Improving Sweet Cherry Fruit Quality

Harvesting, packing procedures, cold chain management and packaging to optimise fruit quality and extend shelf life

A report for

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Executive Summary

For all cherry producers in Australia, quality of fruit is the largest driver of returns. For Tasmanian growers, this is especially true due to greater emphasis on export markets. Many global competitors have increased production and greatly improved fruit quality and as such, achieving these premium returns demands that the greatest quality be presented to the consumer.

Tasmanian growers produce cherries that are highly sought after globally and enjoy an almost unmatched reputation, however current packing practices and cold chain management are still far from perfect.

Many packing lines around the world use increased automation to reduce the cost of labour during processing. The size of most Tasmanian operations ensures that implementing automated packing lines of this scale is impossible. Rather than focusing solely on reducing labour costs, producers would be most benefited by making efforts to improve the overall quality of their fruit to increase returns.

Several improvements can be made to current fruit handling systems to improve fruit quality and increase shelf life. Many of these require financial investment or costly modifications to packing lines but much improvement can be made by placing a greater emphasis on quicker cold chain initiation.

Current packaging used by the Tasmanian cherry industry is incompatible with most post-packing cooling processes used globally. To achieve similar results, boxes will need to be redesigned to include vents, allowing for these processes to take place.

The future of the Tasmanian and greater Australian cherry industry looks promising although significant challenges will be ever present, and producers will need to maintain vigilance and continuously work towards achieving a high-quality product.

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Foreword

I was born into a farming family with my parents owning a small property in the Coal River Valley, Tasmania. Originally a dry cropping and grazing area, the valley has now been transformed by irrigation and as such, horticulture/viticulture enterprises are now numerous. “Lowdina” began operating in the mid-1980s as a mixed cropping property before beginning a transition into commercial orcharding in the mid-2000s, around the time of the start of my working career. Despite never harbouring ambitions to be involved in primary production as a child, the rapid growth and diversification of my local agricultural community caught my attention and led me here.

During these early years of our own fruit production, the cherry industry itself in Tasmania was also comparatively small, with low tonnages but generally high grower returns due to high value exports into Asia. As China began to open itself up to the world economically, its imports of southern hemisphere cherries increased significantly. Subsequently, large scale cherry plantings were established in not only in Tasmania but also in growing regions with a much lower cost of production, most notably Chile.

Figure 1: Author in The Dalles, Oregon

Today, this vastly increased presence of southern hemisphere grown fruit on the global market has seen the profit margins of Australian producers begin to narrow despite increases in yield and grower efficiency. It is clear that the Australian export cherry industry will only remain financially viable if prices maintain current levels and new markets continue to be developed. With increased global competition, the former will only be possible by optimising market timing and/or maintaining and improving fruit quality and shelf life.

My desire to undertake this research project has been due to a personal belief that immediate improvements to fruit quality can and must be achieved and that these changes should be of top priority within the industry. This is also the common belief of many other growers in Tasmania and indeed mainland Australia. Domestic consumption of cherries in Australia is relatively low and committed improvement to a better eating experience for the consumer could lead to increased consumption locally.

The end goal of this research is to develop an understanding of how the best cherry production industries around the globe harvest, pack, present and market their fruit and how any improved techniques can be applied to Tasmanian and Australian conditions.

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Abbreviations

BC – British Columbia

FA – Forced Air

FTA – Free Trade Agreement

HIA – Horticulture Innovation Australia

MA – Modified Atmosphere

NSW – New South Wales

USA – United States of America

USDA – United States Department of Agriculture

Objectives

With low domestic consumption, accommodating growing conditions, increasing tonnages, and reliable access into many Asian markets, the Tasmanian and Australian cherry industry will continue to focus heavily on exports in the near future. The supply chain from tree to consumer is complex and challenging.

This report looks at the changes can be made to produce a better end product. The main objectives are:

- To understand the best handling practice to get fruit from the orchard to the packing shed with as little impact on fruit quality as possible.
- To find the best practice cold chain management procedures for Tasmania and Australia, given that packing technology is constantly evolving globally.
- To understand how the implementation of forced-air cooling could improve cherry fruit quality given the global prevalence of this technique. To compare a variety of packaging types and find what is most commonly used to provide the greatest improvement in shelf life.
- To investigate how the current handling practices of domestic retailers compare with those of their global counterparts.

