Best-practice guidelines for

Cripps Pink

These guidelines aim to improve the quality of Cripps Pink apples through correct pre- and post-harvest practices. Compiled for Hortgro Science by the Store-it Group.

Correct harvest maturity for long-term storage

Harvest maturity is the most important factor contributing to the development of diffuse browning. Do not store fruit that were harvested after optimal maturity for long periods. The criteria for correct harvest maturity are:

Optimal starch breakdown of 20%–30%. Maximum 40%. Fruit can be released at 15% depending on other parameters.

Firmness measured using a 11.1-mm tip must be more than 7.8 kg, as the fruit has to land in the United Kingdom at 6.8 kg.

Total soluble solids must preferably be above 12.5%. It must be 13.0% at reception.

Titratable acids must be 0.75%–0.55%.

Orchard factors that affect storability

The history of progressive defects and ripening rate for each orchard provides an indication of the risk of post-harvest problems. The following factors can increase the likelihood of defects after long-term storage:

Tree age. Preferably do not store fruit from young trees for more than 12 weeks, including shipping.

Crop load. A smaller harvest can be more susceptible to post-harvest defects due to earlier ripening.

Irrigation status. Both too little and too much irrigation can lead to faster ripening and therefore poor storability.

Soil type. Sandy soils tend to increase the rate of ripening.

Mineral nutrition is important for both the rate of ripening and storability.

Topworked trees may have a greater risk of internal browning due to higher stress levels.

Stress. Fruit from trees that have experienced any type of stress during the season should be packed and sold within one week — maximum six weeks including all handling and shipping.

Ways to reduce variation

Sort orchards according to harvest maturity three weeks before harvest. Take samples to assess the rate of ripening and storability before delivery to the pack house. Market fruit from orchards with more rapid ripening first rather than attempting to store it under controlled-atmosphere conditions.

Determine the maturity of fruit from both the inside and outside of the canopy. Fruit from the outside will be harvested first because it will meet the block colour standard of 40% — 60% for some markets — earlier.

Fruit from the inside of the canopy is often left longer to develop better red colour. Keep in mind that these fruit may be more mature than those from the outer canopy even at the first picking. Inner canopy fruit should therefore preferably not be stored under controlled-atmosphere conditions or for longer than 12 weeks including shipping.

Avoid a protracted picking window and long intervals between harvesting fruit.

The colour of fruit from the inner canopy can potentially be improved by using reflective mulch. Leaves may also be removed after the first pick if the risk of sunburn is not too high.

Fruit from the second pick can be stored in long-term controlled-atmosphere conditions depending on their starch-breakdown levels and the extent of the first pick.

Fruit with starch-breakdown levels of more than 50% should however not be stored in controlled-atmosphere conditions for longer than 12 weeks. Such fruit may possibly be stored successfully in a regular atmosphere with or without 1-MCP or in short-term controlled-atmosphere conditions.

Handling after harvest and during storage

Do not leave bins of fruit in the sun. Accumulate them in the shade before transporting them as soon as possible — the same day as they were harvested — to the pack house.

Load the fruit into the cold room as soon as possible — within six hours — after delivery to the pack house. Do not leave fruit outside the pack house in the shade or overnight to cool.

Cold-room temperatures must not fluctuate above 3°C–4°C while warm fruit is added. Excessive temperature fluctuation can impair the cooling of fruit. Curtains that separate warm and cold fruit inside the cold room can help to reduce fluctuation. The cooling capacity of the cold room does however need to be sufficient for the volume of fruit — monitor this. Load two to three cold rooms simultaneously to achieve more even cooling.

Pulp temperature must reach 4°C after 48 hours. Fruit should be cooled stepwise thereafter – refer to protocols below. Stepwise cooling yields better results than single-temperature storage at 1°C for radial and diffuse browning after long-term — more than seven months — storage in controlled-atmosphere conditions.

Monitor CO_2 levels when warm fruit is closed in a cold room. CO_2 levels should never exceed 1%. Use additional lime or new-generation scrubbers to reduce CO_2 levels to 0.5%.

Ethylene inhibitors — 1-MCP — benefit fruit by reducing the rate of ripening, as well as greasiness, superficial scald, and internal browning. Fruit must be treated within three — maximum seven — days of harvest, especially if it will be stored in regular atmosphere for long periods of up to three months, or controlled-atmosphere conditions for longer than three months. Ethylene inhibitors should be used in combination with stepwise cooling, especially for longer storage.

Stepwise cooling: experimental results

The following protocols for stepwise cooling were tested. All reduced the occurrence of internal browning, but stepwise cooling starting at 3°C — protocol 2 — yielded the best results.

1-MCP in the form of SmartFresh was applied within seven days of harvest in all cases. Controlled-atmosphere conditions in all cases were O_2 levels of 1.5% and CO_2 levels of 0.5%.

Protocol 1

Start with 30 days at 4°C.

Followed by 30 days at 3°C.

Followed by 30 days at 2°C.

Then maintain at 1°C.

Protocol 2

Start with 30 days at 3°C.

Followed by 30 days at 2°C.

Then maintain 1°C.

Protocol 3

Started with 14 days at 2°C in a commercial controlled-atmosphere store.

Followed by 14 days at 1°C in a commercial controlled-atmosphere store.

Thereafter 0.5°C was maintained until fruit was moved to the Stellenbosch University experimental store in September.

After this 1°C was maintained.

