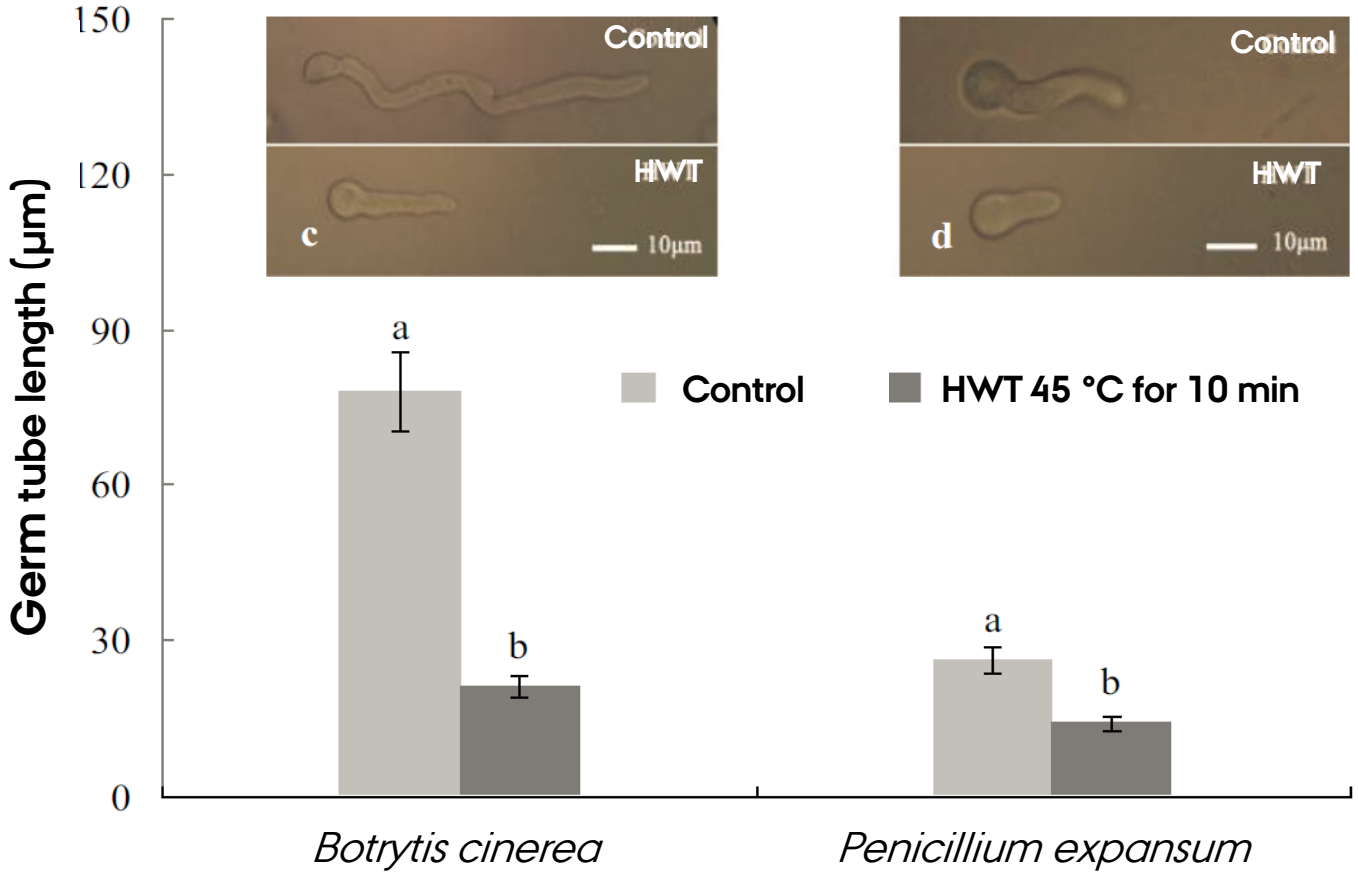
Maxim et al. 2014

Penicillium expansum

Neofabraea spp.

Effect on the pathogens

- Lethal or sub-lethal effect on spore germination / mycelial growth
- 3 - 4 log reduction in CFU – and thus a 'cleaner' product

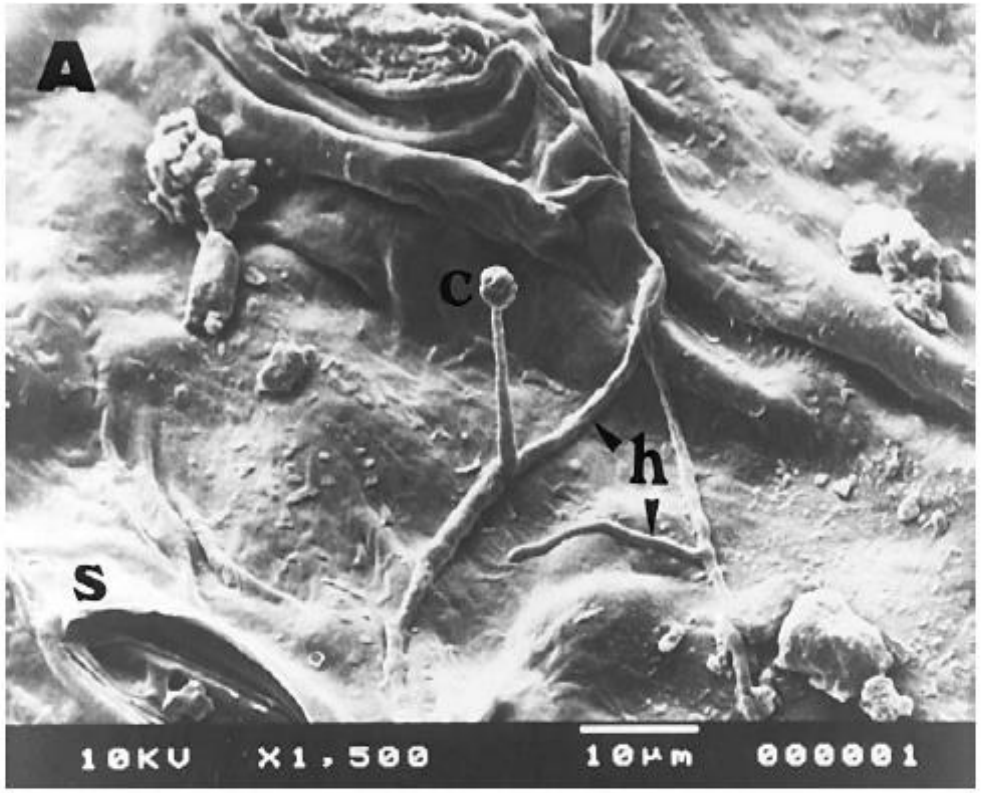


Pathogens isolated from infected kiwifruit

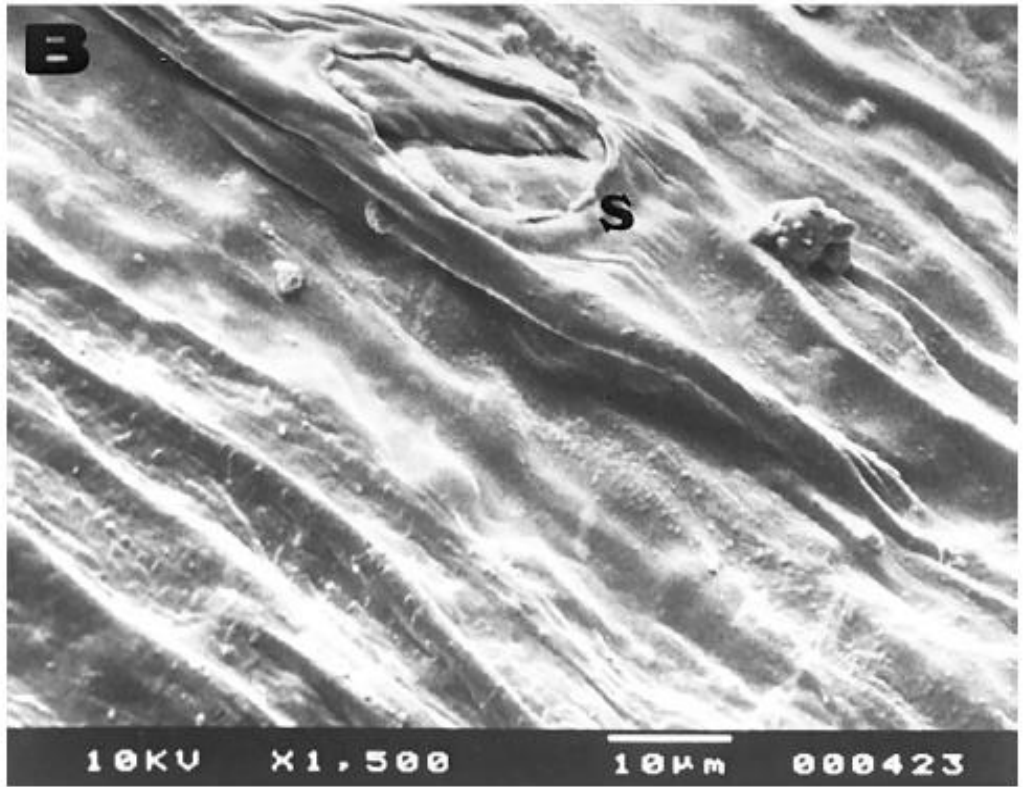
Chen et al. 2015

A more ‘clean’ fruit with brushing and HWT

Brushed



Brushed & hot water rinsed (55 °C for 12 s)



