

AVOCADO FRUIT QUALITY **Problem Solver**





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Guide by Applied Horticultural Research

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01. Introduction

This guide is designed to be used in conjunction with the *Avocado supply chain best practice* guide. It outlines the major fruit quality issues that can occur as avocados travel through the supply chain. The focus is on postharvest issues, so it does not include external defects from the field that would normally be graded out during packing.

Defects are grouped as internal, external or related to ripening and storage. For each quality issue the symptoms, causes and possible remedies are briefly described. More detailed information on issues such as rots, chilling damage and ripening can be found in the best practice guide, the online *Avocados Australia Best Practice Resource (BPR)*  and the pre and postharvest management of avocados review.

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02. Internal Defects

2.1 BRUISING

What is it?

Dark brown to black areas in the flesh. Compared to rots, bruises usually have a rather diffuse margin. They are often associated with cracking and air cavities between the flesh and skin.

What causes it?

Hard green fruit are still susceptible to bruising. However, the damage is often not obvious until the fruit ripens and softens. Sources of bruises include:

- Rough handling at harvest e.g. dropping fruit straight to the bottom of bags attached to mechanical harvest platforms.
- Fruit bouncing or being compressed during transfer from orchard to packhouse.
- Impacts on the packing line.
- Dropping cartons / knocking pallets.

Severity of symptoms increase:

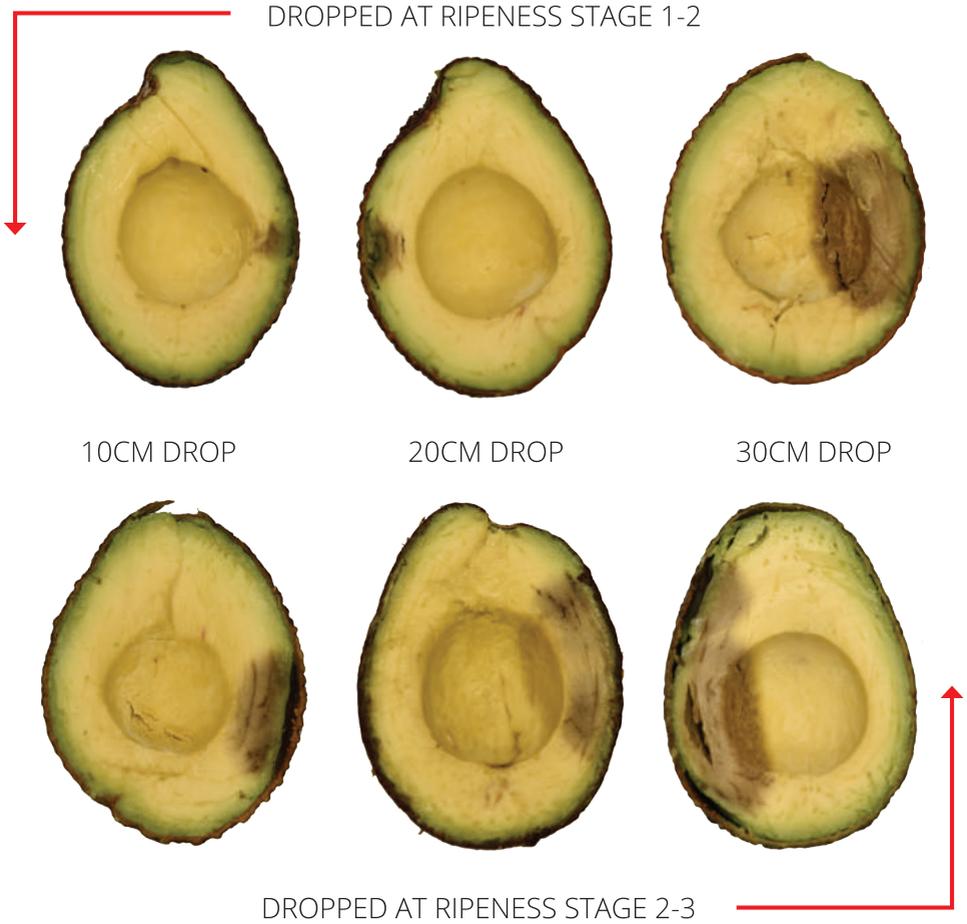
- With impact severity / drop height.
- As fruit ripen (softer fruit bruise more easily).
- At higher storage temperatures.
- Over time (symptoms continue to develop for >1 week post-bruising).



