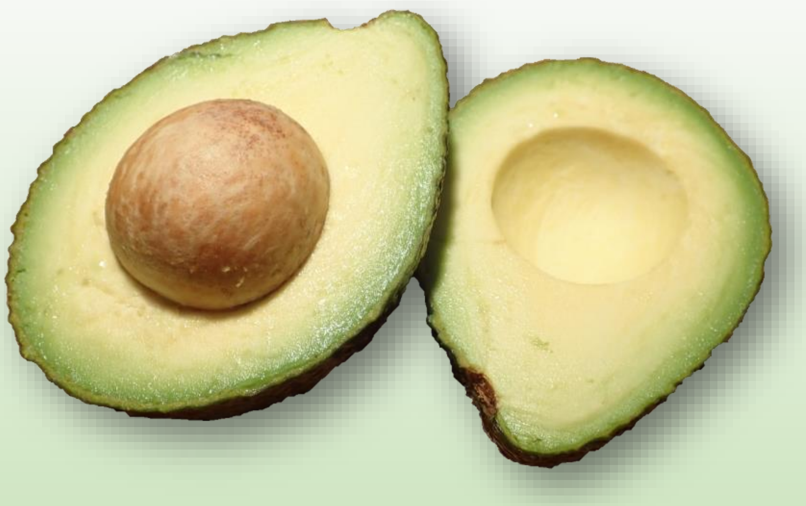
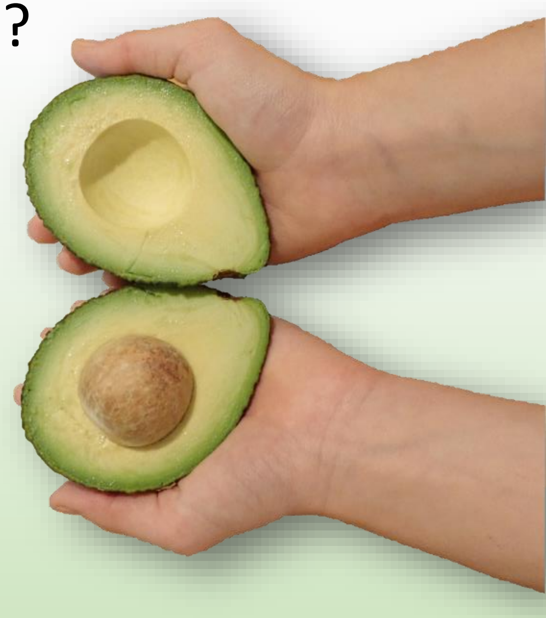
AV15009
Technologies and Practices to Reduce Bruising



Industry update
Avocados Australia Regional Meeting
Sunshine Coast, Queensland, 2 May 2018

Overview of presentation

- Background
- Project scope
- What is flesh bruising and how is it measured?
- What contributes to flesh bruising in avocado?
- Does impact injury also promote body rots?
- What can be done to reduce bruising?
- Spreading the message
- Where to next?
- Concluding remarks



Background

- Flesh bruising is responsible for around half of all avocado internal defects detected at the retail level[1]
- Defects affecting more than 10% of the flesh can negatively affect consumers' repeat purchasing[2]
- Handling by retailers and shoppers is the main cause of flesh bruising at retail[3]
- Post-purchase handling by consumers causes further bruising[3]

Bruising in 'Hass' fruit handled once by each of 20 different shoppers

1. Tyas, J. (2016). Avocado industry fruit quality benchmarking. Final report AV11015. Horticulture Innovation Australia, Sydney.
2. Harker, F.R.,et al. 2007. Australian consumers' perceptions and preferences for 'Hass' Avocado. Final report AV06025. Horticulture Australia Ltd, Sydney.
3. Joyce, D.C., M.S. Mazhar, and P.J. Hofman (2015). Understanding and managing avocado flesh bruising. Final report AV12009. Horticulture Australia Limited, Sydney, Australia.

Background

- 97% of Australian avocado consumers admit to squeezing fruit to test ripeness[1]
- Shoppers handle 3 times more avocados than they buy[2]
- Awareness of shoppers regarding their contribution to bruising seems to be increasing…

Five years ago…

42% of shoppers agreed that "bad" avocados have been handled or touched too much[1]

Now…

92% of shoppers know that squeezing avocados too hard causes bruising[3]

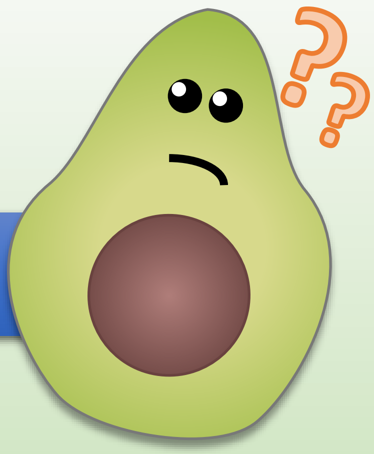
1. Jones, T. (2014). Project avocado education QN. Final report AV12035. Horticulture Australia Limited, Sydney.
2. Joyce, D.C., M.S. Mazhar, and P.J. Hofman (2015). Understanding and managing avocado flesh bruising. Final report AV12009. Horticulture Australia Limited, Sydney, Australia.
3. Quantum Market Research (2017). Avocado buyer segmentation. JN17051. Hort Innovation, Sydney.

Background

But inconsistent quality remains an issue…

- Around 1 in 5 avocados at retail level do not meet consumer expectations for quality[1]
- 45% of avocado shoppers at least sometimes felt dissatisfied with the quality once they had cut into an avocado at home[2]

What is the solution?