Scanning electron microscopy of the calyx after 2 weeks at 7 °C

Fallik et al. 1999

S: stomata; C: conidiophore/conidium; h: hyphae

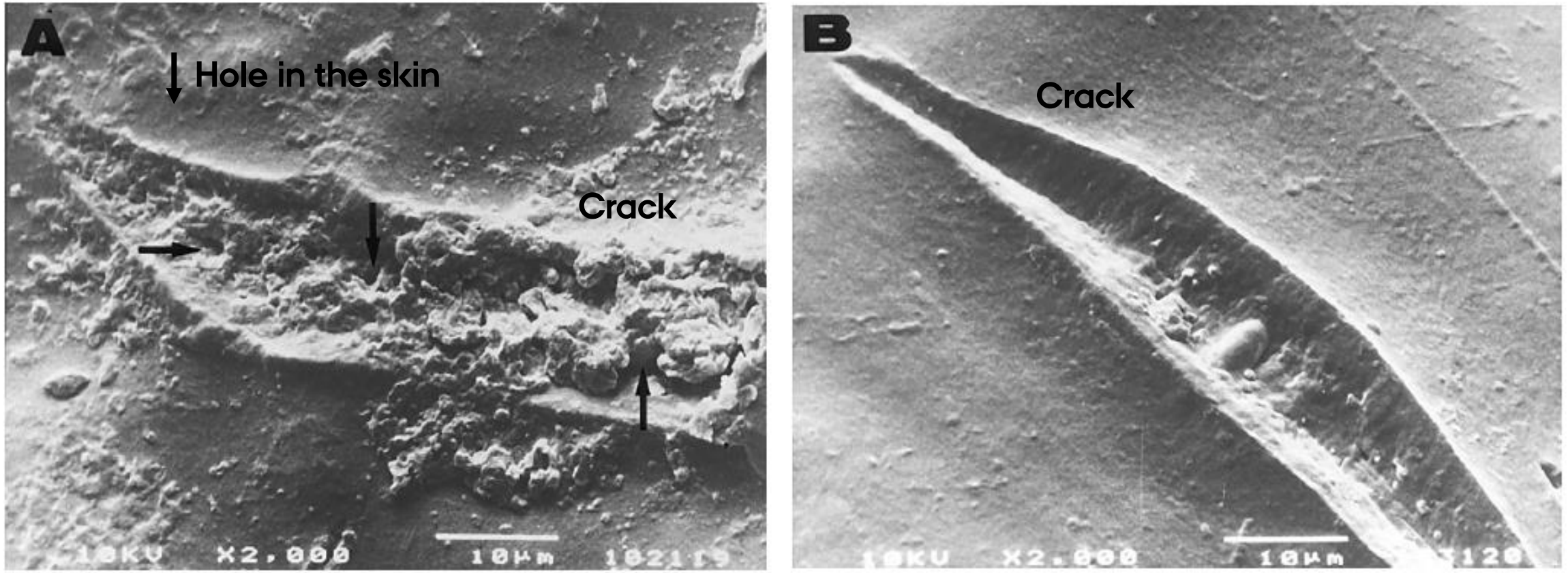
Effect on the fresh produce

- Melting of the epicuticular wax
- Occlusion of entry points for wound pathogens
- Physiological changes that induce resistance
- HWT is a balance between mild stress and wounding

Melting and occlusion of entry points in pepper fruits

Untreated

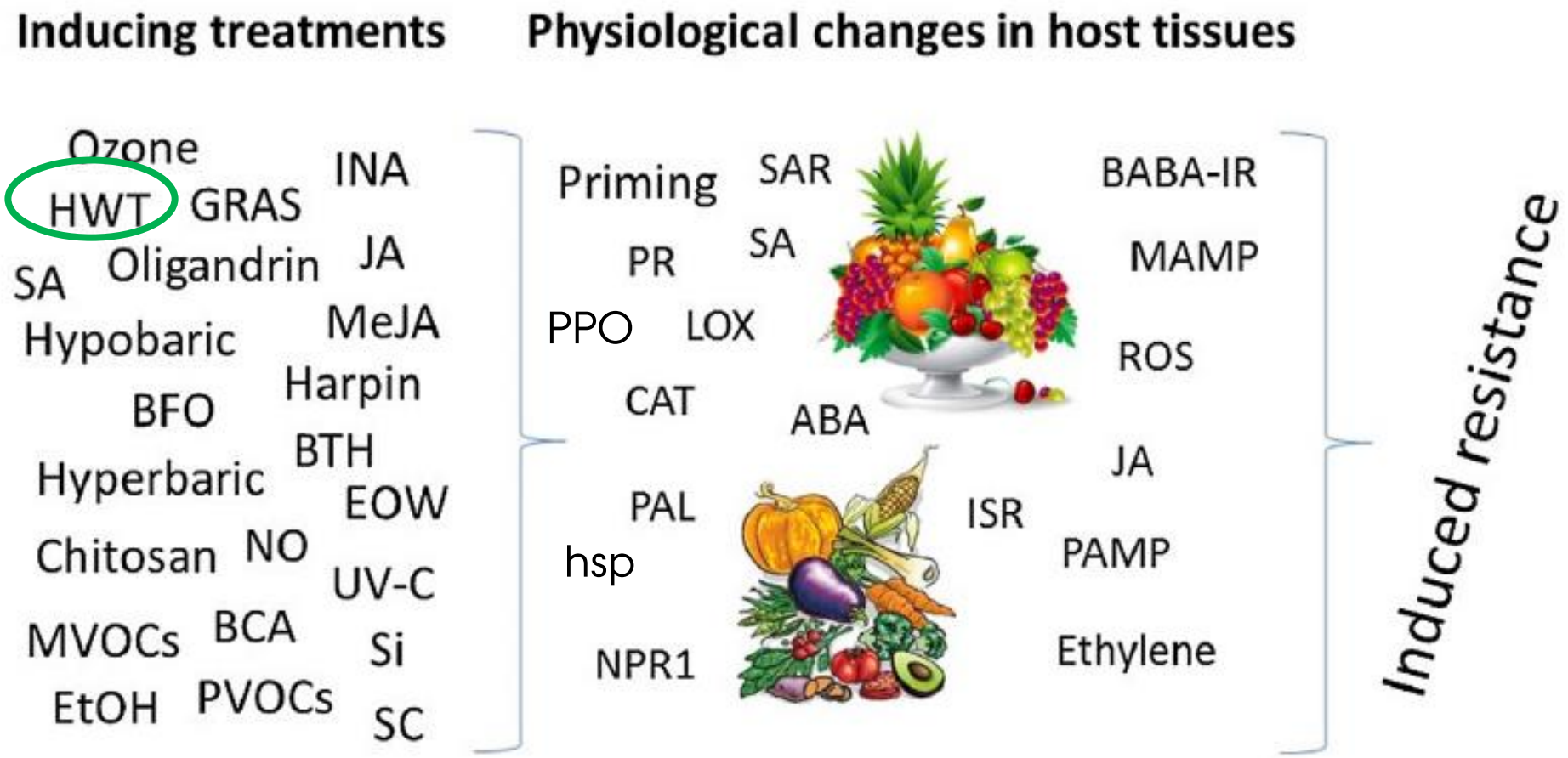
Brushed & hot water rinsed (55 °C for 12 s)