Sensitivity to bruising is highest at retail, where rough handling of ripe fruit by retail staff and squeezing by consumers can cause significant damage.

How can it be minimised or prevented?

- Train workers that ALL fruit drops should be minimised.
- Use rope extenders around picking bags to limit the height of fruit drops.



- Reduce fruit bouncing during transport to the packhouse by keeping access roads smooth, servicing suspension on trailers and limiting speed to 20kph.
- Use foam pads and baffles on the packing line to reduce the height of drops and the speed of direction changes. An impact recorder can be used to check for potential damage points (max G > 200).

- Use strong cartons, stabilise pallets and avoid condensation.
- Use suitable vehicles to transport ripening avocados.
- Maintain the cold chain through to retail display.
- Reduce consumer squeezing of fruit by segregating ripe and unripe fruit, and removing over-ripe fruit.



Pinkish spores of *Colletotrichum* sp. on the outside of an avocado, and a fruit cut open showing the underlying disease.



2.2 ROTS

Body rot - Anthracnose

(*Colletotrichum* sp.)

Defined brown or black areas on the skin.

As the rot develops, pale pinkish spores appear at the centre of the lesion.

The disease spreads from the skin into the flesh, appearing as brown, semi-circular lesions with defined margins. Diseased flesh may stick to the skin at the infection point.

Stem-end rot

(*Fusicoccum aesculi*, *Lasiodiplodia theobromae*, *Phomopsis perseae*, etc.)

The skin around the stem end of the fruit becomes blackened, especially as the fruit ripens. Internally, the disease spreads from the stem attachment through the flesh, often also resulting in vascular browning.



Early symptoms of stem-end rot in an unripe fruit, more advanced symptoms in a ripe fruit.





Clipping fruit at harvest can help reduce stem-end rots compared to plucking.

What causes it?

The fungal pathogens that cause postharvest disease occur naturally on avocado trees, especially in dead leaves and twigs and on rotting fruit. Initial infection can occur at any time during fruit development. For example, the fungus that causes anthracnose can directly penetrate the skin of fruit still attached to the tree, while pathogens causing stem-end rot can grow through the vascular system. Stem-end rots also often infect fruit through the fresh wound created at harvest.

Disease development is suppressed during fruit growth by anti-fungal dienes (produced within the avocado), which prevent spores germinating and/or growing. However, these decline after harvest and especially as fruit ripen, allowing pathogens to grow. Factors that increase infection include:

- Ineffective application of pre-harvest fungicides.
- Wet weather, especially at harvest.
- Poor field hygiene / canopy management.

- Inadequate crop nutrition.
- Low fruit calcium levels; >400mg/kg Ca is associated with reduced disease.
- Water stress, especially during the 3 months post-flowering.
- Inappropriate ripening conditions (e.g. >20°C).
- Impacts on green fruit (even if avocados are not bruised internally, dropped fruit may be more likely to develop rots).
- Lack of sanitiser in water dumps at bin tip.

How can it be minimised or prevented?

Orchard practices

- Apply protective copper fungicides every 2–4 weeks from fruit set to harvest, ensuring fruit is kept well covered as it expands.
- Apply strobilurin fungicides alternately with protective products. Use a maximum of 3 sprays per season, including one prior to harvest.
- Orchard hygiene – remove old fruit, dead twigs and branches.
- Prune and shape the tree canopy for good ventilation.
- Monitor nitrogen to calcium ratios in fruit – lower ratios will reduce risk of infection.

Harvest practices

- Harvest fruit once it has reached minimum maturity standards.
- Avoid harvesting wet fruit.

- Clip fruit at harvest, rather than simply plucking (stem-end rot only).
- Keep harvested fruit shaded, and deliver to the packhouse as soon as possible.