Guidelines for controlled-atmosphere O_2 and CO_2 levels

These guidelines were obtained from Hortgro and the ARC. O_2 levels of 3% and CO_2 levels of less than 1% are achieved by displacement with N_2 during the first 48 hours after the room is sealed. Levels are thereafter maintained as set out in table 1.

Table 1

Target levels of O_2 and CO_2 in controlled-atmosphere storage according to Hortgro and the ARC.

	%O_2	**%CO_2**
Minimum	1.0	0.0
Optimum	1.5	0.5
Maximum	2.0	1.0

Guidelines for dynamic controlled-atmosphere (DCA) storage

Van Amerongen ACR system (DCA-RQ)

The guidelines in table 2 are based on the Van Amerongen ACR system and the experience of pack houses. This system relies on measuring the ratio of CO_2 production to O_2 consumption — known as the respiratory quotient or RQ. Consult the service provider for their specific guidelines

It is good practice to monitor ethanol levels in fruit in dynamic controlled-atmosphere storage.

Table 2

Guidelines for dynamic controlled-atmosphere storage using the Van Amerongen ACR system. Fruit temperature is 1.5°C–2.0°C at all times.*

	Period	**%O_2**	**%CO_2**

Room being filled.	5–7 days	-	Below 1%. Preferably 0.5%.
Room full. Fruit at temperature.	3 days	-	Below 1%. Preferably 0.5%
Reduce O_2 to 6%.	2 days	Maximum 6%	Below 1%. Preferably 0.5%
Respiration reduces O_2 to 1.2%.	7 days	Maximum 1.2%	Below 1%. Preferably 0.5%.
Controlled atmosphere. O_2 at 1.2%.	14–28 days	1.2%	Below 1%. Preferably 0.5%
ACR system in use.	From 28 days	Minimum 0.6%	Below 1%. Preferably 0.5%.

*Protocol supplied by Van Amerongen. For more information, visit their website at https://van-amerongen.com/en or http://a-r-e.co.za/.

Isolcell or Gas At Site DCA-CF system

The guidelines in table 3 are based on systems used by Isolcell and Gas At Site, among others. These systems measure chlorophyll fluorescence — CF — as an indicator of O_2 demand. Consult the service provider for their specific guidelines

It is good practice to monitor ethanol levels in fruit in dynamic controlled-atmosphere storage.

Table 3

Guidelines for dynamic controlled-atmosphere storage using the CF system.*

	Period	**%O_2**	**%CO_2**
Room filled at 4°C.	5–7 days	-	Below 1%. Preferably 0.5%.
Room full. Fruit temperature 2.5°C.	11–14 days	-	Below 1%. Preferably 0.5%.
Reduce O_2 to 4%.	2 days	Maximum 4%	Below 1%. Preferably 0.5%.
O_2 consumed by respiration.	3 days	Maximum 1%	Below 1%. Preferably 0.5%.
O_2 at 1%.	7 days	1%	Below 1%. Preferably 0.5%.
Remove O_2 by respiration or displacement with N_2	3 days	Minimum 0.4%.	Depends on O_2 levels. Below 1%. Preferably 0.5%.

Monitor chlorophyll fluorescence.	Remaining storage period.	Minimum 0.4%.	Depends on O_2 levels. Below 1%. Preferably 0.5%.

*Protocol supplied by Zanella for the 2019–2020 season in Northern Italy. For more information, contact Gas At Site at info@GasAtSite.com.

Specific post-harvest defects: risk factors

Diffuse browning

Maturity as measured by starch breakdown is linked to the development of both diffuse and radial browning. Preharvest factors which increase the rate of ripening are linked to the development of diffuse browning.

Starch breakdown 15%–40%. The risk of diffuse browning during storage for three months is low. The risk of diffuse browning when storage is longer than three months will depend on other factors.

Starch breakdown 40%–50%. The risk of diffuse browning during storage for three months is moderate. The risk of diffuse browning increases when storage is longer than three months.

Starch breakdown more than 50%. The risk of diffuse browning during storage for three months is high.

Radial browning

Maturity as measured by starch breakdown is linked to the development of both diffuse and radial browning.

Starch breakdown 15%–20%. The risk of radial browning after long-term storage appears to be higher, especially if a single storage temperature of 1°C is applied.

Radial browning seems to be linked to preharvest temperatures. Preliminary results show a greater occurrence of radial browning in seasons where temperatures are lower and growing degree days fewer than normal during cell division — 0–50 days after full bloom — and cell enlargement — 50–100 days after full bloom. Take season into account when deciding about long-term storage of fruit. Note that more research is needed to confirm these results.

Both diffuse and radial browning

Low storage temperatures are associated with the development of both diffuse and radial browning. Temperatures of -0.5°C–1°C have been linked to the development of diffuse browning after only three months of storage.

All stepwise-cooling protocols reduce both diffuse and radial browning after long-term — more than seven months — storage in controlled-atmosphere conditions, compared to storage at a single temperature of 1°C.

CO_2 browning

Cripps Pink is sensitive to CO_2 and will readily develop CO_2 browning when CO_2 levels rise above 1%.

Unperforated bags can lead to the accumulation of CO_2, especially when temperatures fluctuate during shipping and distribution. Therefore, do not pack medium- to high-risk fruit in closed bags in boxes.

Consider leaving the vents on shipping containers open at $15m^3$ per hour.

Soft scald

As is the case for internal browning, the risk of soft scald is reduced by stepwise cooling.

Due to the risk of soft scald, Cripps Pink should never be shipped at temperatures below 0°C.