Boosting raspberry storage life

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Despite their name and presence in this journal, raspberries are not actually berries. Rather, they are an aggregate fruit – a cluster of 75 to 85 ripened ovaries (drupelets) produced on the receptacle by a single flower. The drupelets 'stick' together with the aid of tiny, interlocking surface hairs. If the number of developing drupelets is reduced by poor pollination, pests or disease, then it is like leaving a few Lego bricks out of a wall. Even a gentle touch from a picker results in the complex structure crumbling into an unmarketable mess.

So begins the postharvest life of the supremely delicate raspberry. Few fruits are as fragile and short lived. Yet, somehow, raspberries must be transported thousands of kilometres while remaining fresh, unsquashed and rot-free. They must survive wholesale, distribution and retail to reach the fridge of a consumer, where they still need to be good to eat for several days. Maintaining postharvest quality of raspberries is, therefore, a major challenge. However, there are a range of postharvest technologies that can help.

Temperature is the number one factor determining storage life of all fresh products.

Temperature affects metabolic activity within the fruit, as well as the growth of fungi and bacteria that are present inside and out. If temperature management is poor, then no amount of fancy packaging or high-tech coatings is going to compensate. The faster products are cooled after harvest, the less moisture they will lose and the longer their storage life will be.

Cooling fruit

Raspberries are often room cooled. That is, packed punnets are put in a cold room. This is cheap to do and easy, saving on labour costs. However, room cooling is also slow, energy inefficient and likely to result in condensation on the product. Moreover, as raspberries stay warm longer, weight loss is increased – even if relative humidity (RH) inside the room is high.

Forced air systems are a major improvement over room cooling.

Actively pulling cold air through the punnets can cool fruit up to ten times faster than if the same product was simply stacked in the corner of a cold room. Because the cold air warms as it moves through the packed product, condensation is avoided – vital for stopping development of rots.

Vacuum cooling

The gold standard in cooling is the vacuum cooler.

Vacuum coolers work by pumping the air out of a sealed container. This causes water in the product to 'boil' i.e. turn from liquid to gas. This absorbs energy, effectively cooling the product extremely quickly.

While this does mean there is some water loss from the product (about 1% for every 6°C drop in temperature), this is similar to or less than forced air cooling, and definitely a lot less than the weight loss experienced during room cooling.

For vacuum cooling to work, products need to lose water easily. This method is therefore highly suitable for mushrooms, leafy vegetables, broccoli and herbs. While there does not seem to be any information on vacuum cooling of raspberries, in theory it should be ideal.

A vacuum cooler should be able to reduce the temperature of packed raspberries from 18°C to 2°C in around 15 minutes.

Other potential advantages of vacuum cooling include:

- **Reduced venting on punnets** – as vents are only needed for air to escape, not for air to flow over the raspberries, punnets can have fewer vents, thereby reducing weight loss during storage and transport
- **Energy efficiency** – almost all of the energy used goes to cooling the product; vacuum cooling is 80-90% energy efficient, compared to energy efficiencies of approximately 70% and 30% for forced air and room cooling respectively
- **More efficient spacing of pallets** – cool rooms are used to maintain temperature, not cool the product, thereby reducing load on existing plant
- **Short pre-cooling times** – this reduces time from pick to send, allowing more efficient logistics and cold chain management

Vacuum coolers are not cheap. Buying a two-pallet system is likely to cost at least $100,000. However, units can be leased, which could be an attractive option for growers with relatively short harvest seasons. As the units are portable, they can be trucked in as needed. An indicative price for a small (single pallet) vacuum cooler would be around $600 to $800/week, at least some of which could be recovered through reduced energy costs.

Figure 1. Forced air (top) and vacuum cooling systems (bottom). Photo credit: AHR, Quik-Cool

Atmosphere

Ethylene

Many fruits, including bananas, tomatoes and avocadoes, are ripened after harvest. In these ‘climacteric’ fruit, changes in sweetness, texture and flavour are stimulated by a burst of ethylene production and increased respiration.

In contrast, there is little change in respiration rates of non-climacteric fruit during development, and once they are picked no further ripening occurs.

