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Post-Harvest Fruit Management Part 2

In March I examined some aspects of the management of fruit after harvest. The discipline is complex and cold store operators have to be part engineer, part fruit physiologist, be experienced but also willing to seek and try new techniques as they are developed. The aim is always to manage fruit well to provide a good eating experience for consumers and a good financial result for the business.

The art of post-harvest management is to slow down the respiration process and to manage the fruit and its environment so that disorders and rots don't reduce the health or acceptability of the fruit.

Let's review five topics that were discussed in March;

1) The traditional tools to slow the respiration process have been lowering temperatures and restricting the oxygen available for the apples and pears to breathe.

2) Cooling fruit is usually a dynamic process starting with: 1) removal of initial field heat, 2) a period of time where the temperature is lowered in a step wise manner to reach, 3) the final storage temperature for the majority of storage life. Step-wise cooling is kinder on the fruit and less expensive.

3) The three gases that need to be managed when storing fruit are; oxygen (O_2), carbon-dioxide (CO_2) and ethylene. Oxygen is what the apple breathes in during respiration and CO_2 is what it breathes out. Ethylene is the natural fruit ripening plant hormone produced during respiration that speeds up ripening and then causes fruit to break down and rot.

4) Ethylene management includes picking fruit before it starts the ripening process (when too green), keeping temperatures low and adjusting atmospheres, and removing it from the atmosphere within the store. The modern way to manage ethylene is by using the SmartFresh technology which works on a molecular level to block the fruit's ethylene receptors and shut down ethylene production.

5) There are a lot more storage disorders than diseases; the four most common cold storage disorders being superficial scald, water core, bitter pit and internal browning. All have major influences that start in the orchard so their management starts in the orchard.

    a) Superficial scald which is managed by reducing O_2 in atmospheres and using either two products to control superficial scald; DPA and SmartFresh.
    b) Water core only develops on the tree, but can reduce in storage or develop into a dark breakdown. Water core is caused when the air spaces between cells become flooded with sorbitol. Fruit with mild water core water can be managed by delaying its final cooling and keeping fruit in regular atmosphere, which will reduce its severity. It may disappear with 2-3 months of regular atmosphere storage.
    c) Bitter pit is caused by calcium deficiency and can be reduced with post-harvest calcium dips. There are orchard factors that also play an important role in the development of this disorder; mainly tree nutrition, watering, climate, crop load and tree vigour. High levels of fruit calcium are also important in increasing fruit firmness, lowering respiration rates, reducing ethylene production and reducing fruit rots.
    d) Internal browning is mainly a disorder of Pink Lady apples but can also occur in Sundowner apples. Stepwise cooling and delaying the imposition of CA atmospheres reduces the risk of internal browning. There are no direct positive or negative effects of Smartfresh on internal browning however the use of SF allows fruit to be step-wise cooled

and stored at warmer temperatures with more confidence of maintaining firmness and greenness of the background colour.

Now I will discuss the management of fruit rots, the importance of fruit maturity and the way new technology will continue to drive post-harvest practices.

Fruit rots

Just as atmospheres and temperatures are managed to maintain fruit quality and minimise disorders, fruits rots are managed rather than eliminated. Keeping rots from growing on moist, sugary organic material (such as fruit) for a long period of time in a high humidity situation is very difficult. In fact plant pathologists use moist agar-sugar solutions as a medium on which to grow funguses in their laboratories.

A novice may think that controlling rots would be most easily done with fungicides, but an experienced manager knows that they are the last line of defence, with sanitation, hygiene and fruit handling practices the most important tools.

Sanitising is different from cleaning, it is the use of a chemical to remove and kill disease spores. Hard surface sanitising is the treatment of all surfaces that fruit may be exposed to. These include bins prior to harvest, grading equipment and coldroom walls. It is a very important component of integrated disease management because it reduces the challenge from *Penicillium* (blue mould) and other fungi. Two common products used are Vibrex Horticare which is a chlorine dioxide product and Deccosan 315 which contains two forms of ammonium chloride (quaternary ammonium). Both products do not require a rinse after application and the safe contact time is as soon as the surfaces are dry. Wash water sanitising is treatment of pack house flume water, rinse water in washing/polishing units and hydrocooling water (used in stonefruit). Nylate, Tsunami and Vibrex are common products used.

Growers that are using SmartFresh and not dipping in DPA for scald control have also found they do not need to dip in fungicides if they have lowered their risk by good sanitation and good orchard fungicide programs. It's only really a practice that is possible in districts that have dry summers. However an alternative practice could be to drench fruit with sanitised water before SmartFresh treatment to sanitize fruit from surface pathogens. It will also commence the removal of field heat. This was previously not possible as sanitisers and DPA don't mix. Nylate is a sanitiser that is compatible with calcium chloride if growers are dipping in calcium.

Fungicides. There are currently fungicides from four groups registered for apples and pears. They are; Fungaflor (imazalil), Rovral (iprodione), Scholar (fludioxonil) and Vorlon/Tecto (thiabendazole) . If they all did the same job good resistance management could be obtained by using them in a four-yearly rotation. But unfortunately this is not the case.

Disease	Fungicide
Blue mould	Fungaflor, Rovral, Scholar, Vorlon
Botrytis	Rovral, Scholar, Vorlon
Neofabria	Rovral, Vorlon
Storage black spot	Pre-harvest
Alternaria	Pre-harvest
Glomerella	Pre-harvest
Core Rots	Pre-harvest (blossom primarily)

Blue mould is the main post harvest rot to be managed. Rotation to avoid fungicide resistance has traditionally been a big issue in choosing blue mould dips. In the 1980's there were instances of failures due to resistance in the benzimidazole group of fungicides (Benalte, Bavistin, Spin-flo, Tecto/Vorlon). After this the recommendation was to always mix benzimidazoles with Rovral. When Fungaflor became available the recommendation changed to alternating benzimidazole+Rovral with Fungaflor+Rovral each year. Now the benzimidazole group has just one member left available – thiabendazole (Tecto and Vorlon). However in the past few years a new product, Scholar has been released and is achieving good results.