Postharvest management

- Apply a postharvest fungicide within 24 hours of harvest to control rots.
- Use sanitisers in water bin dumps.
- Remove field heat as soon as possible, especially if fruit are >30°C.
- If fruit cannot be packed and cooled within 24 hours of harvest, pre-cool fruit below 16°C within 6 hours and pack within 3 days.
- Keep fruit at the recommended storage temperature (5–7°C) through the cold chain.
- Do not exceed maximum recommended storage times before ripening.
- Ripen fruit at 16–18°C, maintaining air circulation through trays.
- After ripening, forced-air cool fruit to 5–7°C.
- Don't store ripe fruit, but minimise the interval between ripening and retail.

2.3 DIFFUSE DISCOLOURATION

What is it?

Diffuse areas of grey to brown flesh with poorly defined margins. Usually starts at the bottom of the fruit near the seed, spreading upwards and outwards. Sometimes associated with vascular browning.

What causes it?

Diffuse discoloration is a form of chilling injury. It is caused by a combination of long storage times and low temperatures. Sensitivity to chilling injury is highly variable. It is most likely if:

- Fruit are immature, or over-mature, at harvest.
- Fruit start to ripen during low temperature storage.
- Ripening is interrupted, with fruit cooled after ethylene has been applied but before fruit have softened.
- Green fruit are stored for >2 weeks at 5°C before ripening.
- Pre-conditioned / breaking (Stages 2-3) fruit are stored at <5°C for more than 3 days or at 5–8°C for more than 5 days.

How can it be minimised or prevented?

- Ensure fruit are stored at the temperature recommended for that variety.
- Maintain the cold chain; ripening can be triggered if fruit warm up during postharvest handling. This is especially important for late season fruit.
- Ensure fruit are not exposed to ethylene (>5ppm) during cold storage by:
 - Scrubbing the air using an ethylene absorbent filter or by reacting ethylene with ozone.
 - Venting the room.
 - Not storing avocados in the same room as ripening fruit.
- Check stored fruit every 1–2 days and remove if there are signs of ripening.
- Commence ripening within 2 weeks of harvest.



Normal (left); discoloured flesh (centre) and severe flesh discoloration (right), as well as rots and vascular browning, in a fruit damaged by low storage temperature.

2.4 VASCULAR BROWNING

What is it?

Browning of the vascular bundles that run through the avocado flesh.

What causes it?

Like stem-end rot, vascular browning can be caused by a number of different fungal pathogens. It is often associated with stem-end rots, in which case the symptoms can be severe and appear soon after harvest. Vascular browning can also be increased by:

- Extended storage before ripening, especially of late season fruit.
- Storage under conditions likely to cause chilling injury (e.g. 4 weeks at 4°C).
- Fruit starting to ripen during cold storage.
- Sun exposure, especially after harvest.
- Heat / cold events during development.
- Phytophthora infection of the tree.

How can it be minimised or prevented?

- Control stem-end rot organisms and Phytophthora through an effective fungicide program.
- Avoid harvesting wet fruit.
- Harvest fruit only once it has reached minimum maturity.
- Keep harvest bins shaded.
- Ensure fruit are stored at the temperature recommended for that variety.
- Do not exceed maximum recommended storage times before ripening.
- Check that ethylene in cold storage rooms is <5ppm.
- Check stored fruit every 1–2 days and remove if there are signs of ripening.



Early symptoms of vascular browning caused by a stem-end rot organism (left); slight (centre) and severe (right).

2.5 STONES IN THE FLESH

What is it?

Hard lumps or 'stones' form in the flesh adjacent to the skin. These 'stones', which can be up to 5mm diameter, usually stick to the skin when the avocado is peeled, but are not harmful if eaten. Dark spots or holes can also sometimes be seen on the outside of the fruit.

What causes it?

The stones are caused by insect damage. Most commonly, they are the result of feeding damage by the fruit-spotting bug (FSB) before harvest.

The stones are the fruit's natural defence response to insect damage (often referred to as stings). The avocado fruit reacts to injury by partitioning off the damaged part of the flesh, resulting in hard, spherical 'stones'.



'Stones' in the flesh adhere to the skin when the fruit ripens. Photo by DAF Queensland.

How can it be prevented or minimised?