1. Tyas, J. (2016). Avocado industry fruit quality benchmarking. Final report AV11015. Horticulture Innovation Australia, Sydney.
2. Quantum Market Research (2017). Avocado buyer segmentation. JN17051. Hort Innovation, Sydney.

Scope of project AV15009

Objectives:

- To qualify influences and interactions that cause and contribute to flesh bruising
- To qualify, develop and promote tools and technologies for reducing flesh bruising at retail

Activity areas:

- Review contributing factors to fruit **susceptibility to bruising** to identify gaps in research
- Review relationships between **disease and flesh bruising** to identify gaps in research
- Document **best practice** to prevent fruit bruising at retail for implementation in retail education
- Develop and test **alternative technologies** that reduce handling by retailers / consumers

AV15009 project team

Daryl Joyce (QDAF)
Project Leader

Project Team Members

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Lindy Coates (QDAF)

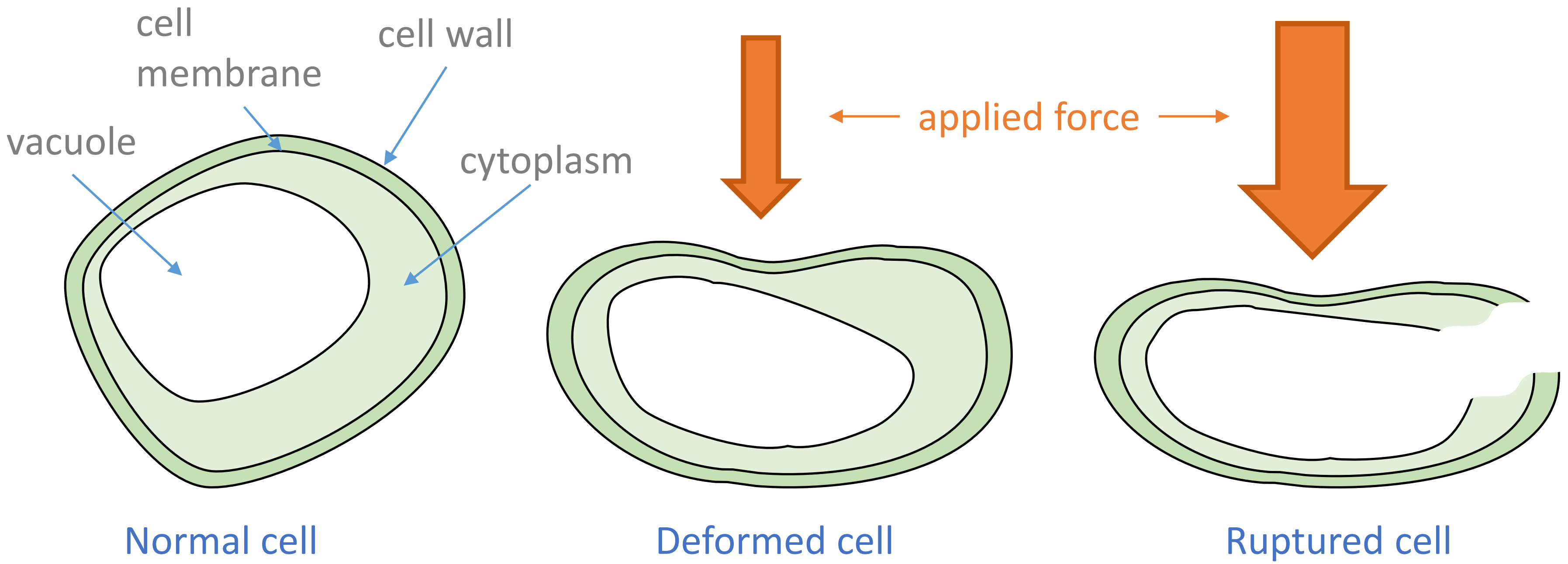
Peter Hofman (QDAF)

Sohail Mazhar (UQ)

Melinda Perkins (UQ)

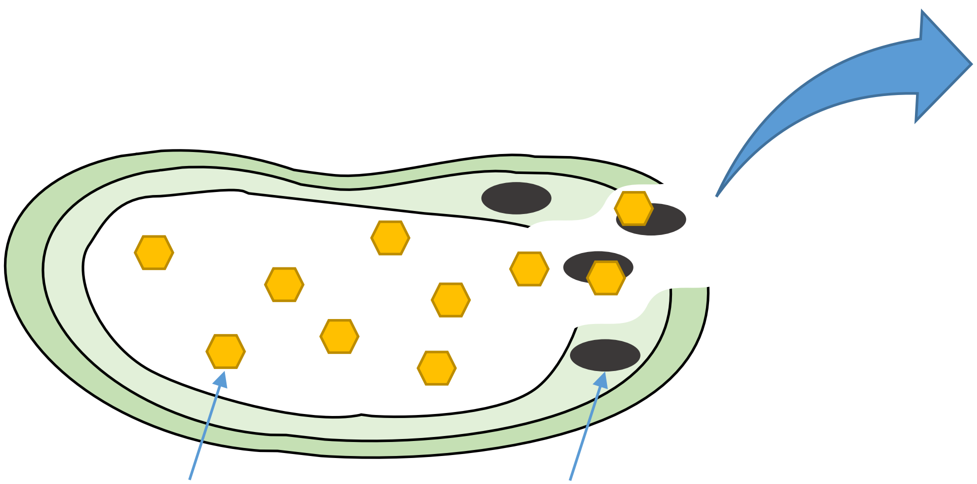
What is flesh bruising?