Chapter 1: Introduction

Significance of export markets

The Australian cherry industry has undergone significant growth over the last ten years, with the majority of that growth coming between 2008 and 2015 where production rose sharply from approximately 9,000t to 15,000t. While that rate of growth has somewhat slowed, yields of 15,000t and 18,000t are generally expected with 15,650t harvested in 2017-18. This pattern of growth has also been reflected in the Tasmanian industry with large scale plantings established in the mid-2000s, increasing the state's crop to 3,928t in 2017-18, with total yields generally around the 4,000t mark. This represents approximately 25% of Australia's cherry production with New South Wales and Victoria each making up a further 25-30% (Horticulture Innovation Australia, 2018).

Of the 11,722t produced on mainland Australia in 2017-18, 1,979t was exported, accounting for 17% of total volume. It is in this regard where the Tasmanian industry differs drastically. During the same season, 2,135t of Tasmania's 3,928t cherry crop was exported (Table 1.) This represents 54% of the total and is reflective of an average season.

Table 1: Cherry exports by state of origin (tonnes). Source data: Horticulture Innovation Australia, 2015; Horticulture Innovation Australia, 2018

Year Ending June	2013	2014	2015	2016	2017	2018
Tasmania	1,499	1,316	1,560	2,872	1,381	2,135
Victoria	515	485	1,015	1,274	507	1,235
New South Wales	828	889	711	1,033	539	604
South Australia	38	4	246	324	4	125
Queensland	6	28	10	17	7	16
Other	***2***	***-***	***10***	***72***	***24***	***< 0.5***
TOTAL	**2,888**	**2,722**	**3,551**	**5,593**	**2,462**	**4,114**

The main factor for Tasmania's reliance on the international market is the access it enjoys through being a recognised fruit fly Pest Free Area. This internationally recognised status does not apply to mainland Australia and provides the state's cherry growers a considerable advantage over their mainland counterparts. Access to high value protocol markets for most Australian cherry growers has been restricted, although progress has been made in recent years. Currently, methyl bromide fumigation is the only cherry treatment accepted by China. This process undoubtedly reduces the shelf life of the fruit but does allow some mainland growers the opportunity to air freight fruit into China during times of low supply, often yielding strong returns.

Tasmania's harvest timing and the short shelf life of cherries creates another issue, the domestic price in Australia has a tendency to drop in December and January. This is largely due to the large Victorian and Tasmanian crops over-supplying the domestic market. Even with improved access to Asia for Victorian growers removing some of that fruit from the domestic market, continuously increasing yields will inevitably continue the price squeeze. Any increase in domestic consumption would be unlikely to outpace, or even match the increase in production from these areas. Tasmanian and mainland growers alike must grow new markets and maintain current exports to avoid this domestic market saturation.

Currently, the majority of Tasmanian cherry exports end up in South East Asia with Hong Kong and China the two largest importers, making up approximately 50%. Other markets of significance include Taiwan, Vietnam, Indonesia, Thailand, United States of America (USA), Malaysia, Singapore and Japan (Table 2).

Table 2: Tasmanian cherry exports by market (Prowse, 2019)

	Volume Tonnes				Value $ Million AUD			
Market	Mar to Feb-18	Mar to Feb-19	Change to 18	Share %	Mar to Feb-18	Mar to Feb-19	Change to 18	Share %
TOTAL CHERRIES	2,124	1,898	-11%	100%	35.40	39.26	11%	100%
Hong Kong	442	457	3%	24%	7.50	11.77	57%	30%
China	665	478	-28%	25%	11.90	9.56	-20%	24%
Taiwan	260	313	21%	17%	4.56	6.60	45%	17%
Vietnam	154	220	42%	12%	2.86	3.71	30%	9%
Indonesia	79	83	5%	4%	1.75	2.40	37%	6%
Thailand	109	61	-44%	3%	1.14	1.13	-2%	3%
United States	88	52	-41%	3%	0.73	1.00	37%	3%
Malaysia	61	61	0%	3%	1.63	0.95	-42%	2%
Singapore	51	45	-11%	2%	0.53	0.67	28%	2%
Japan	33	28	-15%	1%	0.48	0.41	-15%	1%
Korea, South	106	21	-81%	1%	1.48	0.33	-78%	1%
Saudi Arabia	12	25	101%	1%	0.06	0.18	188%	0%
India	12	8	-36%	0%	0.03	0.11	337%	0%
Cambodia	5	9	74%	0%	0.19	0.11	-43%	0%
all other	47	38	-19%	2%	-	0.33		1%
TOTAL Cherries	**2,124**	**1,898**	**-10.6%**	**100%**	**35.40**	**39.26**	**11%**	**100%**