Scanning electron microscopy of skin after 2 weeks at 7 °C

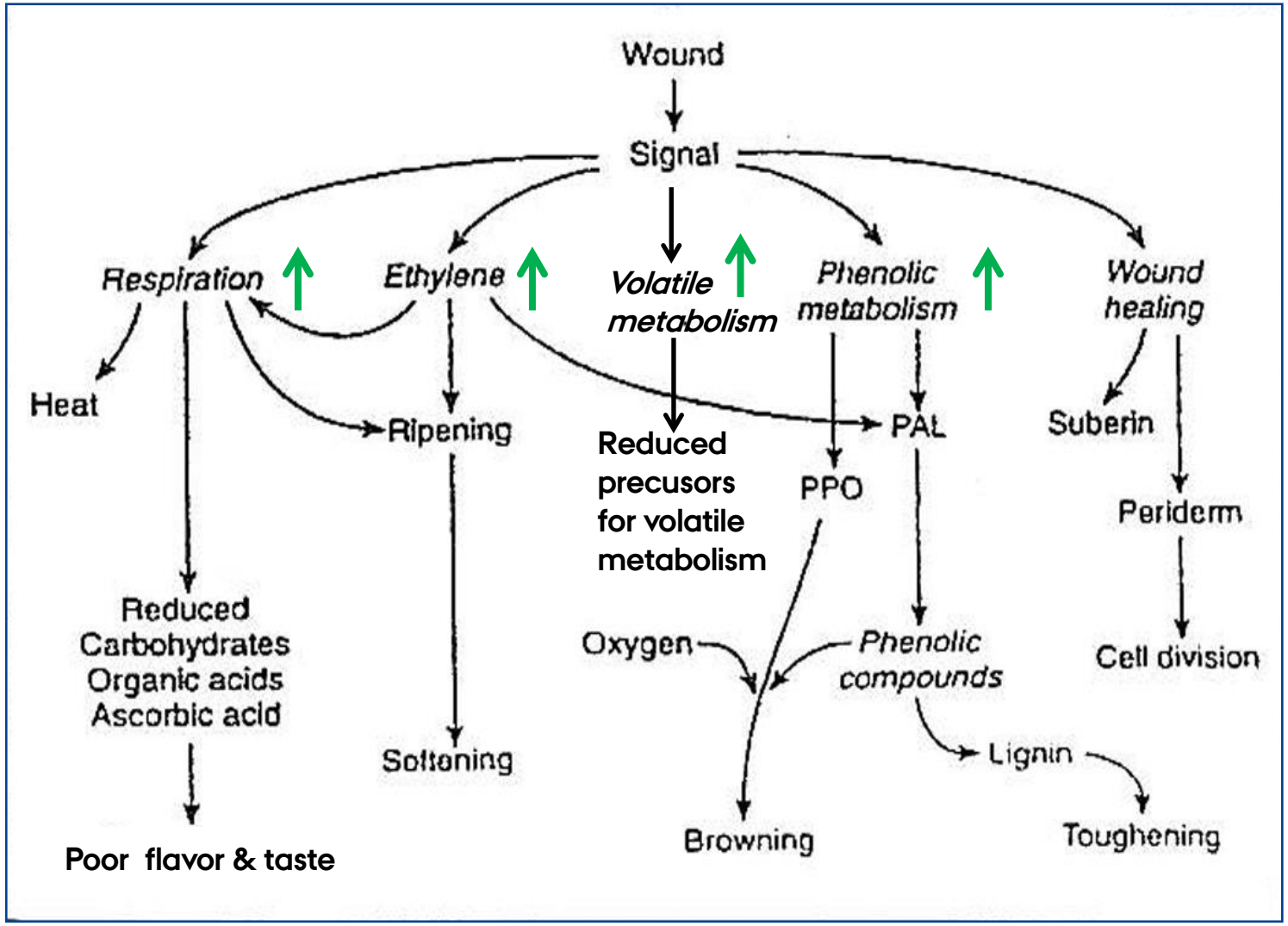
Fallik et al. 1999

Physiological changes that induce resistance



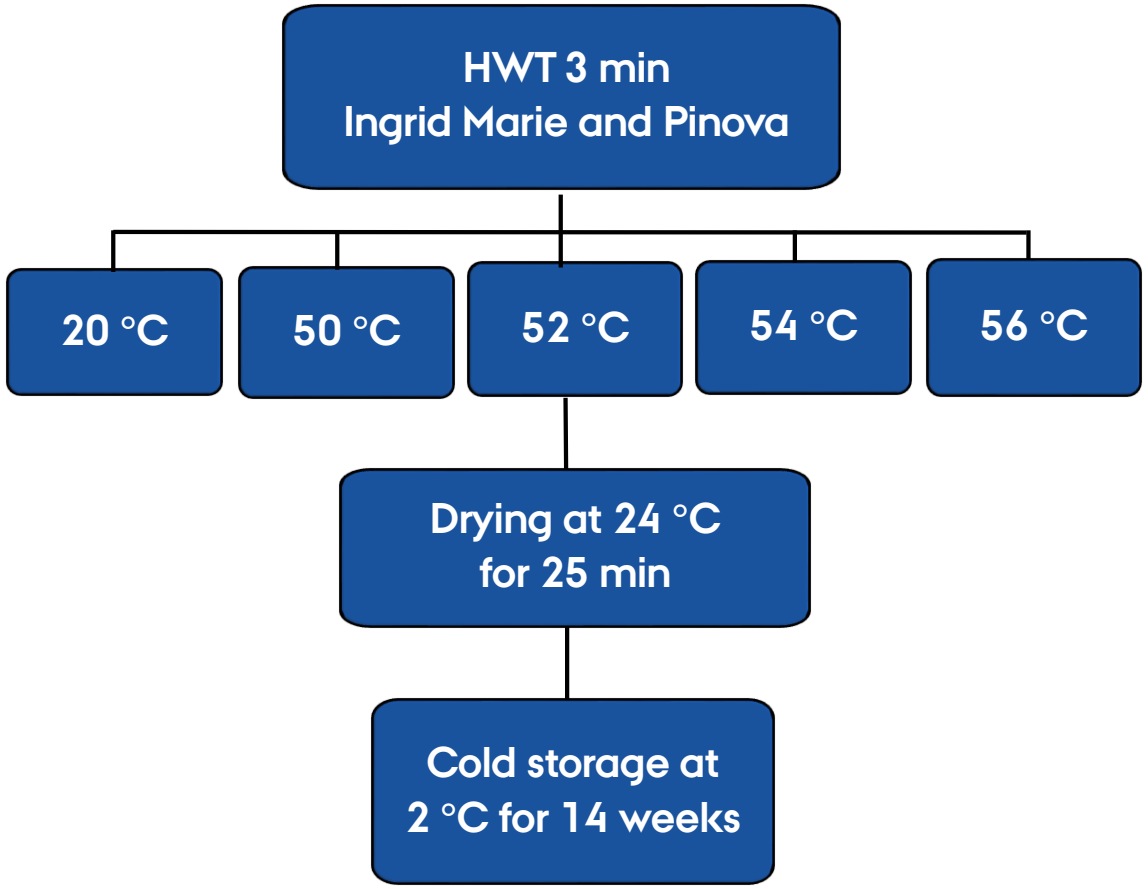
Romanazzi et al. 2016

HWT is a balance between mild stress and wounding

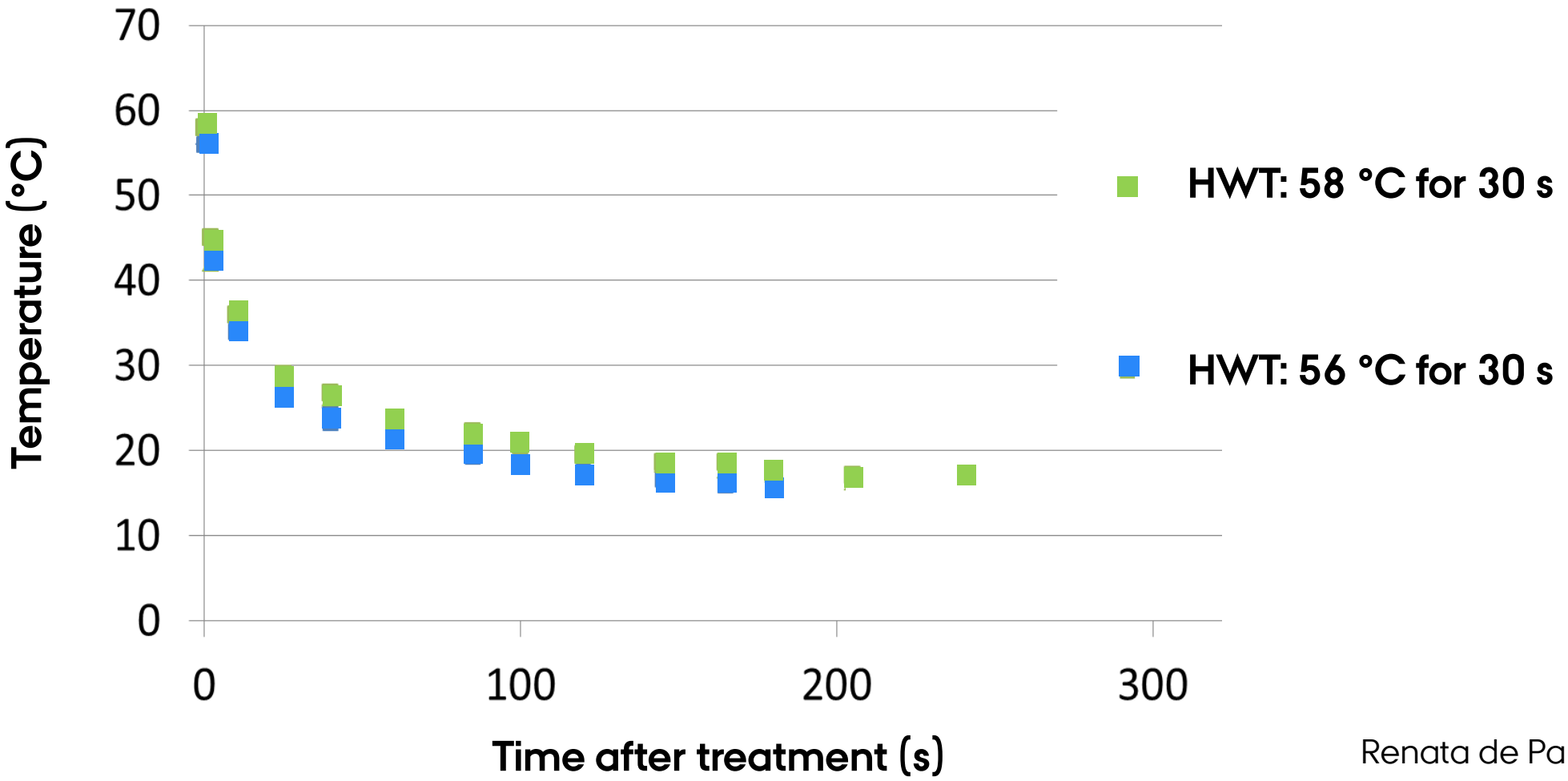


PAL: phenylalanine ammonia-lyase **PPO**: Polyphenol oxidase Partly from Saltveit 2003