The bruising process at a cellular level…

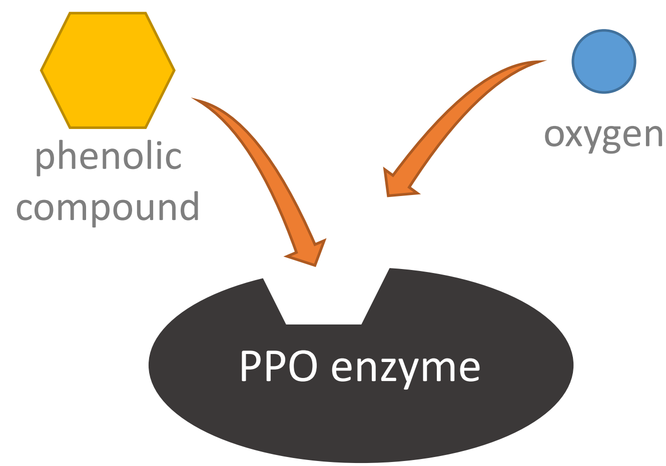


What is flesh bruising?

Cell damage brings together browning enzymes and their substrates…



In the presence of oxygen, dark pigments are formed…



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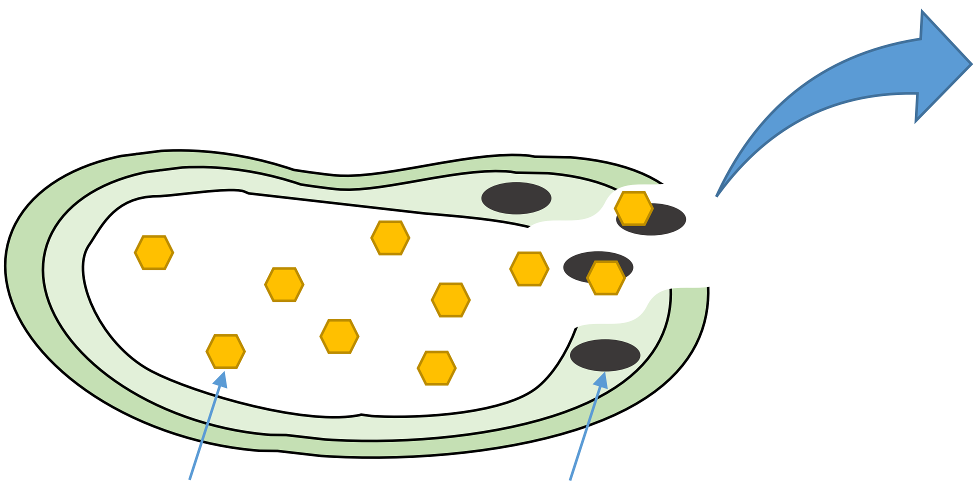
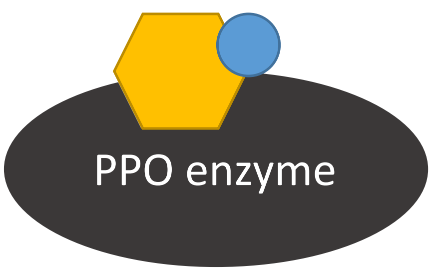


In the presence of oxygen, dark pigments are formed…

Substrate
Phenolic compounds

Enzyme
Polyphenol oxidase (PPO)



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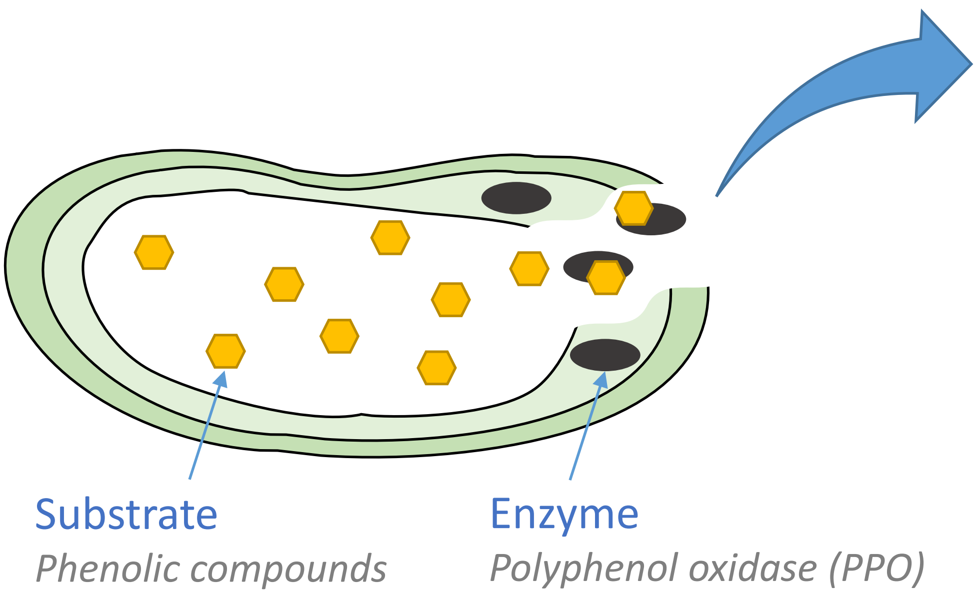