The vast population of Asia, its close proximity to Australia, and increasing disposable income of its residents make the region an attractive proposition for fruit producers. It should also be noted that Chinese Lunar New Year falls between 22-January and 19-February. This festival season is preceded by a short period of incredible demand for premium cherries. Harvest timing of Tasmanian fruit, combined with efficient, affordable (comparatively) air-freight services means that many producers have a high chance of getting their fruit into a high-value market more often than not.

Rapidly increasing market competition

The cherry industry in Chile is one that prides itself on high export volume, and an increasingly consistent quality of fruit. Chilean producers are heavily export focused with approximately 90% of the crop being exported. 180,000t was exported from Chile in 2018-19 with around 87% of this volume, (157,710t) going to China. Export volume is expected to rise to over 220,000t in 2019-20. Planted area in Chile has grown roughly 10% per year over the past five years and thus, total production area has tripled over the last decade (USDA Foreign Agricultural Service, 2019).

Whilst cherry production has grown at a rapid pace, consumption in Asian markets has grown to accommodate the greater volume of fruit. Cherry imports into China over the last five years have grown by over 350%, with the vast majority of this growth coming from increased Chilean presence in the market (Figure 2).

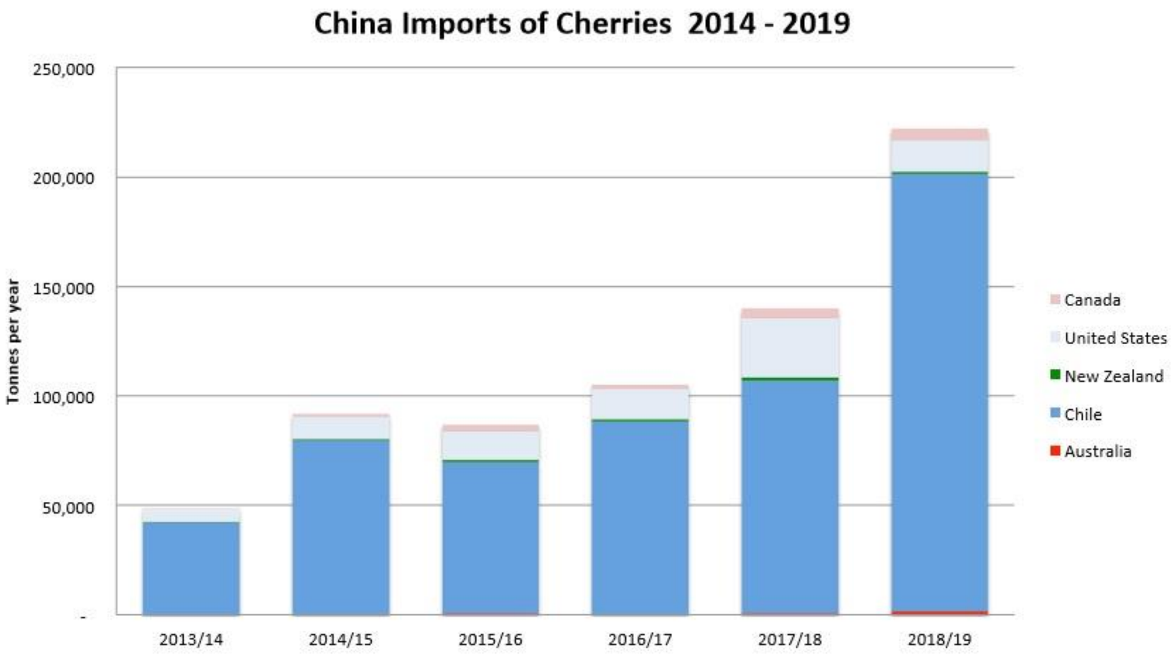

Figure 2: China imports of cherries 2014-19 (Prowse, 2019)

Although the Chinese market has grown significantly, this growth is not endless and has been recognized by the Chilean industry. Twenty-six Free Trade Agreements (FTAs) encompassing 64 different economies have been the driving force behind Chile's US$5.5 billion fruit export industry expansion into other markets across the globe (Caballero, 2019). This government driven trade policy shows strong support for Chilean producers and has ensured that Chile is here to stay in the Asian cherry market.