Raspberries are classified as non-climacteric as they ripen slowly while attached to the plant. Despite this, ethylene production increases considerably as ripening progresses, especially in faster developing varieties[1]. However, ethylene is produced mainly by the receptacle, not the edible drupelets.

Raspberries do not produce significant ethylene after harvest. While they appear to be relatively unresponsive to ethylene in the storage environment, effects are unclear. While there are some reports suggesting that ethylene can stimulate growth of grey mould (*Botrytis cinerea*) and increase darkening, other researchers have found little or no effect [2].

Removing ethylene from storage rooms using potassium permanganate-based scrubbers may well improve storage life of other fruit, but benefits for raspberries are unclear.

For what is an increasingly significant crop, there is a disappointing lack of information regarding the effects of ethylene on Australian raspberries.

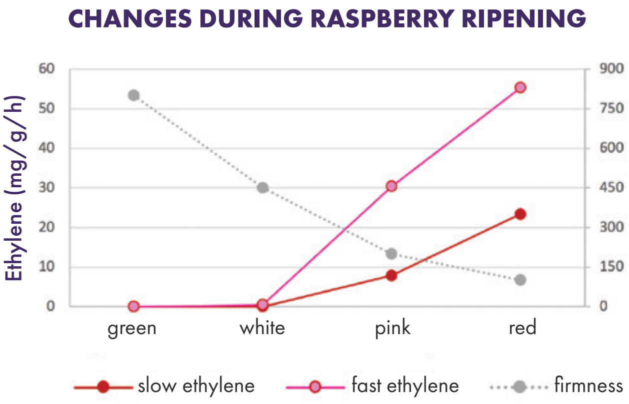

Figure 2. Increases in ethylene production by fast (•) and slower (•) developing raspberry varieties and changes in firmness during pre-harvest ripening.
Derived from Iannetta et al., 2008.

Ozone

Another way to remove ethylene from the storage atmosphere is to react it with ozone. Ozone can also destroy mould spores, helping to reduce spread of disease. Unfortunately, ozone not only reacts with spores and ethylene, but also with packaging, door seals and – most importantly – people. Fortunately, new systems are available which either retain the ozone inside the treatment system or maintain it at low and safe levels within the room.

There is some evidence from Italy that low levels of ozone can increase raspberry storage life, although higher concentrations may damage fruit[3]. It is unclear whether this effect is due to mould suppression or inhibition of ethylene. Again, these technologies have yet to be tested under Australian conditions.

Modified atmospheres

Development of mould, usually Botrytis, is a frequent cause of disappointment in consumers and rejection by retailers. Although infection occurs in the field, the fugus stays dormant until after harvest.

Growth of Botrytis can be reduced using a modified atmosphere (MA). Modified atmosphere systems use the respiration of the product to increase carbon dioxide (CO_2) and reduce oxygen (O_2) inside a gas-permeable package. To significantly inhibit Botrytis, the atmosphere needs to contain around 10% CO_2 or more. However, films that achieve this level of CO_2 often result in O_2 falling dangerously low; low (<5%) O_2 concentrations not only have no effect on decay but can cause off flavours and aromas.

One of the other issues with using modified atmospheres is that raspberries are hard to cool once inside the bag or pallet wrap. They must, therefore, be cooled first. But at 0°C the respiration rate of cold raspberries is only ~12ml CO_2/kg/h (UC Davis Produce Facts). This limits development of a beneficial atmosphere inside the package.

A recent review of postharvest technologies for berries[4] found mixed results for MA of raspberries. Several studies found that although mould growth was reduced by high CO_2, berry softening, and development of off odours meant they were no longer acceptable. In other cases, perforated films did not generate high enough levels of CO_2 to reduce rots. The best results were reported when a tray liner was combined with a CO_2 emitter (BioFresh®, Multisorb Technologies). This raised CO_2 to over 10% while maintaining O_2 at 5-10%, increasing storage life by at least one-third[5].