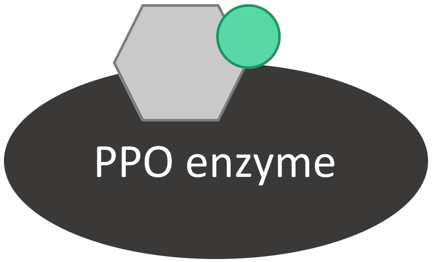

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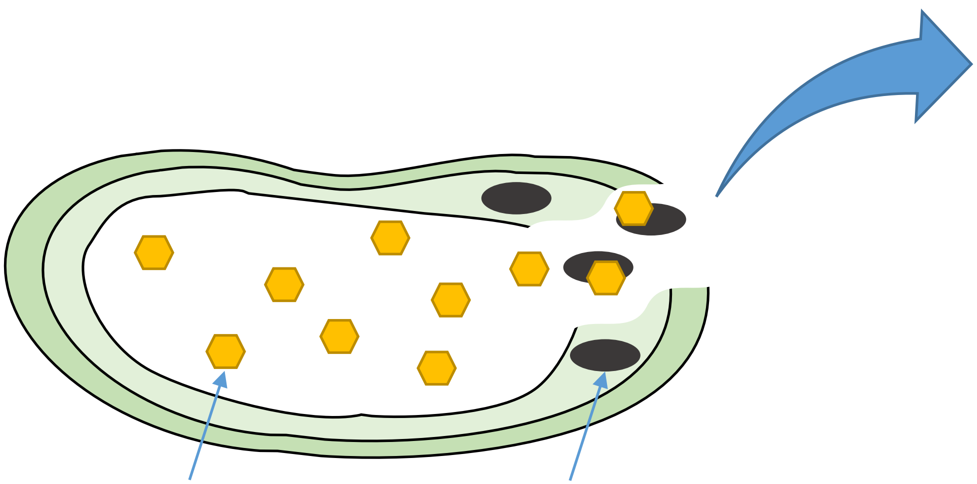

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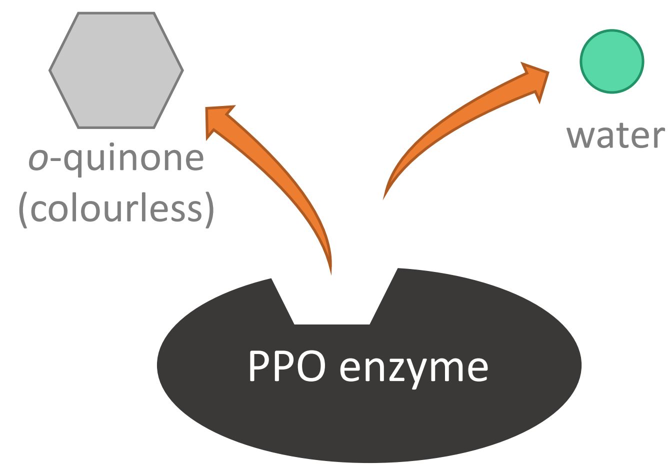

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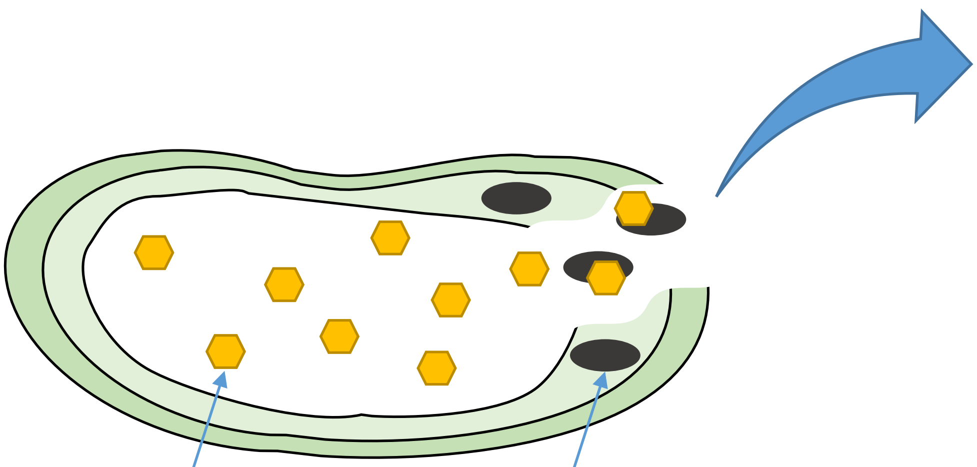