HWT of apples



Effect of HWT on skin temperature



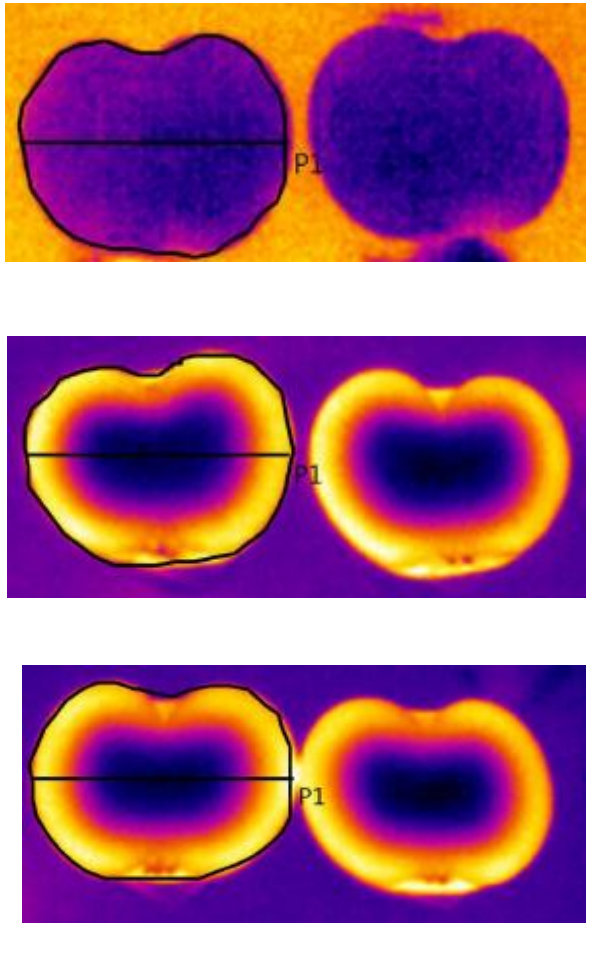
Renata de Paulo Rocha, 2014

Effect of 3 min HWT on fruit temperature

20 °C

52 °C

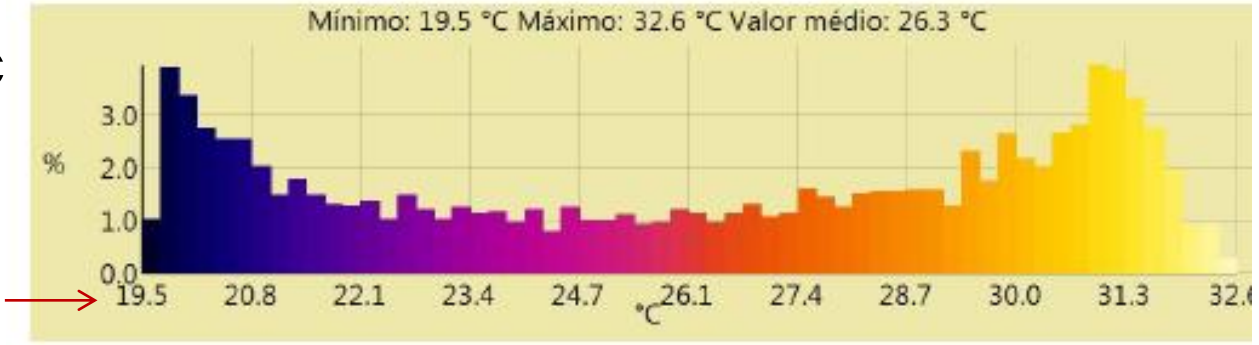
54 °C



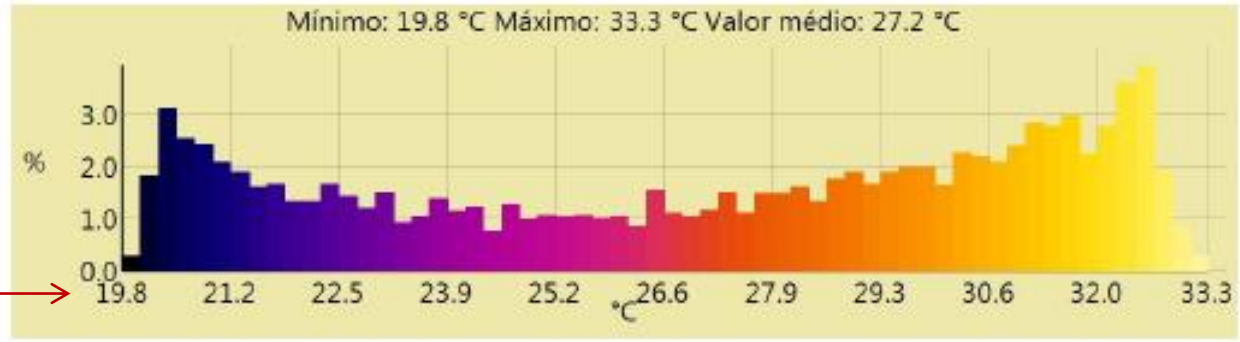
Effect of 3 min HWT on fruit temperature