Figure 3. All too often, storage life of raspberries is ended by grey mould (*Botrytis cinerea*)
Photo credit: AHR

Key conclusions

There is no doubt that good temperature management can increase storage life of raspberries. The faster fruit are cooled to 2°C, the longer they will last. Forced air cooling systems are effective, but vacuum coolers, potentially, could provide even better results – although this has yet to be tested.

The effect of ethylene on raspberries is poorly understood. Exposure may increase development of rots and reduce storage life, but even this is unclear. While some benefits have been reported using ozone, this has not been tested under Australian conditions.

Nevertheless, reducing development of rots is key to increasing storage life of raspberries. Temperature fluctuations during storage and transport allow condensation, which inevitably increases mould growth.

Although development of *Botrytis* can also be reduced by high CO_2, this may be difficult to achieve under commercial conditions without negatively affecting flavour and texture. However, there are evolving technologies which could make this, and other options, viable in the future.

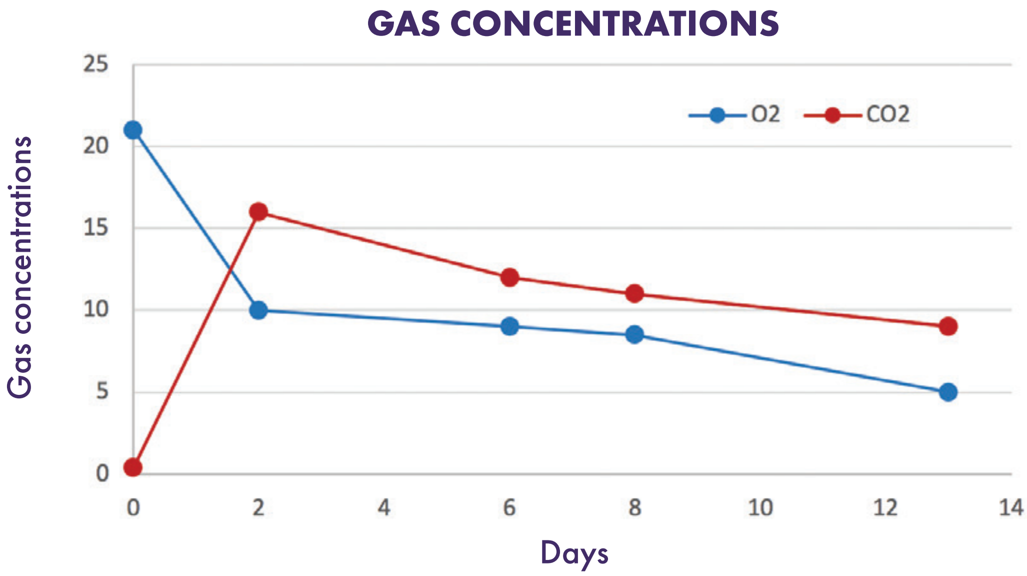

Figure 4. Changes in gas concentrations inside MA packages containing raspberries plus a BioFresh CO_2 emitter (top) and changes in firmness inside these MA packages compared to air (bottom). Red line indicates limit of consumer acceptability (23 Nmm firmness). Derived from Adobati et al., 2015.

References:

[1] Ianetta PPM et al., 2008. The role of ethylene and cell wall modifying enzymes in raspberry (Rubus idaeus) fruit ripening. Physiologia Plantarum https://doi.org/10.1034/j.1399-3054.1999.105220.x

[2] Palonen P, Weber C. 2019. Fruit color stability, anthocyanin content, and shelf life were not correlated with ethylene production rate in five primocane raspberry genotypes. Sci Hortic. 247:9-16.

[3] Giuggioli NR et al. 2015. Quality effect of ozone treatment for the red raspberries storage. Chem. Eng. Trans. 44:25-30.

[4] Huynh NK et al. 2019. Recent advances in postharvest technologies to extend the shelf life of blueberries (Vaccinium sp.), raspberries (Rubus idaeus L.) and blackberries (Rubus sp.). J. Berry Res. 9:687-707.

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Jenny is a postharvest physiologist and communicator who works to maximise produce freshaness and value while minimising supply chain losses. She is passionate about applying science to improve commercial and consumer outcomes.