Scholar is registered on pome fruit at a range of rates; 130 – 260 mL/100 L. The recommendation is that if Scholar is mixed with Rovral it can be used at the lower rate. Hence there are now three options for resistance management; alternating Scholar+Rovral, Vorlon+Rovral and Fungaflor+Rovral every third year.

The reason mixing two fungicides is recommended is because there are some strains of blue mould that have shown resistance to the benzimidazole group (which includes Tecto and Vorlon) and the dicarboximides group (includes Rovral). Resistance could develop to other groups and mixing and rotating groups will reduce the chance of resistant strains becoming dominant and causing large losses due to rots. Remember, diseases in orchards and cold stores cannot be eliminated, but they can be managed.

Pears are more prone to rots than apples because they have thinner skins and often suffer from stem punctures. Wounds are an entry point for many fruit diseases. Also ripe pears can be very moist and sweet which is very conducive to fungal growth. If pears are to be cold stored for long periods and if there are any other disease risk factors (e.g. a wet growing season, sub-optimal hygiene and sanitation practices) and any history of rots in the cold store facility then a strong fungicide program should be used. This would avoid Tecto and Vorlon in favour of Fungaflor and Scholar as there is less chance of rot due to resistance with these products.

Fruit and bins catch and absorb dip mixtures (up to 8 L/bin with wooden bins). Hence dip levels drop as they are used. The recommendation to maintain efficacy of all dip components is to mix once, top-up twice then discard the entire dip mix. Dip pumps can strip the components of dips out of the mixture and fruit, organic matter and dirt can absorb and bind components. Dip test kits allow operators to check the concentration of DPA in dips before topping up. Test kits are not available for fungicides and labels do not allow topping up at more than label rates.

Fruit maturity

Getting the most out of all the post-harvest tools to slow respiration and prevent disorders and rots is of limited use if fruit is not at best maturity at harvest. Fruit maturity is the variable that can make the post-harvest manager's task hard or easy. Maturity determines how long fruit can be kept, what its eating potential is and how many inputs have to be thrown at it for successful storage. As a general observation a third to a half of Australian fruit is picked more mature than growers would like. This is partly because of the challenges of getting enough good labour to remote locations and partly due to the hot weather that can unpredictably prevail during harvest. Over-mature fruit is respiring faster than desired and will continue to mature quickly unless respiration can be slowed. The four tools to slow respiration are; lowering temperature, lowering oxygen, raising carbon dioxide and managing ethylene.

One of the arguments against starting harvesting earlier has been that early harvested fruit is more prone to superficial scald and the traditional solution of DPA didn't always completely prevent scald or that the rates required were too high and there was a risk of fruit dip burn and unacceptable DPA residues in fruit. However, with the new tools of the SmartFresh and DCA technology, scald control on early picked fruit is more assured.

Consumers demand good tasting apples but sometimes this is hard to define. Of the three components of taste; sugar, acidity and firmness, the fruit's firmness is the one that shows up as most important in taste panels. People will eat a crunchy bland apple but don't like a tasty soft apple. Ideally the apple has a good sugar - acid balance AND is firm. It's said that the long supremacy of the Red Delicious variety was because it was firm and didn't have a particularly strong flavour so it passed the crunch test and never offended anyone who had a particular flavour preference. This desire for crunchy Red Delicious used to lead to a lot of the crop being harvested too early before it had developed sugars and flavours. Hopefully, with modern ethylene management tools and advanced CA management, there are ways to keep the fruit firm other than picking it when immature.

Harvesting at the *right* maturity means growers need to be measuring starch, sugar and firmness in the lead up to harvest, as well as looking at seed colour, and fruit background colour. Fruit acidity is harder to measure on the farm but is also an important part of an apple's taste profile. Just like starch levels, the fruit acid levels also fall during storage. Slowing respiration will slow the loss of acid, and hence maintain flavour.

An experienced cold store manager recently said to me that looking at and tasting fruit when a room is opened is the second best way of evaluating the results of all the TLC that was put into growing and then storing it. The best way of evaluating the result is to place it on the kitchen table for a week or so and then eating it, because that's what the consumer does.

The Future of Post-Harvest Management

Keeping fruit in good condition for months after harvest is not an easy task and will always involve skills and technology. Using and improving technology always has a cost, and technology will only be adopted if the benefits outweigh these costs. New engineering equipment typically has high one-off purchase costs and can have reasonably high annual running costs. There is an annual charge for the servicing of the SmartFresh Technology, which growers are offsetting with savings in DPA, electricity and improved pack-outs. There are no silver bullets and the best managers will continue to combine and balance each new technology with their existing practices as part of the continuous improvement best-practice cycle.

Controlled atmosphere storage practices took a big leap forward when small scale nitrogen generation equipment became reasonably affordable in the 1990s. Many further improvements in cool storage practices then flowed from the introduction of the SmartFresh technology some eight years ago. This has allowed excellent ethylene management, a less aggressive approach to cooling, a reduction in DPA use and the maintenance of fruit quality that relies less on strict atmosphere management. We look forward to further evaluating new engineering and biochemical improvements as the industry seeks to meet the cost, quality and consistency challenges that will inevitably come.

Blue mould growing readily on cold stored pears that did not receive a post-harvest fungicide dip.