'Cripps' Pink' Best Practice

1. Correct harvest maturity (for long term storage)

- Starch breakdown: optimum 20-30% and < 40%. Can be released at 15%, depending on other parameters.
- Firmness: > 7.8 kg (11.1 mm tip) as they have to arrive in UK at 6.8 kg.
- Total soluble solids (TSS): advisable to be above 12.5% (13% at receival)
- Titratable acidity: 0.75 – 0.55%

NOTE: Maturity is the biggest factor in diffuse browning development. Post-optimum harvested fruit should never be stored long-term.

2. Reduce variability

- Orchards ranked 3 weeks before harvest on maturity and then pre-delivery samples to determine ripening rate and storability.
- Market fruit from orchards with faster ripening rates first and do not store in CA.
- Inside and outside canopy fruit maturity differences need to be determined.
- The outside, well-coloured fruit will be harvested first due to block colour standard of 40% (some markets 60%).
- The inside pale fruit will be left for last in order to potentially colour up. Consider leaf-stripping after first pick when sunburn risk has diminished. Rather consider reflective mulching should sunburn be a risk.
- These inside canopy fruit may be riper (even at the first pick) and should not be stored in CA / longer than 12 weeks (including shipping time).
- Depending on the size of the first pick, the second pick may be put into CA / long term storage depending on the starch breakdown.
- Avoid extended periods between picks / long picking window.
- Do not harvest after 50% starch breakdown for CA storage purposes longer than 12 weeks. May be fine for RA and RA + 1-MCP and short-term CA storage,

3. Long term storage - orchard history ranking

- Age of trees - do not store fruit from young trees longer than 12 weeks (including the shipping time).
- Light crop load fruit may be more susceptible to disorders / earlier ripening.
- Irrigation status (under or over irrigation may result in faster ripening rates and poor storability).
- Soil types (sandy soil orchard fruit tend to ripen faster).
- Mineral nutrition (important in storage quality / ripening rate).
- History of progressive defects and ripening rates pre-harvest of each orchard.
- Grafted trees may also have a higher internal browning risk due to increased stress.

- Fruit that experienced any type of stress during the season should be packed within one week and sold (maximum of 6 weeks including all handling and shipping).

4. After harvest and storage handling

- Harvested bins should not remain in the sun and should be accumulated in a shaded area before transport to the packhouse as soon as possible (within the same day of picking).
- At the packhouse fruit should be loaded into the cold room as quickly as possible (within 6 hours from delivery).
- Fruit should not be accumulated outside the packhouse in the shade / overnight to facilitate initial cooling.
- The cold room temperature should not be fluctuating above (3 °C - 4 °C) while adding warm fruit. This may lead to excessive temperature fluctuations / cooling maintenance or poor removal of field heat.
  Separated areas with curtains in the cold room to split warm and cooled fruit may help to avoid this.
  Make sure the cooling capacity of cold store can remove the heat from the volume of warm fruit. This should be closely monitored.
  Load two or three rooms simultaneously to get even cooling rates.
- Attain pulp temperature of 4 °C after 48 hours.
- CO_2 should be monitored when warm fruit are closed in a cold room.
- CO_2 levels should never reach levels higher than 1%.
- Use additional lime / new generation scrubbers to reduce CO_2 to 0.5%.
- Fruit should further be cooled stepwise (see below).
- Fruit will benefit from ethylene inhibitors (1-MCP) (to reduce the ripening rate, greasiness, superficial scald and internal browning) and should be treated within 3 days of harvest (maximum 7 days) especially if stored for extended periods in RA (3 months) or CA (> 3 months), but should be used with a stepwise cooling treatment especially for longer storage periods.
- Stepdown cooling treatment protocols (see below) perform better in terms of diffuse and radial browning prevention after long term CA storage (>7 months), in comparison to single storage temperature regimes at 1 °C.

5. CA O_2 and CO_2 gas regimes - Industry Guidelines (ARC/HORTGRO)

***Nitrogen Flushing**: attain gas regime of 3% O_2 + <1 % CO_2 within 48 hours of sealing the room.*

Table 1: Regimes (Appendix 2 Industry Guidelines Apples (ARC/ Hortgro):

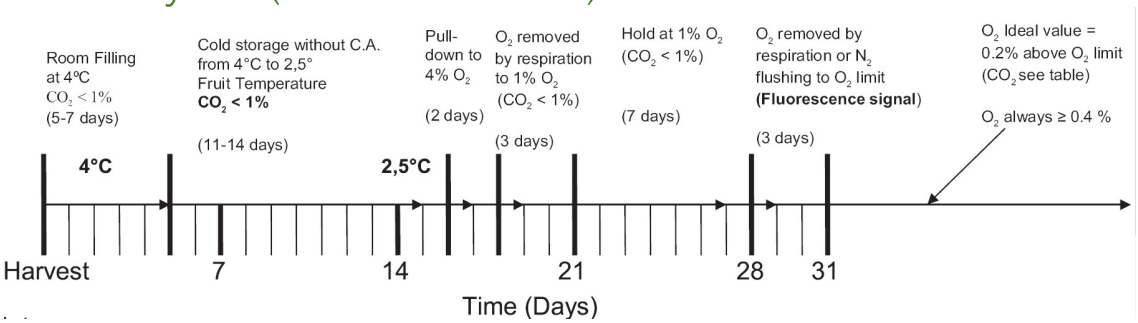
Gas regime:	***O_2 (%)***	***CO_2 (%)***
Optimum	*1.5*	*0.5*
Maximum	*2.0*	*1.0*
Minimum	*1.0*	*0.0*