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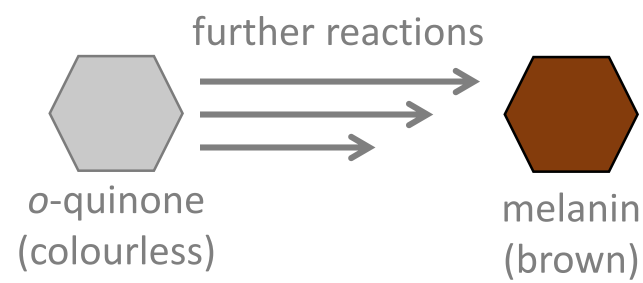
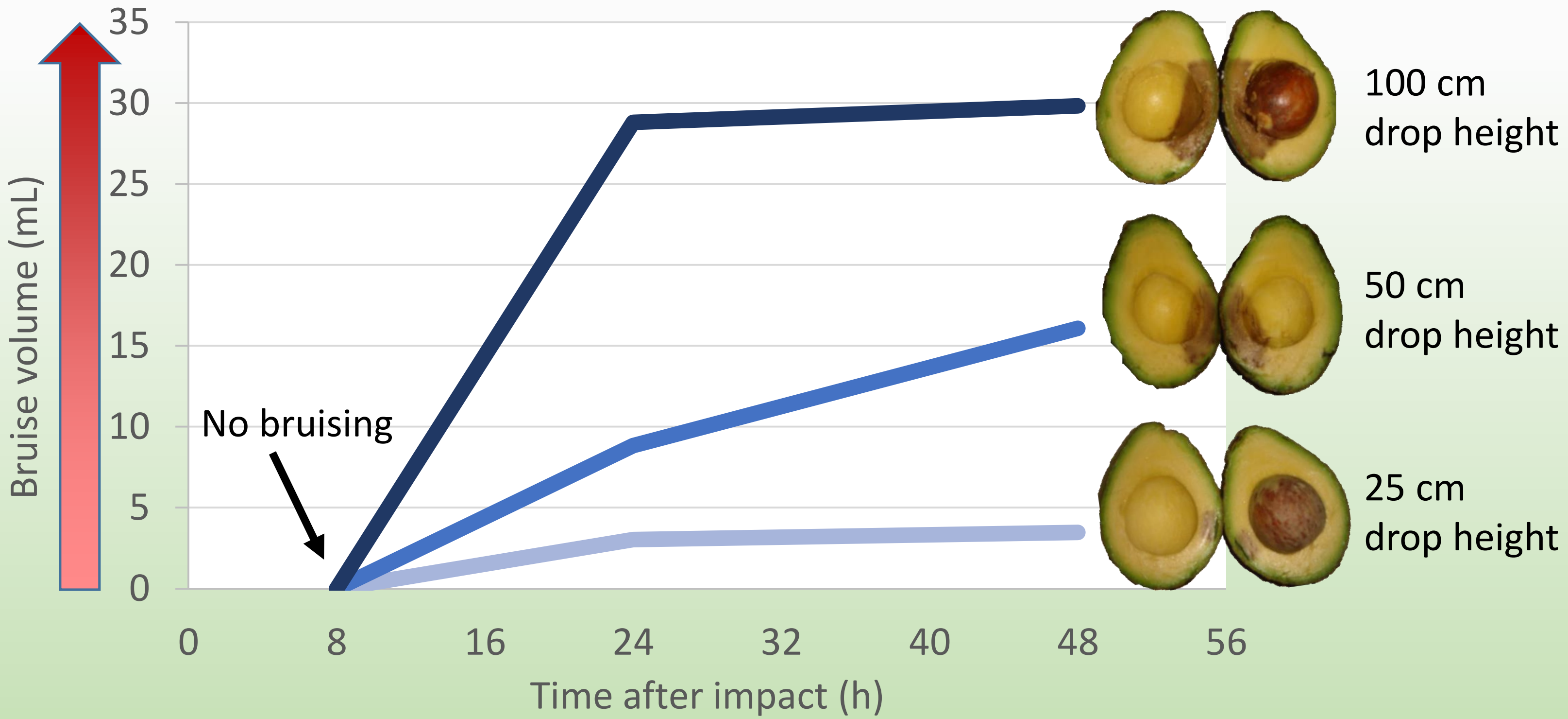


What is flesh bruising?

- Rate of browning also depends on temperature and pH
- At 20°C, visible bruising can take 24 hours to develop



How is flesh bruising measured?

Bruise incidence

- Number of bruised fruit in a given sample (e.g. tray) of fruit

Often expressed as a percentage of the total number of fruit

3 out of 10 = 30% incidence

OR…

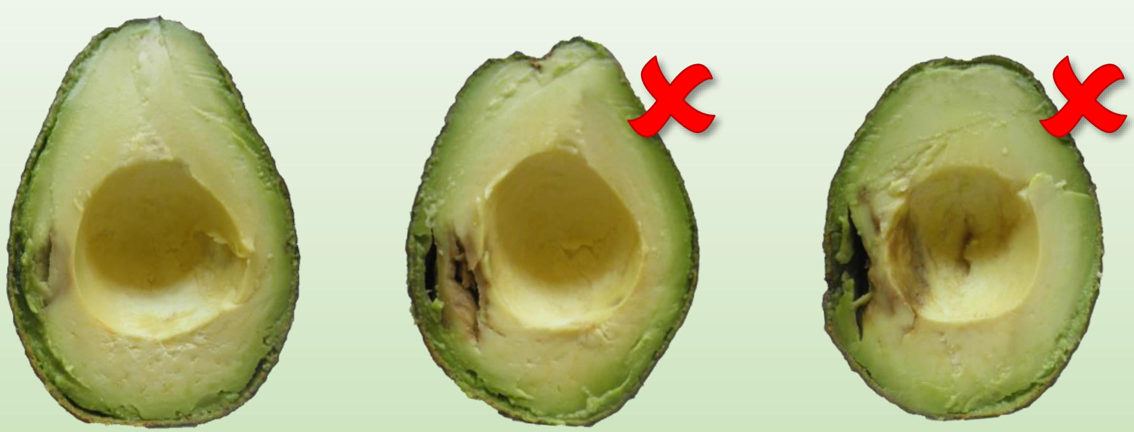
- Number of bruises on an individual fruit

1 2 3

How is flesh bruising measured?

Bruise severity

- Volume or area of bruised flesh in individual fruit
- May be converted to a percentage of the total fruit flesh volume or area of cut surface
- 10% bruise area is generally considered unacceptable to consumers



5% 10% 15%

How is flesh bruising measured?

Bruise intensity

- Relative darkness of a bruise

  Can be scored visually (e.g. light brown to black) or measured with a colour meter

Bruise susceptibility

- Degree of ease or difficulty by which a fruit bruises

  Expressed as ratio of bruise volume to impact energy

Using a colour meter to measure bruise intensity

What contributes to flesh bruising in avocado?