With Chile having the benefits of low cost of production, cheap sea freight, and far greater economies of scale, direct competition by Tasmanian and Australian growers will not be possible. Based on current exchange rates, the average value of Chilean cherries in China during the 2017-18 season was around AU$7.78/kg (Caballero, 2019), whereas the value of Tasmanian cherries in that same market was AU$17.89/kg (Prowse, 2019). This differential is largely due to both a greater fruit quality, and the consumer perception of a greater fruit quality. If the quality gap is not maintained, exporting cherries into Asia between December and January will not be financially viable for Australian and Tasmanian cherry growers. Paired with increased pressure on the domestic market and constantly increasing cost of production, the need to grow a premium piece of fruit has never been greater.

Chapter 2: Field Handling

Cherries face consumer and retailer pressure unlike almost any other fruit. This is especially true in Asian markets where even higher quality standards are in place. Although all parameters of fruit can be measured accurately and precisely, it is the consumer who is the final determinant of fruit quality. It is simply not sufficient for a box of cherries to have uniform size, shape, colour and maturity. The skin must be smooth, glossy, and free of pitting or “alligator skin”, while the flesh must be firm. Having a long green, firmly attached stem, has long been associated with the cherry being fresh and of good quality. While this link is not proven (and some research has in fact found no improvement to fruit quality), it is a benchmark that is well established in the eyes of the consumer. Only after the cosmetic qualities of the fruit have achieved the required standard will a buyer move on to the taste of the fruit, more specifically the total sugars and acidity and balance between the two. These combined attributes have been most closely related to consumers' acceptability and sale price (Dever, et al., 1996).

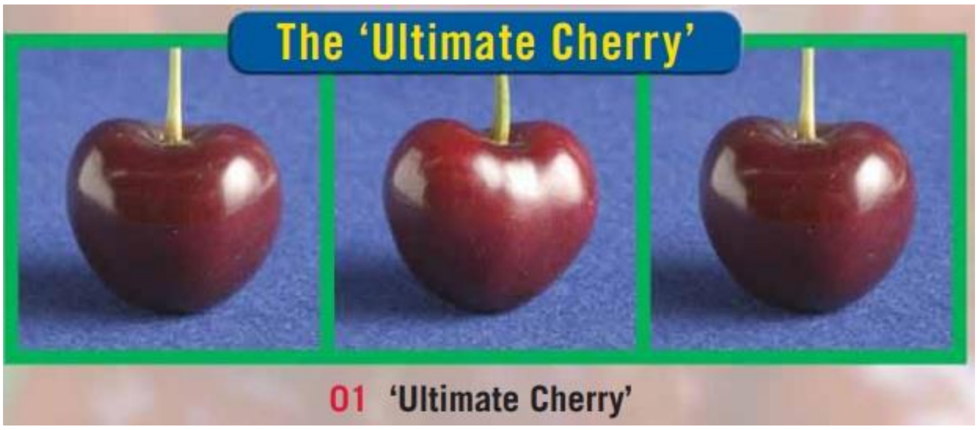

Figure 3: The ‘Ultimate Cherry’ (Cherry Growers Australia, 2011)

Many factors share responsibility for the final fruit quality of a cherry, and some are still poorly understood. Pre-harvest growing conditions are believed to have a strong effect on post-harvest fruit behaviour but difficulties in conducting relevant, controlled experiments make defining this link difficult. To achieve the required fruit quality consistently, the main causes of fruit degradation, and the best handling practices to reduce and prevent them must be understood.

Harvest

Unlike bananas or several other fruits, cherries are non-climacteric, meaning they will not continue to ripen with large increases in sugar during storage. For this reason, the harvest timing of cherries is especially important and can have one of the largest impacts on final fruit quality. Fruit harvested immature will never gain the sugars or colour deemed acceptable by the consumer despite having a greater storage potential. Conversely, fruit harvested over mature will be much sweeter but lack required firmness as well as having much reduced storage potential (Golding, 2017).