- Control FSB (and other insect pests) in the orchard with an extensive management system – more details can be found in the NSW DPI Management Guide (available in the 'Library' section of the online *Avocados Australia BPR* ) .
- Stings can provide entry to infection by anthracnose, so control of FSB can also help to reduce body rots.

The effects of insect 'stings' are easily seen when fruit skin is peeled. Photo by C. Maddox, NSW DPI.







03. External Defects

3.1 LENTICEL DAMAGE

What is it?

Small brown or black spots on the skin, generally less than 3mm diameter. In Hass, these spots are mostly the broken tops of the nodules on the skin surface.

Symptoms are not usually evident at packing, but progress during storage as small injuries dry and blacken.

While lenticel damage can increase susceptibility to body rots, the symptoms are usually superficial. In Hass, lenticel damage becomes less obvious as fruit ripens.





Lenticel damage at retail

What causes it?

Lenticel damage is caused by abrasion during harvest and packing procedures. It can be caused by fruit rubbing against other fruit as well as by impacts with hard surfaces such as bins, rollers or stiff brushes. Damage is most likely if fruit are fully turgid and the skin is relatively soft, such as can occur after rain, irrigation or extended dampness due to condensation.

The symptoms can be exacerbated by postharvest moisture loss, which allows the necrotic area to continue to expand from the point of initial damage.

How can it be minimised or prevented?

- Avoid harvesting wet fruit.
- If possible, reduce irrigation prior to harvest.
- Train pickers – ALL fruit drops should be minimised.
- Reduce fruit movement during transport to the packhouse by keeping access roads smooth, servicing suspension on trailers and limiting speed to 20kph.
- If using a wet bin dump, ensure fruit moves through the water evenly, preferably less than 2 minutes.

- Adjust packing line speed and loading to ensure fruit do not rub against each other.
- Only brush fruit for long enough to remove dirt and residues, say 1 minute only.
 - Fruit should move through the brushes smoothly and without bumping.
 - Ensure brushes are soft and cleaned regularly.
- Pack trays and stack pallets tightly to avoid movement during transport.
- Maintain >85%RH during storage and ripening.

3.2 DISCRETE PATCHES

What is it?

Irregular black or brown patches on the skin with clearly defined edges. Although patches can be large, symptoms are superficial, not extending into the underlying flesh.

What causes it?

Discrete patches are usually the result of a combination of rough handling during harvest and/or packing and extended storage at low temperatures. Potential causes include:

- Drops >10cm during harvest.
- Rough handling during packing.
- Fruit starting to ripen during cold storage.
- Storage at temperatures below 3°C.
- Green fruit stored for 3–4 weeks at 5°C or >2 weeks at 4°C before ripening.

- Pre-conditioned / breaking (Stages 2-3) fruit stored at <5°C for more than 3 days or 5–8°C for more than 5 days.

How can it be minimised or prevented?

- Train staff – ALL fruit drops should be minimised.
- Adjust packing line speed and loading to ensure fruit do not rub against each other.
- Ensure ethylene in cold storage rooms is <5ppm.
- Store fruit at recommended temperatures.
- Do not exceed maximum recommended storage times before ripening.





04. Ripening and Storage

4.1 UNEVEN RIPENING

What is it?

Fruit ripening and colour development (Hass only) is uneven within trays, between trays on a single pallet, or between different pallets from the same batch.