Bruise susceptibility

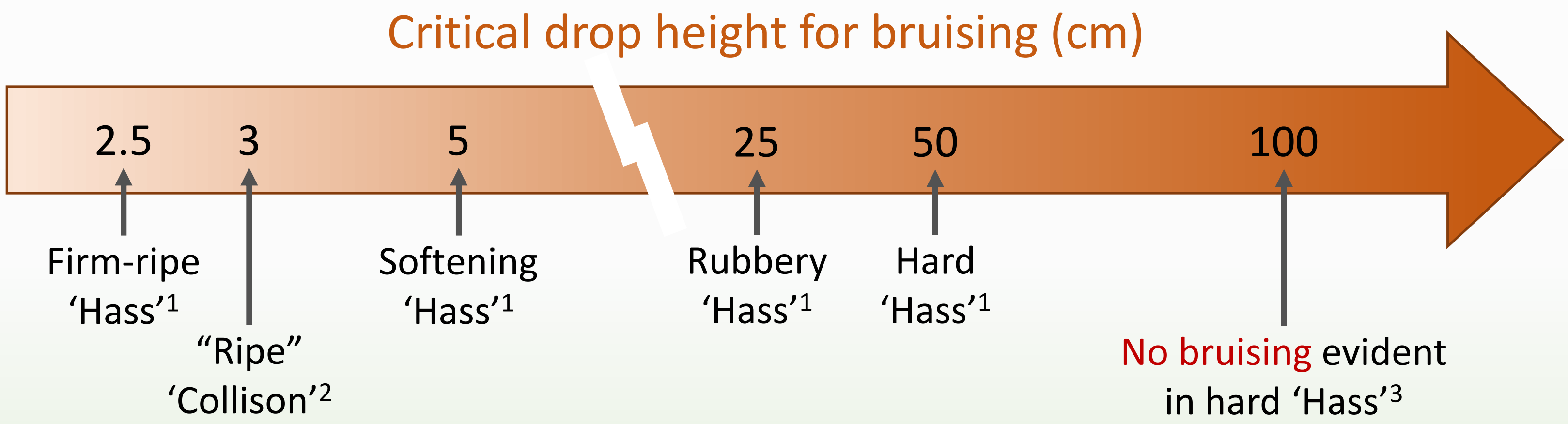
- Firmness
- Dry matter
- Temperature
- Time in system

Exposure to injury

- Impact (dropping)
- Compression (squeezing)
- Vibration

What contributes to flesh bruising in avocado?

- Firmness



- Dry matter

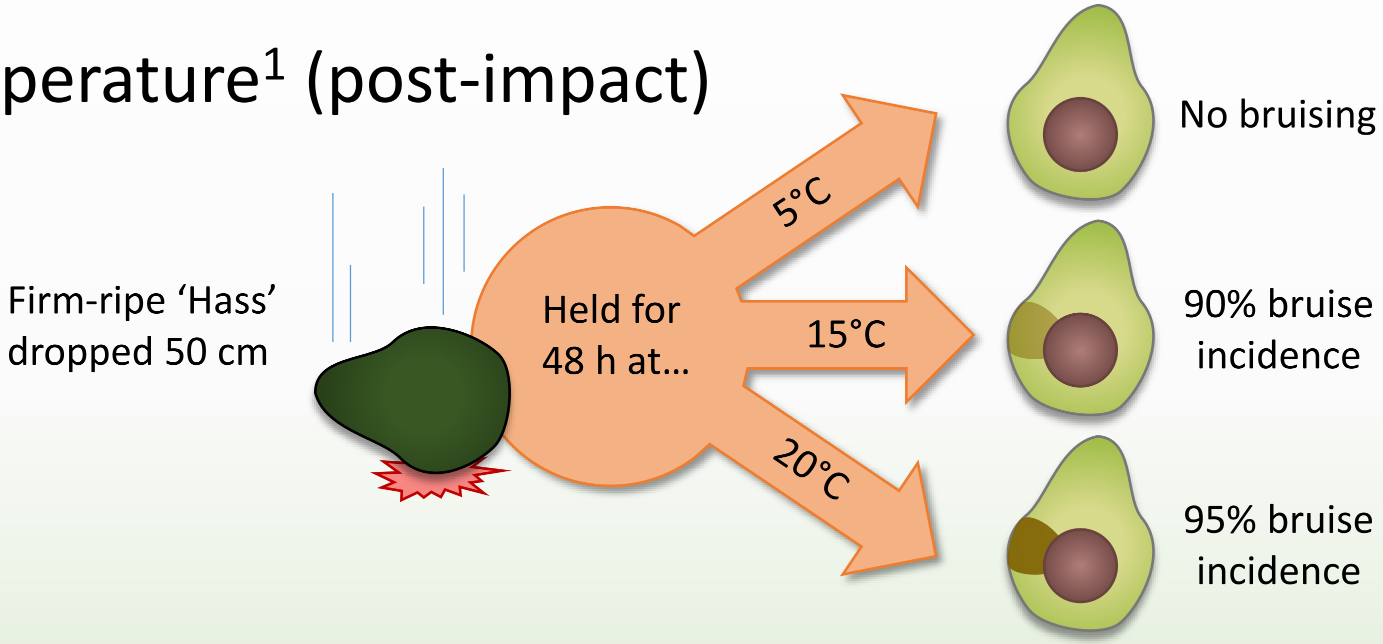
  ↑ dry matter = ↓ bruise susceptibility in firm-ripe 'Hass' avocados subjected to a 50 cm drop height[4]

  Bruise volume progressively decreased as dry matter increased from 22 to 33%

1. Ledger, S.N., Barker, L.R., 1995. Black avocados - the inside story, Australian Avocado Growers Federation Conference - The Way Ahead, pp. 71-77.
2. Baryeh, E.A., 2000. Strength properties of avocado pear. Journal of Agricultural Engineering Research 76, 389-397.
3. Mazhar, M., et al. (2015). Non-destructive 1H-MRI assessment of flesh bruising in avocado (*Persea americana* M.) cv. Hass. Postharvest Biology and Technology 100, 33-40.
4. Joyce, D.C., et al., 2015. Reducing flesh bruising and skin spotting in 'Hass' avocado. Final report AV10019. Horticulture Australia Ltd, Sydney.