Determining optimal harvest timing will often depend on balancing several factors, quite often in conflict with each other. These can include availability of pickers, market opportunity, climatic conditions and prioritisation among cultivars or blocks. For an individual cherry to reach its greatest potential, the optimum harvest window between under maturity and over maturity is relatively narrow.

Whilst fruit quality can vary drastically between growing seasons, orchards, and cultivars, selecting an appropriate harvest window and harvesting quickly and efficiently offers producers the first practical step towards achieving an optimum result. It is critically important that fruit has the correct balance of sugar and firmness at harvest as a lack of either will greatly diminish fruit quality. Neither problem can be rectified after this point as cherry quality cannot be improved after harvest.

Despite growing techniques differing drastically from orchard to orchard, harvesting generally follows a consistent model across most global commercial cherry production. Picking occurs early in the morning to avoid the heat of the day, in some cases commencing at midnight with pickers using personal headlamps. Proper training of workers is crucial as cherries are very sensitive to physical damage during harvest. This damage is often not detectable for up to ten days. Fruit must be removed from the tree either individually or in bunches and placed into a picking lug with care taken not to remove buds from the tree, or stems from the fruit. Most compression damage or bruising found in stored fruit is caused by rough handling by pickers (Thompson, *et al*., 1997).

Fruit is transferred from the tree to a bin in many ways. It almost always begins with cherries being picked and placed directly into buckets or small lugs, weighing between 5 and 8kg. From this point an orchard can utilise a no-tip, one-tip, or two-tip system, with each providing its own advantages and disadvantages.

With a no-tip system, the original picking lug is removed from the picker's harness and stacked directly into a larger bin. The picker would then take another lug and repeat the process. This method provides the gentlest experience for the fruit as it is picked directly into a receptacle without further handling, with every point of tipping bringing further opportunity for physical damage. This method does however provide the least efficient use of space in transport and in cool room storage as the lugs take up significantly more room in bins than tipped fruit. To keep fruit in the original lug also requires an orchard to have access to considerably more bins due to this inefficiency in storage as well as vastly more lugs as a great number will be holding fruit at any given time. This also means large numbers of lugs and bins need to be constantly ferried from the shed to the paddock. Despite the clear physical benefits to the fruit, this method is often not viable for most large producers.

Two-tip systems involve pickers picking into lugs/buckets, tipping those lugs into larger totes, and (usually) a pick-up crew tipping those totes into bins for transport. This greatly improves the transport, storage and logistical issues encountered in a no-tip system but most growers aiming to produce a premium product would view the potential physical damage to cherries as unacceptable.

One-tip systems can involve pickers picking into lugs, tipping into a larger tote (10-14kg) and stacking those totes into larger bins for transport. This system was frequently observed in Chile, where commitment to fruit quality is high (Figure 4).

Figure 4: Plastic bins filled with totes awaiting processing. Curico, Chile (Author, 2018)

Alternatively, pickers may tip their lugs directly into a bin. This offers supervisors greater opportunity to inspect picked fruit as well as giving maximum transport and storage efficiency, although it does still require fruit to be tipped once, as observed at Tennesson Orchard in Oregon (Figure 5).

Figure 5: Picker tips directly into MacroBin 12-FV. Oregon, USA (Author, 2019)

Most modern commercial orchards across all regions visited have converted entirely from wooden fruit bins to plastic bins with the MacroBin 12-FV being the dominant choice in North America. These bins offer many advantages over traditional wooden bins including having rounded internal corners for damage prevention, weighing 60% of a wooden bin, being much quicker and easier to stack, having forklift access to all four sides, and importantly, being non-porous allowing for greater sterilisation.

Growers choosing to keep fruit in totes generally use a plastic full bin with plastic fitted totes to give the highest storage and transport efficiency possible. While both systems are considerably more expensive than conventional systems still in use in Tasmania, the benefit to fruit quality cannot be completely ignored.

Transport to packing shed

Since cherry harvest timing occurs at a ripening stage where respiration is high, fruit deterioration begins almost immediately from the point of removal from the tree. During respiration, internal sugars in the fruit are depleted, contributing greatly to a loss of overall quality. Although the rate differs between cultivars, all cherries respire much more under higher temperatures (Figure 6), to the point where it is said that 'Cherries held at 21°C lose more quality in one hour than they do in one week held at 0°C.' (van den Ende & Gaudion, 2019). This increased rate of deterioration means all picking must be done in the early morning when ambient temperatures are not as high.

