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\(^3\)

Background

• 97% of Australian avocado consumers admit to squeezing fruit to test ripeness\(^1\)

• Shoppers handle \textbf{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\(^3\)

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\(^2\)

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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

Noel Ainsworth (QDAF)
Lindy Coates (QDAF)
Peter Hofman (QDAF)
Sohail Mazhar (UQ)
Melinda Perkins (UQ)
What is flesh bruising?

The bruising process at a cellular level...

- Normal cell
- Deformed cell
- Ruptured cell
What is flesh bruising?

Cell damage brings together browning enzymes and their substrates...

In the presence of oxygen, dark pigments are formed...

- **Substrate**: Phenolic compounds
- **Enzyme**: Polyphenol oxidase (PPO)
- **Oxygen**
What is flesh bruising?

Cell damage brings together browning enzymes and their substrates...

In the presence of oxygen, dark pigments are formed...

Substrate
*Phenolic compounds*

Enzyme
*Polyphenol oxidase (PPO)*

PPO enzyme
What is flesh bruising?

Cell damage brings together browning enzymes and their substrates...

In the presence of oxygen, dark pigments are formed...

Substrate
Phenolic compounds

Enzyme
Polyphenol oxidase (PPO)

PPO enzyme
What is flesh bruising?

Cell damage brings together browning enzymes and their substrates...

In the presence of oxygen, dark pigments are formed...

**Substrate**
Phenolic compounds

**Enzyme**
*Polyphenol oxidase (PPO)*

**o-quinone (colourless)**

**water**

**PPO enzyme**
What is flesh bruising?

Cell damage brings together browning enzymes and their substrates...

In the presence of oxygen, dark pigments are formed...

**Substrate**
- Phenolic compounds

**Enzyme**
- Polyphenol oxidase (PPO)

Further reactions:
- o-quinone (colourless)
- melanin (brown)
What is flesh bruising?

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

![Graph showing bruise volume over time for different drop heights](image)
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
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*
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**

  - Critical drop height for bruising (cm)

<table>
<thead>
<tr>
<th>Firm-ripe ‘Hass’(^1)</th>
<th>“Ripe” ‘Collison’(^2)</th>
<th>Softening ‘Hass’(^1)</th>
<th>Rubbery ‘Hass’(^1)</th>
<th>Hard ‘Hass’(^1)</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>3</td>
<td>5</td>
<td>25</td>
<td>50</td>
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- **Dry matter**

  \[\uparrow\text{dry matter} = \downarrow\text{bruise susceptibility in firm-ripe ‘Hass’ avocados subjected to a 50 cm drop height}\]^4

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

What contributes to flesh bruising in avocado?

• **Temperature**¹ (post-impact)

  - Firm-ripe ‘Hass’ dropped 50 cm
  - Held for 48 h at...

  - 5°C: No bruising
  - 15°C: 90% bruise incidence
  - 20°C: 95% bruise incidence

  - **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

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\(^4\)

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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\(^4-6\)

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
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
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
  
  • Best practice handling to reduce flesh 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*

  - Apply controlled impact treatment to fruit
  - Compare bruising and body rots in impacted and non-impacted fruit
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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