What contributes to flesh bruising in avocado?

- Temperature[1] (post-impact)



20°C > 15°C for bruise intensity

- Time in system[1]

Storage at 5°C for 1 to 5 weeks prior to ripening increased bruise susceptibility of firm-ripe 'Hass' fruit *(vs fruit not stored)*

↑ storage duration = ↑ bruise volume

1. Joyce, D.C., et al., 2015. Reducing flesh bruising and skin spotting in 'Hass' avocado. Final report AV10019. Horticulture Australia Ltd, Sydney.

What contributes to flesh bruising in avocado?

Other factors likely to be involved

- Pre-harvest water stress

  Increases PPO activity in avocado fruit at "eating ripeness"[1]

- High turgor pressure at harvest

  Causes greater lenticel damage in avocado fruit[2]

  Linked to increased bruise susceptibility in apple and pear[3]

- Mineral nutrient balance

  Calcium is important for cell wall strength and membrane stability

  Low calcium and/or high nitrogen in avocado fruit → poor quality

  ↑ body rots[4,5], vascular browning[6,7] and mesocarp discolouration[4,6]

  ↓ firmness after storage[8] and time to ripening[4]

1. Bower, J.P., et al., 1989. Effect of pre- and post-harvest water stress on the potential for fruit quality defects in avocado (*Persea americana* Mill.). South African Journal of Plant and Soil 6, 219-222.
2. Everett, K.R., et al., 2008. Avocado lenticel damage: The cause and the effect on fruit quality. Postharvest Biology and Technology 48, 383-390.
3. Garcia, J.L., et al., 1995. Factors influencing mechanical properties and bruise susceptibility of apples and pears. Journal of Agricultural Engineering Research 61, 11-17.
4. Hofman, P.J., et al., 2002. Tree yield and fruit minerals concentrations influence 'Hass' avocado fruit quality. Scientia Horticulturae 92, 113-123.
5. Everett, K.R., et al., 2007. Calcium, fungicide sprays and canopy density influence postharvest rots of avocado. Australasian Plant Pathology 36, 22-31.
6. Marques, J.R., et al., 2003. Rootstocks influence 'Hass' avocado fruit quality and fruit minerals. Journal of Horticultural Science & Biotechnology 78, 673-679.
7. Thorp, T., et al., 1997. Survey of fruit mineral concentrations and postharvest quality of New Zealand-grown 'Hass' avocado (*Persea americana* Mill.). NZ J Crop Hort Sci 25, 251-260.
8. Defilippi, B.G., et al., 2015. Preharvest factors influencing 'Hass' avocado (*Persea americana* Mill.) quality during long term storage. Acta Horticulturae 1071, 137-141.

What contributes to flesh bruising in avocado?

Other factors likely to be involved

- Cultivar

  'Fuerte' > 'Lerman' for total phenolic content and PPO activity[1,2]

  'Hass' > 'Shepard' for peel phenolic concentrations and diversity[3]

- Rootstock

  'Velvick' > 'Duke 6', 'Duke7' or 'Reed' for fruit calcium concentration and quality, when grafted with 'Hass' scion[4-6]

1. Golan, A., et al., 1977. Relationship between polyphenols and browning in avocado mesocarp. Comparison between the Fuerte and Lerman cultivars. Journal of Agricultural and Food Chemistry 25, 1253-1260.
2. Kahn, V., 1975. Polyphenol oxidase activity and browning of three avocado varieties. Journal of the Science of Food and Agriculture 26, 1319-1324.
3. Kosinska, A., et al., 2012. Phenolic compound profiles and antioxidant capacity of *Persea americana* Mill. peels and seeds of two varieties. Journal of Agricultural and Food Chemistry 60, 4613-4619.
4. Coates, L.M., et al., 2011. Effects of rootstock on avocado fruit quality – assessment of postharvest disease, major cations and biochemical traits. Proceedings of the 7th World Avocado Congress, 2011. Cairns, QLD, Australia, 206-214.
5. Marques, J.R., et al., 2003. Rootstocks influence 'Hass' avocado fruit quality and fruit minerals. Journal of Horticultural Science & Biotechnology 78, 673-679.
6. Willingham, S.L., et al., 2006. Effects of rootstock and nitrogen fertiliser on postharvest anthracnose development in Hass avocado. Australasian Plant Pathology 35, 619-629.

Does impact injury also promote body rots?

- Freshly harvested fruit generally do not bruise if dropped
- But… *they appear to be more prone to body rots upon ripening!*
- 30 cm drop height at harvest caused ↑ body rots at soft-ripe stage *(versus no impact at harvest)*
- Response was consistent for 'Hass' fruit harvested from two orchards in different seasons

Impact from 30 cm drop height

No impact

What can be done to reduce bruising?

- Improve fruit robustness
  - Harvest when dry matter is above 23%
  - Pass fruit through the supply chain as quickly as possible
  - Hold ripened fruit at 5°C
  - Ensure that trees receive adequate water
  - Avoid harvesting fruit when wet
  - Select cultivars that produce fruit with low browning potential
  - Select rootstock cultivars that promote Ca accumulation in fruit

More evidence needed

What can be done to reduce bruising?