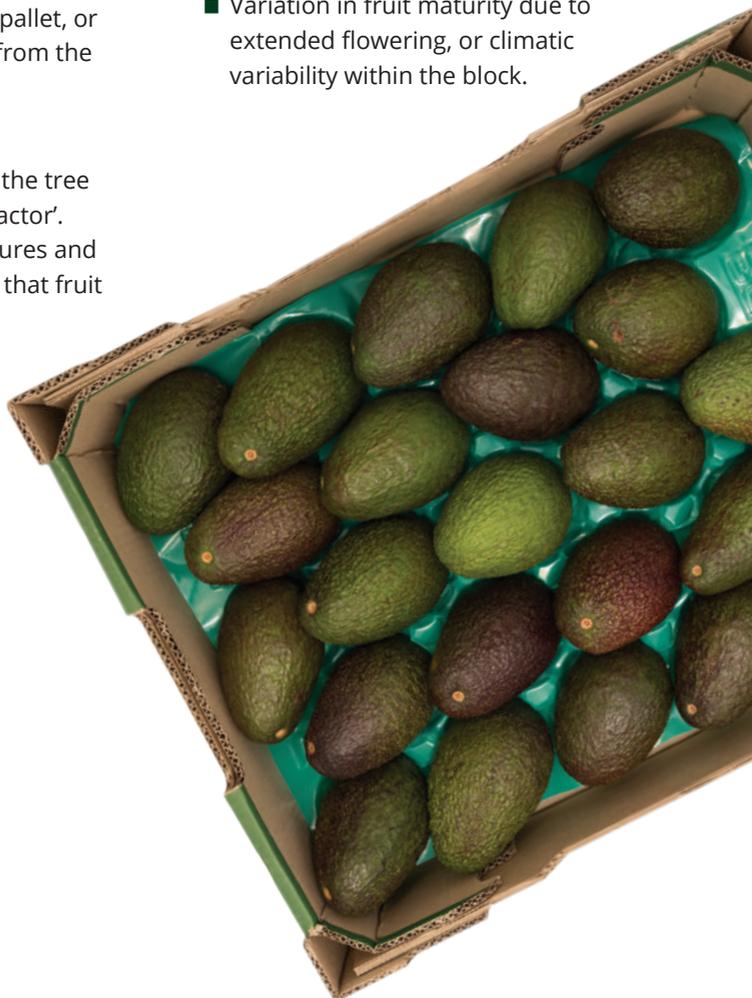
What causes it?

Avocados do not ripen on the tree due to an unknown 'tree factor'. Levels decline as fruit matures and after harvest. It is thought that fruit

only ripens once the 'tree factor' has declined to a critical level.

Factors causing uneven ripening therefore include:

- Variation in fruit maturity due to extended flowering, or climatic variability within the block.





- Variable temperatures from harvest to packing; fruit that stays warm after harvest (e.g. at the centre of a bin) will ripen more quickly than fruit that has been cooled rapidly.
- Variation in temperature after packing due to insufficient airflow through pallets, during either cooling or transport.
- Differences in fruit age, where fruit from a block has been harvested over several days, but packed on one day.
- Ripening without added ethylene, especially low maturity fruit.

How can it be minimised or prevented?

- Avoid mixing batches of fruit from different blocks/orchards/pick dates.
- Avoid temperature gradients before and after packing by ensuring there is good airflow around fruit and using forced-air systems wherever possible.
- Maintain effective ripening conditions, including:
 - 10ppm ethylene continuously or shot injection of 100ppm.
 - High relative humidity (85–95%).
 - Rapid warm up and cool down using forced-air.
 - Good airflow within pallets.

4.2 FLESH ADHERING TO SEED

What is it?

Sections of the flesh fail to ripen, and flesh sticks to the seed when cut.

What causes it?

The causes of uneven ripening within the fruit are unclear. It is most likely to occur in less mature fruit. Other contributing factors are believed to include:

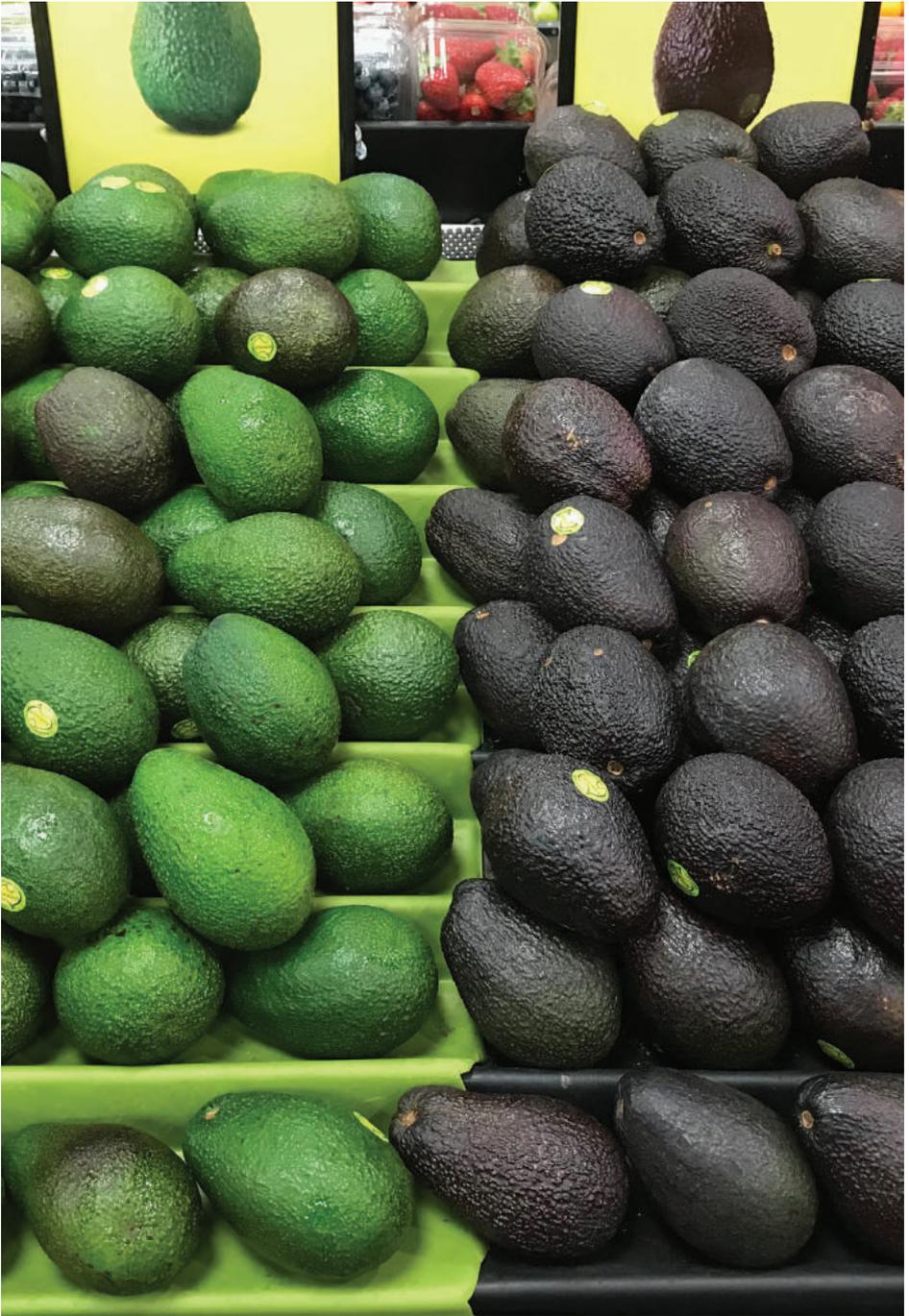
- Poor ripening practices, such as holding fruit at high temperatures (>20°C).
- Incorrect storage procedures.

How can it be prevented or minimised?

- Follow best practice ripening and storage procedures.
- Harvest only once minimum dry matter standards have been reached.



Uneven ripening, with flesh adhering to the seed. Photo by DAF Queensland.



4.3 SLOW RIPENING

What is it?

Fruit takes more than 7 days to move from 'hard green' to 'breaking' (stage 1 to 3).

What causes it?

- Fruit are immature.
- Ripening is attempted too soon after harvest; avocados are unresponsive to ethylene for 2-3 days after picking, regardless of temperature. This is due to inhibition by the 'tree factor'. The inhibition period is longest in less mature fruit.
- Ripening room temperature too low (e.g. $<16^{\circ}\text{C}$).
- Carbon dioxide is accumulating inside the ripening room; levels $>1\%$ reduce the rate of ripening.
- Faulty ethylene addition – empty gas bottle, tube blocked.

How can it be minimised or prevented?

- Check fruit maturity. Dry matter should be above 21% for green skins and 23% for Hass.
- Check room temperature and calibration.
- Ensure carbon dioxide is being vented and ethylene is $>10\text{ppm}$.



4.4 PREMATURE RIPENING

What is it?

Fruit starts to ripen during holding or storage.