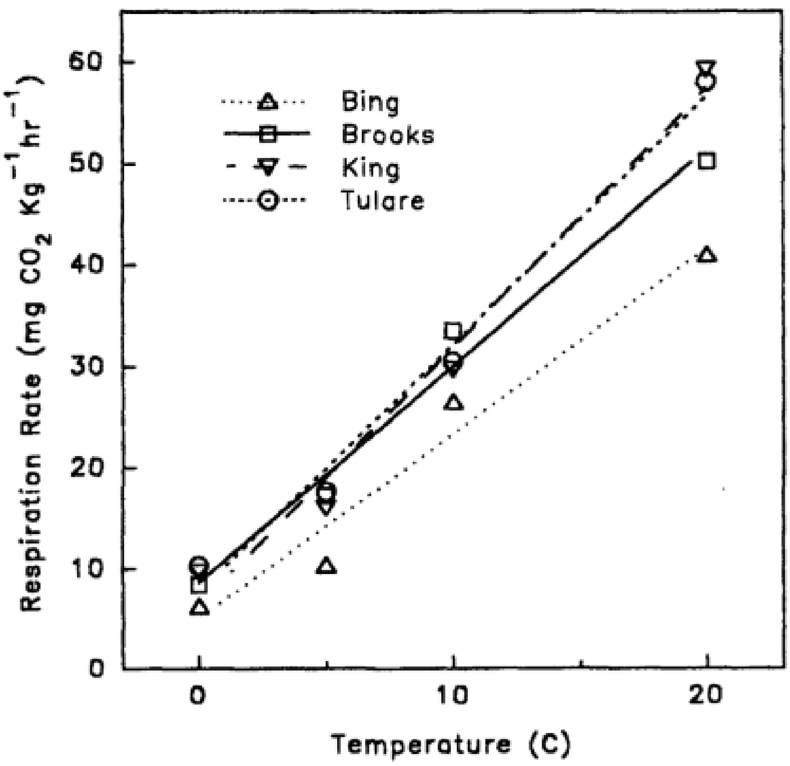

Figure 6: Cherry respiration rates across 4 cultivars at 0, 5, 10 and 20°C (Crisosto, et al., 1993)

Research by Eugene Kupferman of Washington State University shows that in addition to higher temperatures increasing the rate of respiration and therefore degradation in fruit, the exposure of fruit to the sun itself has potential to cause damage and should be avoided where possible (Kupferman & Sanderson, 2005). When fruit is exposed to direct sunlight as opposed to ambient air temperature, core temperature and stem browning increase. Conversely flesh firmness and stem thickness decrease. Although cherries themselves have a thick waxy cuticle layer to protect from water loss, the cuticle of stems is much thinner. This means that stems can dehydrate a rate up to eight times faster than the cherry. Stem browning and shrivelling is exacerbated under warm and windy conditions (Golding, 2017). Again, once this damage has been incurred, it cannot be repaired. Although stem thickness and colour are not true scientific indicators or freshness or quality, research has proven time again that poor stem appearance negatively affects consumer satisfaction and will inevitably result in lower returns for producers. To combat this, producers that require pickers to leave full lugs or totes on the ground to be picked up by another crew should expect that all picked fruit is left in the shade of the tree and that pick-up crews recover all fruit from the orchard promptly. Placing reflective mylar tarps over full bins of harvested fruit has also been shown to be reasonably effective at reducing water loss (Kupferman & Sanderson, 2005).

Regardless of whether an orchard tips fruit into bins or retains fruit in totes, these full receptacles will need to be transported to a packhouse to be cooled. For orchards with a packhouse on site, this can be a simple process where bins are filled (or totes collected) and immediately taken from the field to be received at the packing facility. For larger operations, one central packhouse may provide service to many separate growers or growing sites. Often fruit is collected from the field by tractors (generally 2-8 bins at a time, depending on the size of operation) and transported to a loading area where many at a time are then transported via truck to the packhouse.