6. DCA guidelines

DCA- RQ / ACR system (Van Amerongen) (PACKHOUSE EXPERIENCE / VA)

- Room filling (5-7 days); keep CO_2 <1%
- Room full (3 days) fruit on temperature; keep CO_2 <1%
- Pull down O_2 to max 6% (2 days); keep CO_2 <1%
- O_2 reduction to 1.2% (7 days); keep CO_2 <1%
- O_2 1.2% (14 days); CO_2 <1% (total 28 days).
- ACR mode > 28 days onwards: O_2 > 0.6%; CO_2 <1%
- Keep O_2 between 0.5 - 0.7% depending on the season.
- Always keep CO_2 as close to 0.5% as possible.
- It is a good idea to monitor the fruit from DCA for ethanol levels.
- *PLEASE CONTACT SERVICE PROVIDER FOR THEIR SPECIFIC GUIDELINES*

DCA-CF system (Isolcel / Gas-at-Site)



Reference: Gas-at-Site, Zanella, 2020/21

- *PLEASE CONTACT SERVICE PROVIDER FOR MORE SPECIFIC GUIDELINES*

7. Internal browning considerations

- Fruit maturity (starch breakdown) is linked to diffuse and radial browning development after storage and ripening.

  Starch breakdown 15-40%: lower risk of *diffuse* browning (3 months storage).
  Starch breakdown 15-40%: risk of *diffuse* browning depends on other factors (>3 months storage).
  Starch breakdown 40%-50%: higher risk of *diffuse* browning (>3 months storage).
  Starch breakdown 40%-50%: medium risk of *diffuse* browning (3 months).
  Starch breakdown >50%: high risk of *diffuse* browning (3 months).
  Starch breakdown 15%-20%: seems to have a higher risk of *radial* browning after long term storage, especially in combination with a single storage temperature below 1 °C.

- Low storage temperature is linked to *diffuse* and *radial* browning development. Storage temperatures of -0.5 °C up to 1 °C have previously been linked to *diffuse* browning after only 3 months of storage.
- All stepdown cooling treatment protocols reduced *diffuse* and *radial browning* after long term CA storage (>7 months), in comparison to single storage temperature regime below 1 °C.
- *Soft scald* – risk lowered with stepwise cooling

Stepwise cooling treatments tested:

Treatment 1: 1-MCP (SmartFresh^{SM} used in this trial) within 7 days + 30 days at 4 °C, 30 days at 3 °C, 30 days at 2 °C, remaining days at 1 °C (CA: O_2 1.5%; CO_2 0.5%).

Treatment 2: 1-MCP (SmartFresh^{SM} used in this trial) within 7 days + 30 days at 3 °C, 30 days at 2 °C, remaining days at 1 °C (CA: O_2 1.5%; CO_2 0.5%).

Treatment 3: 1-MCP (SmartFresh^{SM} used in this trial) within 7 days + storage at commercial CA store (2 °C for 14 days + 1 °C for 14 days + remainder at 0.5 °C until room opened; transferred to US-CA-storage from September and stored at 1.0 °C onwards (CA: O_2 1.5%; CO_2 0.5%).

- Pre-harvest factors that affect maturity (i.e. younger trees with lighter crops loads and fruit grown on sandy soils) have been linked to diffuse browning.
- Radial browning seems to be linked to pre-harvest temperatures. Be mindful that the risk of radial browning occurrence may be higher in seasons with lower than usual maximum and minimum temperatures as well as GDD_{10C} after 0-50 DAFB (cell division) and 50-100 DAFB (cell enlargement). When long term storage period is determined and fruit allocated for this purpose, the risk of radial browning in each season should be taken into account. *These results need to be confirmed. Research is ongoing.*
- Irrigation and rootstock trials seem to show differences in maturity / greasiness.
- 'Cripps' Pink' is CO_2 sensitive and readily shows CO_2 browning in cases where CO_2 increased above 1%.
- Non-perforated bags could lead to the build-up of CO_2, especially with fluctuating temperatures during shipping and distribution.
- Never pack high/medium risk fruit in plastic liners in boxes
- Consider shipping container vents 15% open due to CO_2 sensitivity and risk of temperature fluctuations during the voyage.