What causes it?

- Excessive delay before pre-cooling, especially if fruit is very mature.
- Limited air flow through the pallet, resulting in uneven temperatures.
- Poor temperature management during transport.
- High (>5ppm) levels of ethylene in the storage environment, especially if temperatures are >5°C.

How can it be minimised or prevented?

Good temperature management is key to preventing premature ripening.

- Cool fruit to 5–7°C within 24 hours of harvest. Forced-air systems can ensure cooling is rapid and even.
- Don't rely on measuring air temperature only, but check the temperature of the fruit pulp.
- Maintain fruit at 5–7°C during transport and storage.



4.5 POOR SKIN COLOUR (HASS)

What is it?

The fruit starts to soften without the skin darkening.

What causes it?

- Fruit picked early in the season with low or minimum dry matter.
- Low ripening temperatures.

How can it be minimised or prevented?

- Ensure fruit has reached minimum dry matter before harvest.
- Early season fruit should be ripened at 18–20°C.





4.6 INSUFFICIENT SALEABLE LIFE AT RETAIL

What is it?

Fruit quickly becomes over-ripe at retail.

What causes it?

- Fruit has been stored too long before ripening (e.g. >2 weeks from harvest).
- Fruit was ripened at temperatures above 20°C.
- Ripe fruit was not cooled on removal, but remained warm during storage and transport.

How can it be minimised or prevented?

- Forced-air cool fruit once ripe.
- Keep ripe fruit refrigerated until ready for retail display.
- Minimise the delay between completion of ripening and retail sale – this should ideally be less than 5 days.
- Do not display avocados in a hot or sunny location; keep cool and shaded.
- Rotate stock, placing older and/or riper fruit on retail display first.
- Size retail displays appropriately, so that stock is replenished from the cool room every day.

4.7 POOR FLAVOUR

Watery flavour can occur in immature fruit that were harvested with low fruit dry matter and oil content.

Harvest only once dry matter standards have been reached.

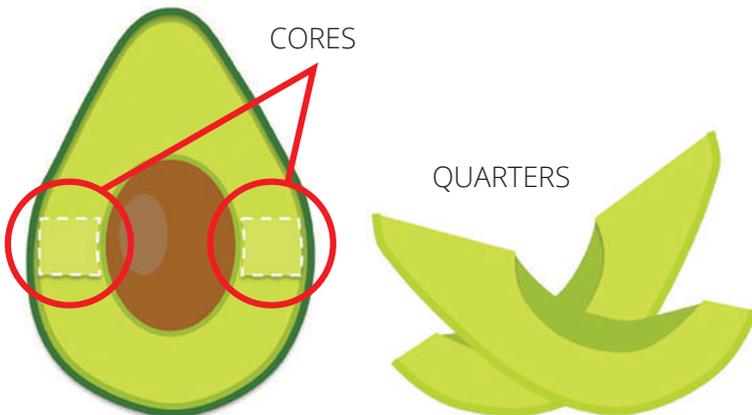
How to measure dry matter

There are two short videos on how to measure dry matter using either the coring method (Hofshi) or the grated flesh method. To view the videos, visit the 'Packhouse' section of the online *Avocados Australia BPR* .

Follow these steps to measure dry matter:

- 1 Peel sections of skin off the 10 fruit.
- 2 Coring method: Take core plugs (minimum 16mm diameter), remove any seed coat (refer to diagram).
- 3 Grated flesh method: Cut quarter sections of flesh from either side of
 - 4 the fruit and remove any seed coat. Shred the quarter sections by hand or using a food processor.
 - 4 Record the exact fresh weight of approx. 100g of shredded flesh or the 20 core sections using an electronic kitchen balance.
 - 5 Dry the sample using a food dehydrator (60-65°C, 24h), oven (100-110°C, 5h), or microwave set on low power. If using a microwave, check the sample regularly to make sure it does not burn.
 - Re-weigh
 - Continue drying
 - Repeat until there is negligible weight change
 - 6 Calculate dry matter = (final weight / start weight) x 100.

Note: steps 4-6 can be automated using a moisture determination balance.



Dry matter can be measured using either fruit cores or grated quarter sections



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