20 °C

52 °C

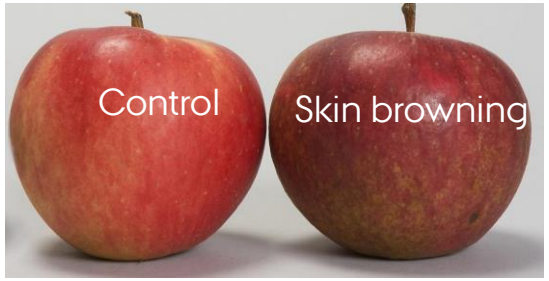


54 °C

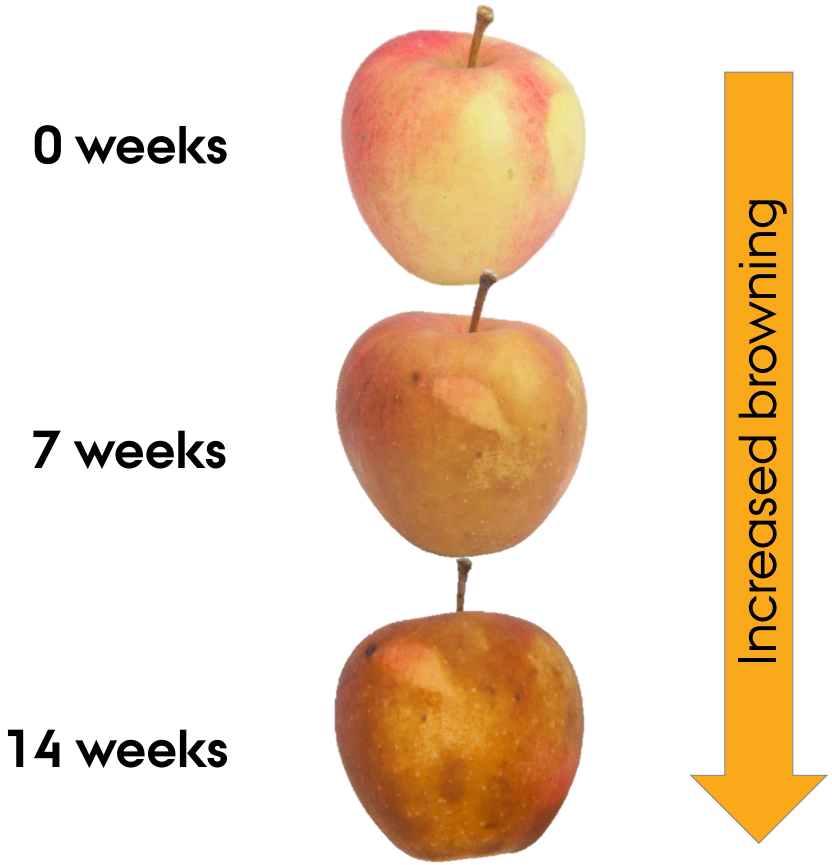


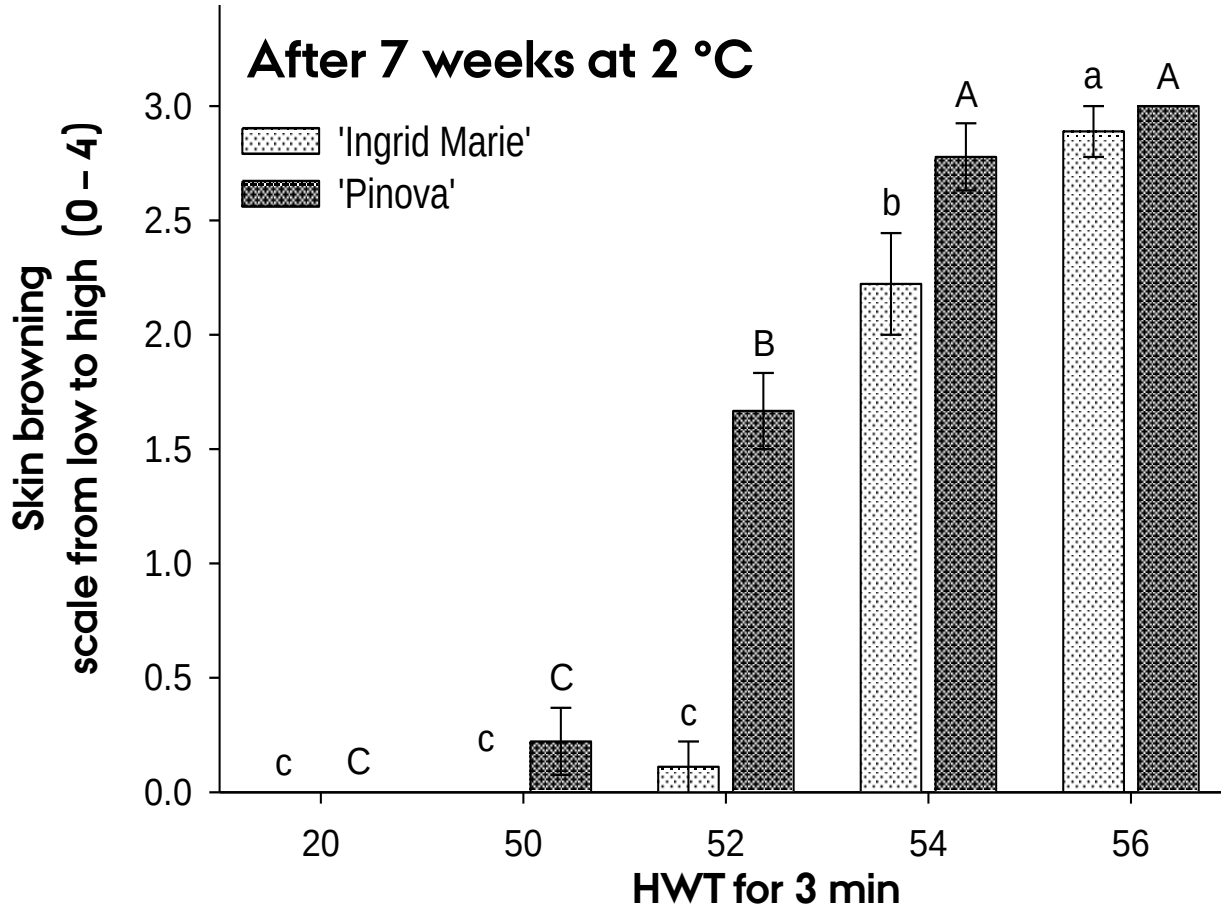
Temperature (°C)		
Min	Mean	Max
18.9	19.6	21.7
19.5	26.3	32.6
19.8	27.2	33.3