- Limit exposure to injury
  - Keep drop heights below 15 cm for hard green mature fruit *(to reduce body rots upon ripening)*
  - Keep drop heights below 10 cm for softening fruit
  - Handle fruit carefully without dropping or excessive squeezing from firm-ripe stage onwards
  - Train retail staff in appropriate handling techniques
  - Arrange retail displays into ripeness categories
  - Provide point of sale information on fruit selection for ripeness
  - Provide shoppers with 'pre-pack' options
  - Inform consumers of appropriate in-home handling and storage techniques

More evidence needed

What can be done to reduce bruising?

- Non-bruising devices for in-store firmness assessment

** $P < 0.01$

Spreading the message

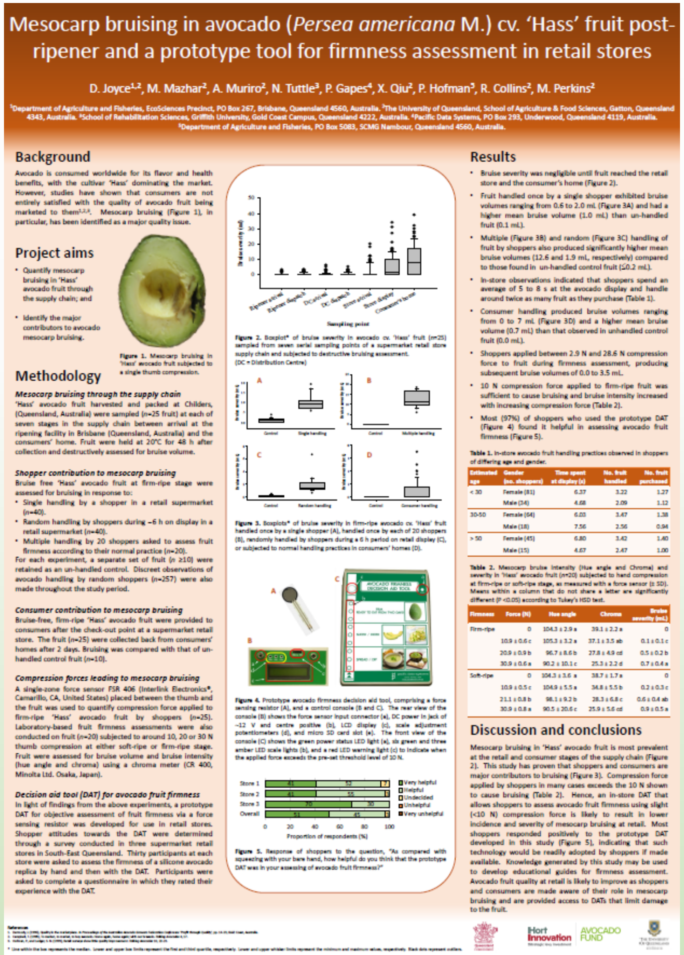
- Articles in *Talking Avocados*
  - New Hort Innovation project to combat flesh bruising in avocado
    Summer 2017 edition
  - Factors affecting avocado flesh bruising susceptibility
    Winter 2017 edition, http://www.avocado.org.au/public-articles/tav28n2_bruising/
  - Best practice handling to reduce flesh bruising
    Summer 2018 edition, http://www.avocado.org.au/public-articles/tav28n4_bruising/
  - Does impact injury at harvest increase body rots at retail?
    Autumn 2018 edition
- Meetings and workshop
  - Avocados Australia 2018 Regional Meetings - Queensland
    Crows Nest, Sunshine Coast, Childers & Mareeba (1 May – 7 June)
  - AV15009 Stakeholder Knowledge Sharing Workshop
    Brisbane Markets (15 May 2018)

Spreading the message

- Poster presentation at TropAg2017 Conference

  *Shopper and consumer contribution to mesocarp bruising in avocado (*Persea americana* M.) cv. 'Hass' fruit and a prototype decision aid tool for in-store firmness assessment*

  - Brisbane, 20-22 November
  - Conference attendance: 720 delegates from 46 countries



- YouTube video

  In production, due for release mid-2018

Where to next?

- Current project (June – October 2018)
  - Monitor fruit quality through two prominent supply chains

Queensland → Victoria *Western Australia → Victoria*

- Simulate supply chain conditions in the laboratory

best practice vs poor practice → final fruit quality

Where to next?

- Concept note submitted to Hort Innovation for future research into:
  - Orchard management practices for effects on bruise susceptibility and postharvest disease expression in ripe fruit at retail level
  - Development of decision aid tools to optimize orchard management and fruit robustness from farm to consumer

There is currently no published research on avocado bruise susceptibility in response to tree vigour, crop load and nutrition!

Concluding remarks

Based on current knowledge, there are changes in harvesting and handling practices that can be made now to reduce flesh bruising

- Harvest above 23% dry matter and when fruit are not wet
- Minimise drop heights – handle ripe fruit “like eggs”
- Maintain fruit temperature of 5°C (except when ripening)
- Pass fruit through the supply chain as quickly as possible

But…

There are many other factors likely to affect flesh bruising at retail

We need to confirm and quantify their contribution…

…and estimate the economic consequences to industry!

Acknowledgements

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The Project Team also wishes to acknowledge the contributions made by Murray Brothers, Farmgate 1411, Redbank Plantation, Brett Jahnke and technical staff and students of the UQ School of Agriculture and Food Sciences.