Effect of HWT on skin browning in apples



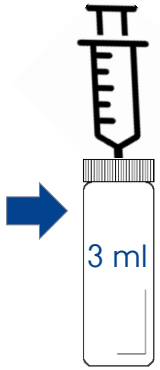
'Pinova' dipped for 3 min at 54 °C



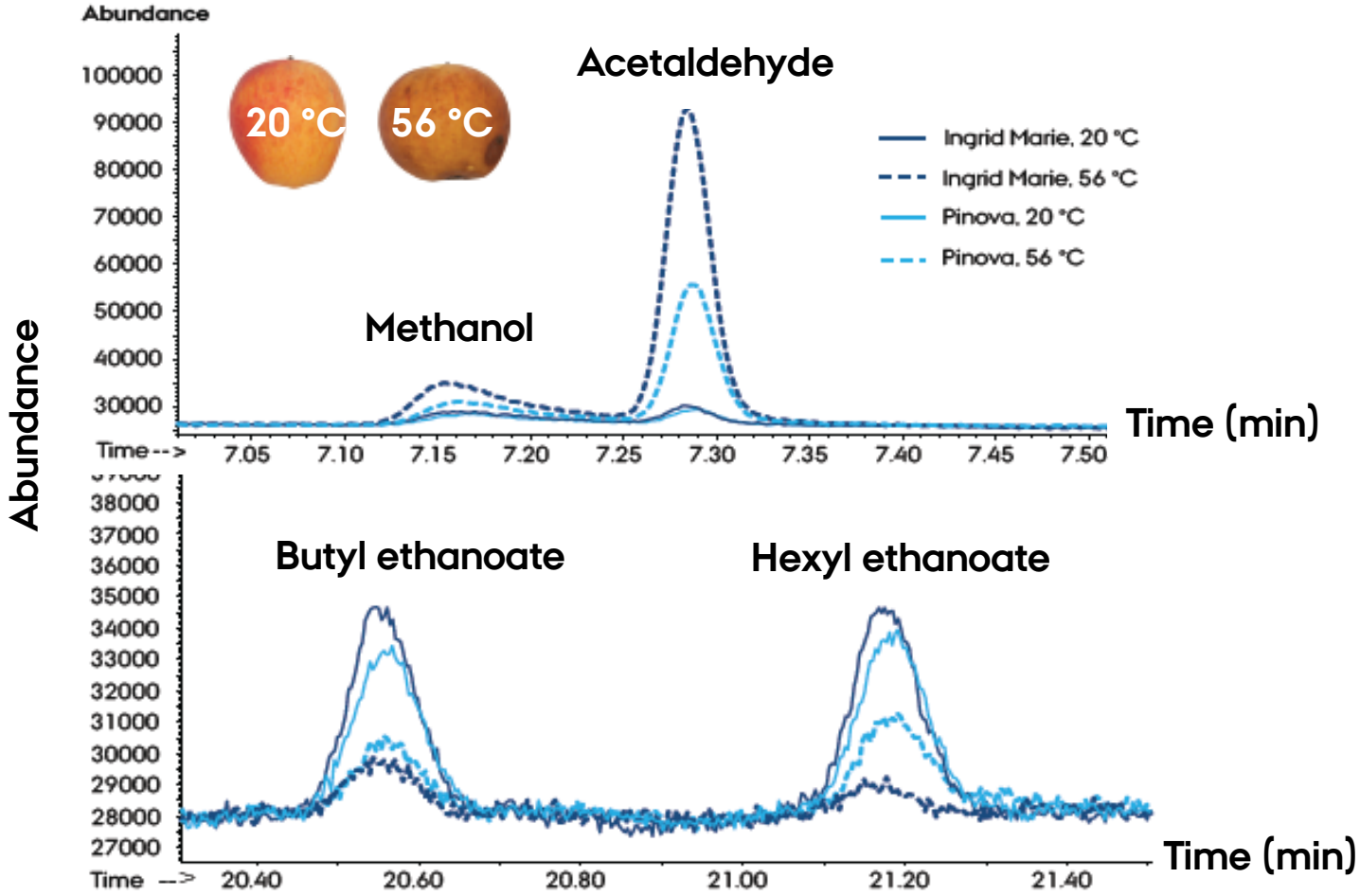


Prediction of skin browning at treatment by volatile analysis

Gas sampling after 2 h at 20 °C

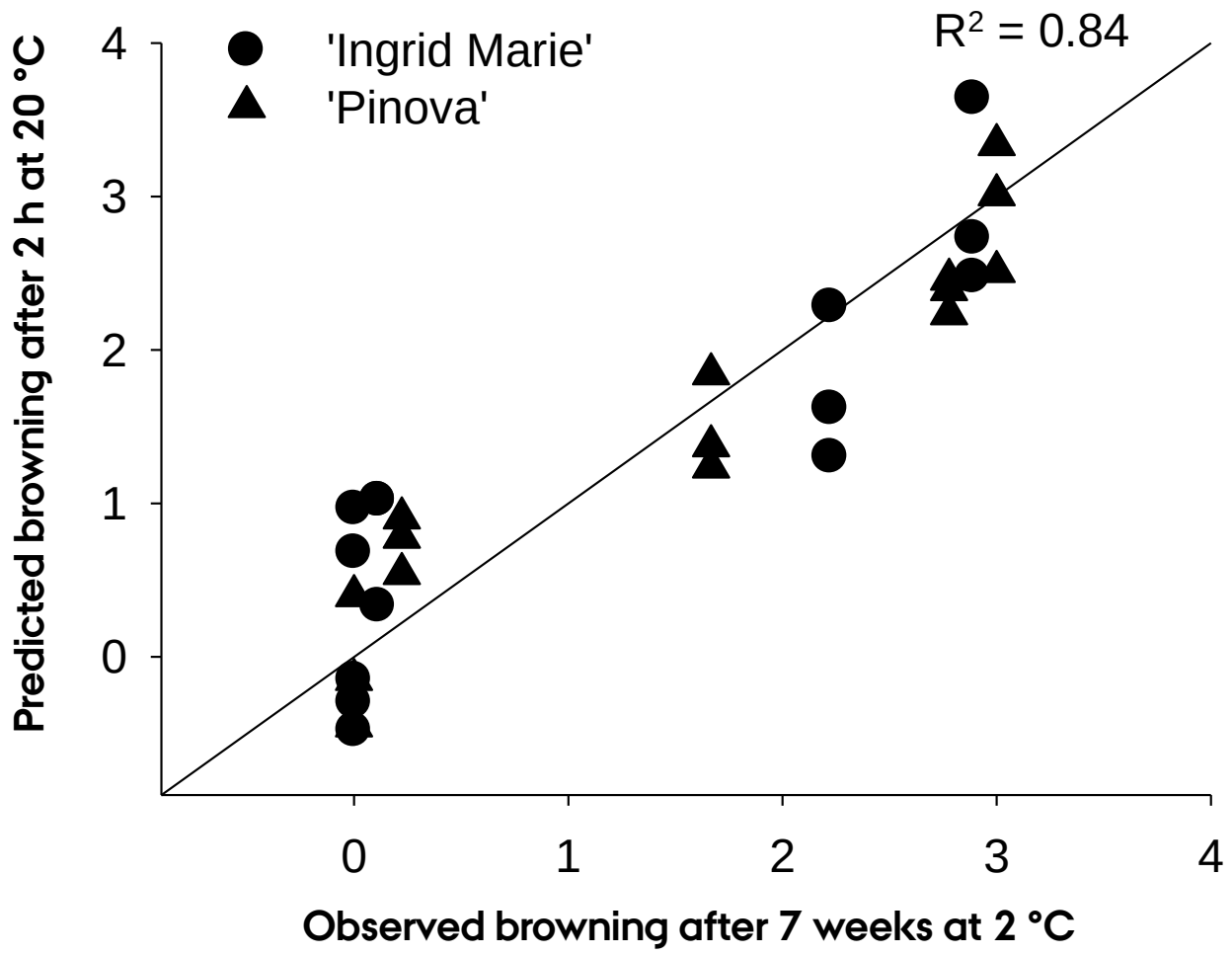


GC-MS analyses

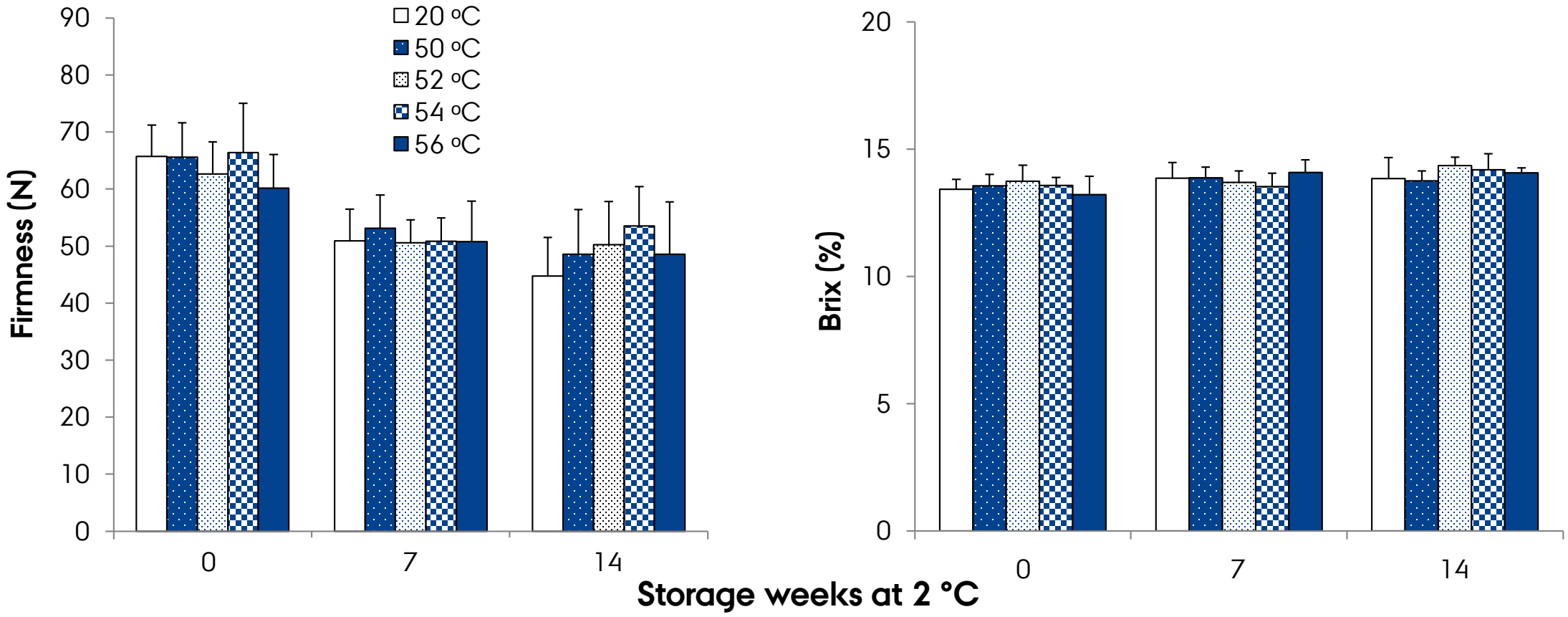


Himmelboe et al. 2016

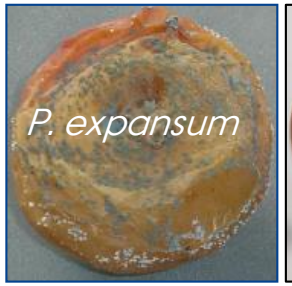
Prediction of skin browning by volatile analysis

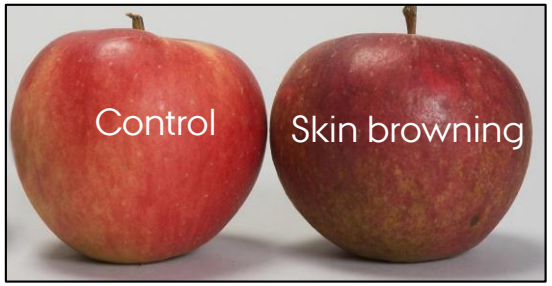


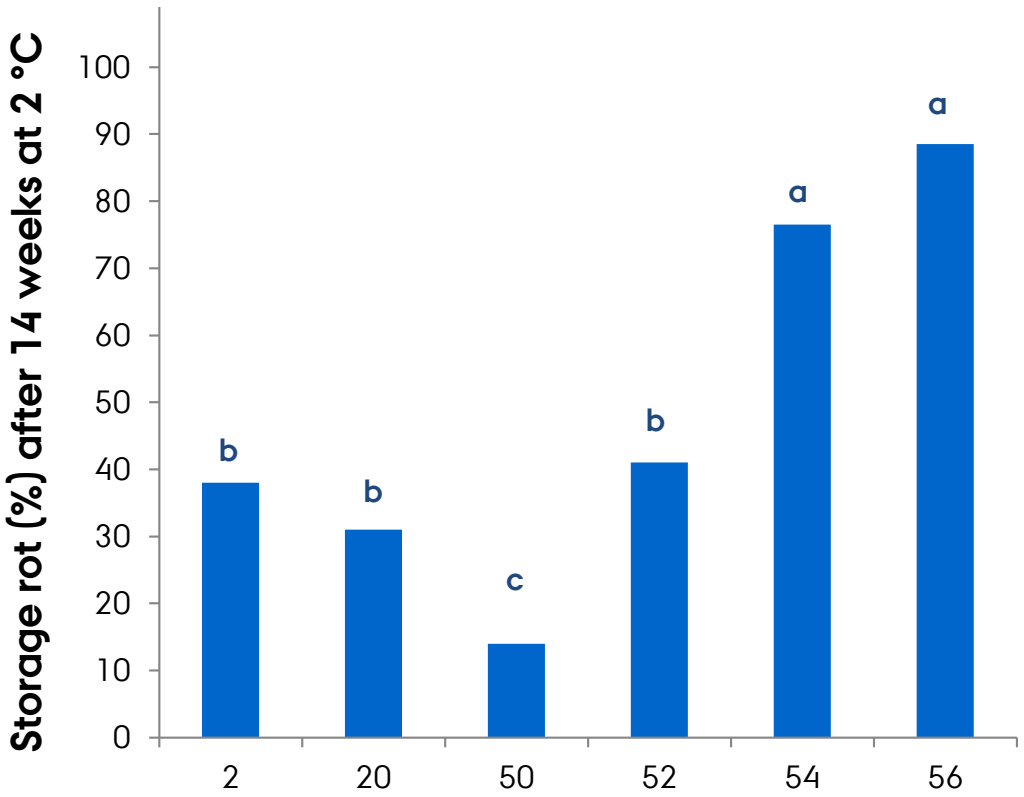
Effect of 3 min HWT on apple quality

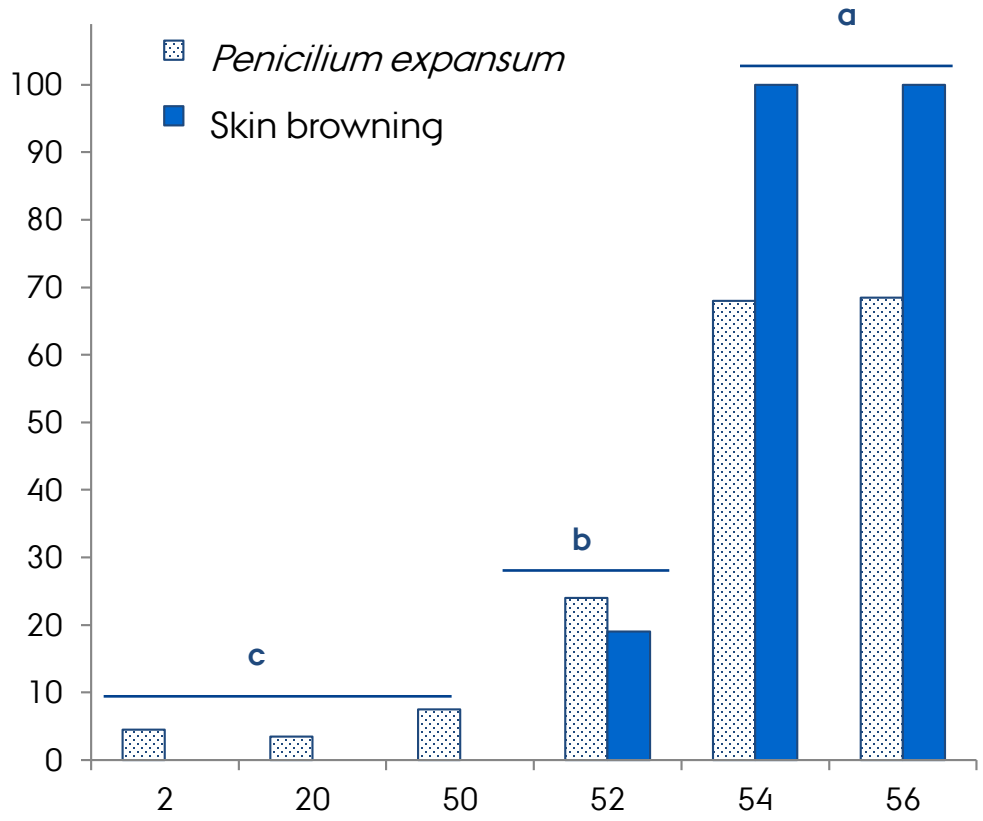


Effect of HWT on storage rot in apples





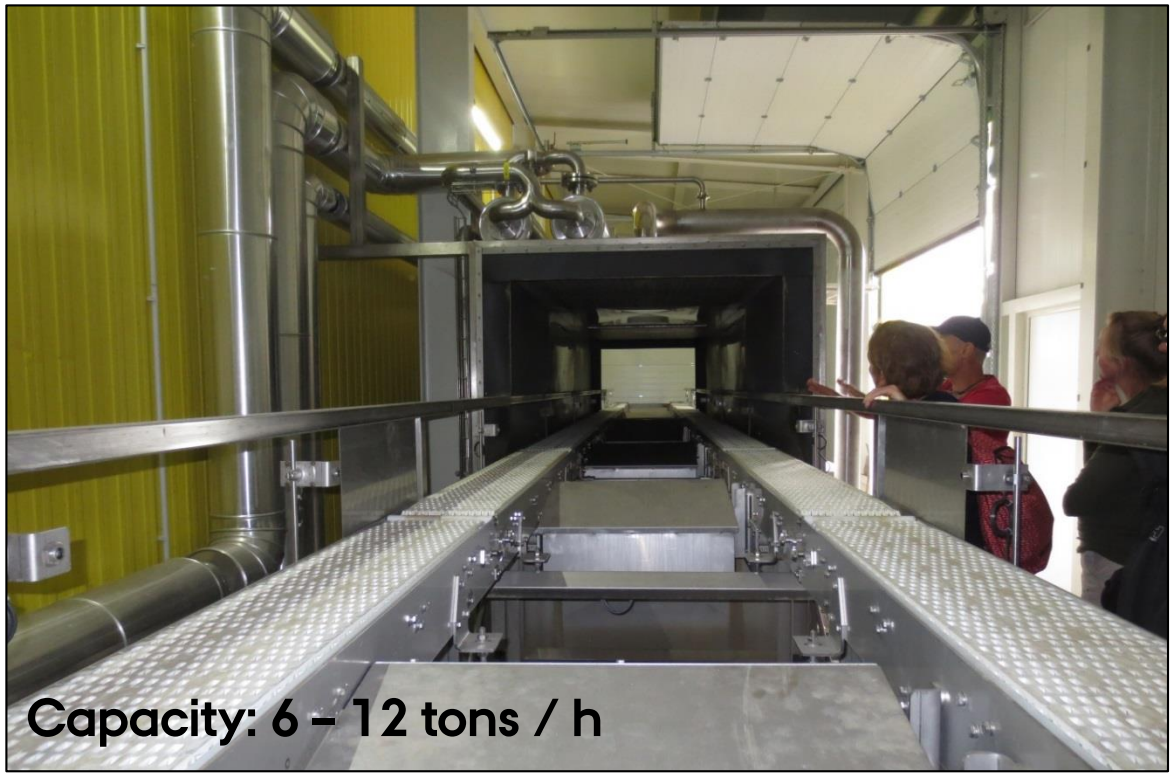




HWT for 3 min

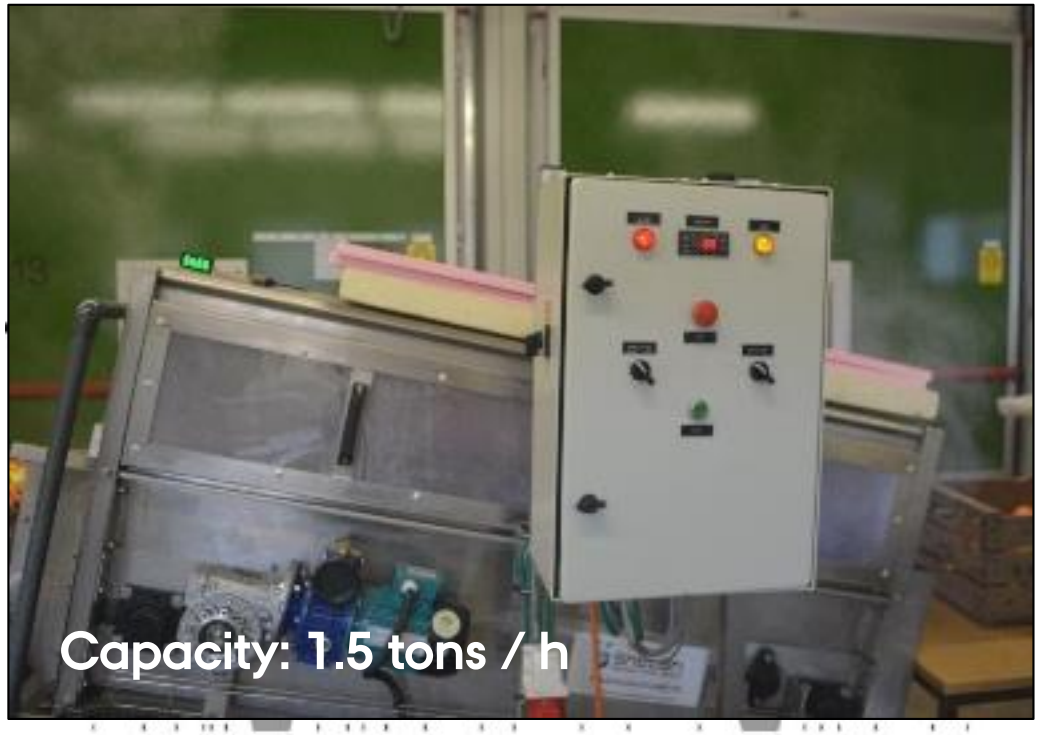
Equipment for hot water showering

Showering of big boxes with apples



Developed by Möstl Anlagenbau, Passail, Austria
Photo: Hanne Lindhard Pedersen. AU, DK.

Showering of single fruits



Developed by Shelah Systems, Kibbutz Alumim, Israel
Modified by ESTEBURG Obstbauzentrum, DE.
Photo: Hinrich Holthusen, ESTEBURG Obstbauzentrum, DE.

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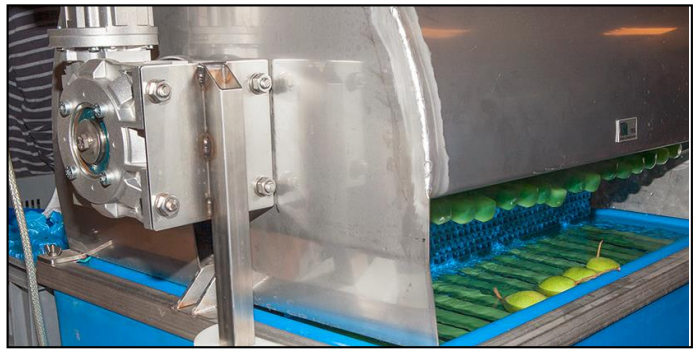
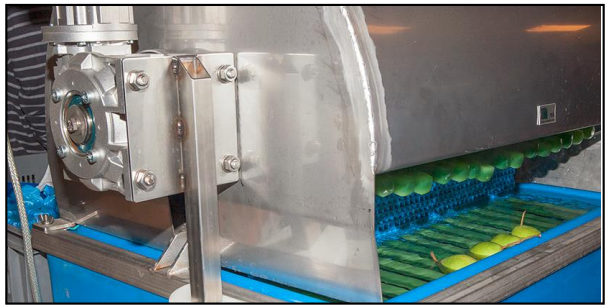
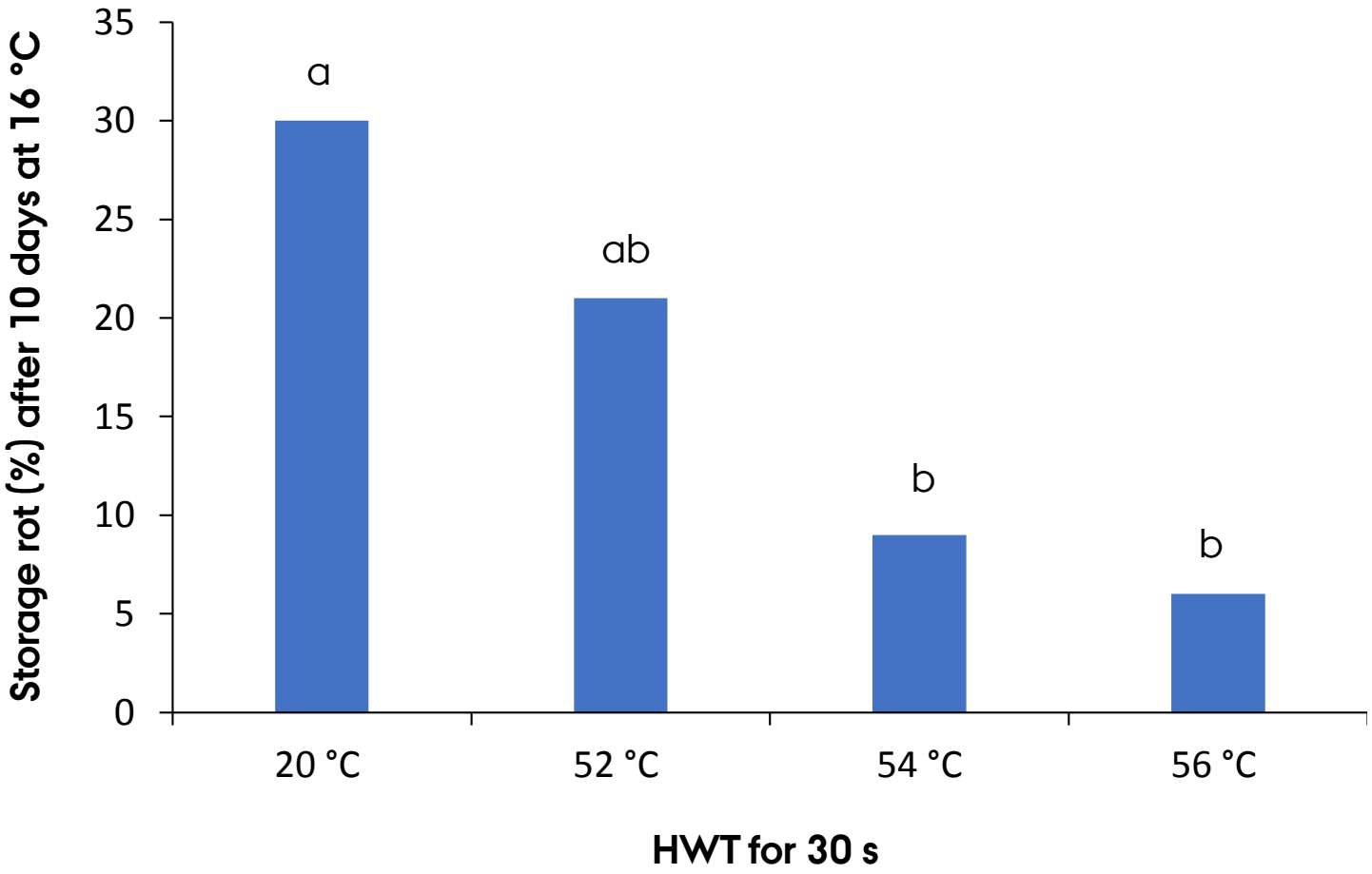
Equipment for hot water dipping of single fruits



Developed by Innotheque Aps, Røjle, Denmark.
Photoes: Kim Nielsen, AU, DK

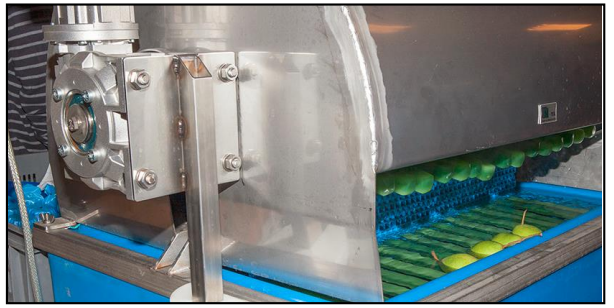
Effect of short time HWT on rots in pears

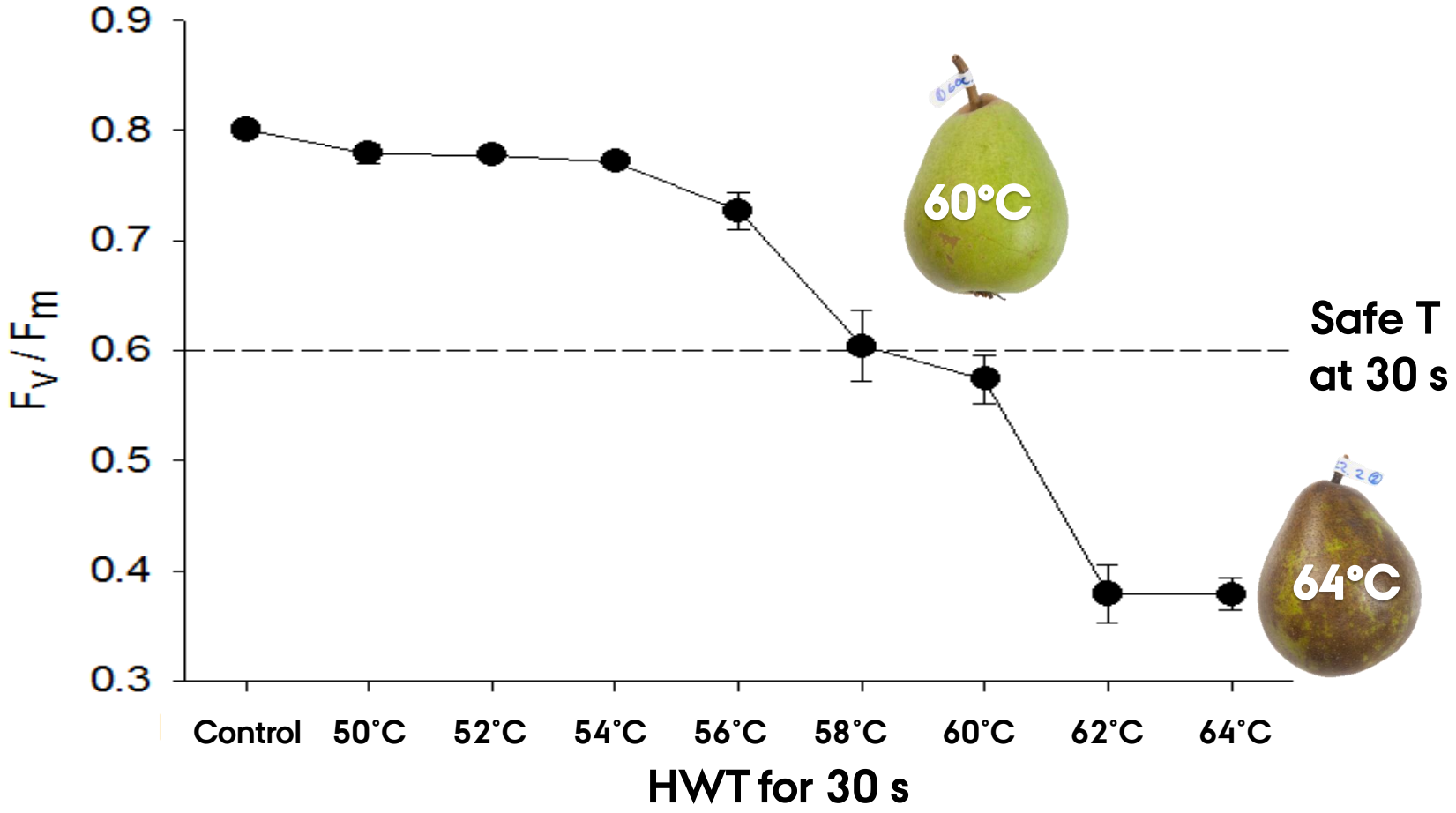




Marianne G. Bertelsen, 2015

Effect of short time HWT on skin browning





Chlorophyll fluorescence

Future for hot water treatment

- Cheap, safe and eco-friendly
- HWT is more suitable for fruit than vegetables
- HWT can be used at harvest and or before packaging
- A strict control of temperature and time is a paramount
- HWT is a balance between mild stress and wounding
- HWT can be used alone or in combination with other techniques
- Improper HWT should be prevented – screening methods before treatment are needed
- A better understanding of the pathogen / tissue response to HWT would help further developments

Acknowledgements

Department of Food Science

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Thank you for your attention!

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