Chapter 3: Initiating the Cold Chain

Hydrocooling

While harvested cherries are held in a loading area prior to transport, a hydrocooler will most likely be utilised to remove field heat. Hydrocooling units typically consist of a large shower using chilled water to bring the fruit core temperature down as low as possible and practical. Water used for these operations is recycled through a refrigeration unit and commonly treated with chlorine products to sterilise the fruit. Due to the diverse geographical range that cherries are produced in, this loading area can be in a remote location and a portable hydrocooling unit can be set up on site, as witnessed in Washington State, USA (Figure 7). These large units provide their own cooling and often their own power via a large portable generator, allowing hydrocooling to be undertaken in almost any environment.

Figure 7: Mobile hydrocooler at loading bay, Washington State, USA (Author, 2019)

For most modern producers, hydrocooling represents the start of the cool chain. From this point, harvested cherries will ideally remain in a completely controlled environment until the final point of retail sale. Where fruit is grown in the same location as the packhouse, this hydrocooling is followed by fruit being transferred to a cool room where it will stay until being packed. Although other utilised methods include “forced air” and “passive room cooling”, hydrocooling is the fastest and as such is commonplace throughout the world. The chilled water moving across the fruit cools uniformly and under ideal conditions, cools about 15 times faster than passive air (Golding, 2017).

Despite shower-type hydrocoolers providing the most efficient cooling capacity, care must be taken to ensure operations are completed correctly. As the chilled water for hydrocooling units is generally recycled and treated with chlorine products, these levels of sanitiser must be properly monitored and maintained. Often automatic dosing systems are used for this task although manual monitoring with test strips is still required. Higher than desired levels of chlorine in treatment water can be detrimental to the fruit while lower levels could potentially expose further equipment or water supplies to Salmonella, E. coli, or several other harmful bacteria.

Research has shown that decreasing the water drop height in shower-type hydrocoolers can significantly reduce the incidence of pitting damage in cherries. Thompson, et al., (1997) found that water drop heights of one metre could cause pitting damage to approximately 40% of all fruit directly impacted by water. Conversely, water drop heights below 20cm reduced the amount of damaged cherries to under 10%. This figure lowers once again when a plastic mesh screen was added to diffuse the water and reduce water droplet size and velocity. The same research showed that shower-type hydrocoolers were causing pitting damage to 18.6% of fruit and bruising damage to 9.6% of fruit in current systems at the time.

Pitting is a major post-harvest defect characterised by irregular 'pits' on the cherry surface. These marks often appear on the shoulders of the cherry and are caused by physical damage during packing. Pitting generally becomes visible several days or even weeks after picking, meaning that it is next to impossible to grade out, even with modern electronic graders. Apart from detracting from the visual appearance of fruit, pitting also increases the respiration rate, which speeds up the rate of decay at the injury site, and in turn reduces shelf life.

Whilst pitting can be caused at many different stages of the packing process, most notably by the cluster-cutter or cherries dropping onto dry belts, improper hydrocooler setup can cause damage to fruit and poor systems can and should be easily redesigned.

Figure 8: Pitting damage to cherries (Cherry Growers Australia, 2011)

Packing

Packing begins with full bins or totes of cherries being transferred, usually into a water filled dip tank, before being sized and sorted. This tipping is done in a number of ways including:

- Lifting the bin slowly and letting cherries roll down a ramp into water.
- Rotating the bin upside down with a canvas lid that slowly retracts letting cherries fall into water.
- Fully submerging the bin and completing the tip entirely underwater.

Tipping bins underwater is now commonplace for large commercial sheds as it offers far less potential for damaging fruit, although perhaps it is only viable for packhouses with a high throughput. Tipping a full bin instantly requires that fruit to be transferred from the water and through the system fairly swiftly as excessive submerged periods can lead to fruit cracking, particularly in some cultivars.

Tipping fruit from totes once again provides the greatest benefit to fruit quality but increases the cost of handling and reduces fruit throughput. In the Pacific north-west of the USA, many large sheds, such as The Dalles Fruit Company in Dallesport, use a rotary tote tipping machine to handle sensitive cultivars such as Rainier. The premium returns for these cultivars offset the extra care in packing and increased cost of labour. In fact, most packing sheds handling these cultivars have designed their lines so that the electronic grader can be fed through the conventional bin dump, or through the rotary tote tipper. Generally, the fruit from the totes will travel through an alternate cluster cutter. This cluster cutter belt will be running at a slower speed to the conventional line as it has been shown to reduce damage (Figure 9).

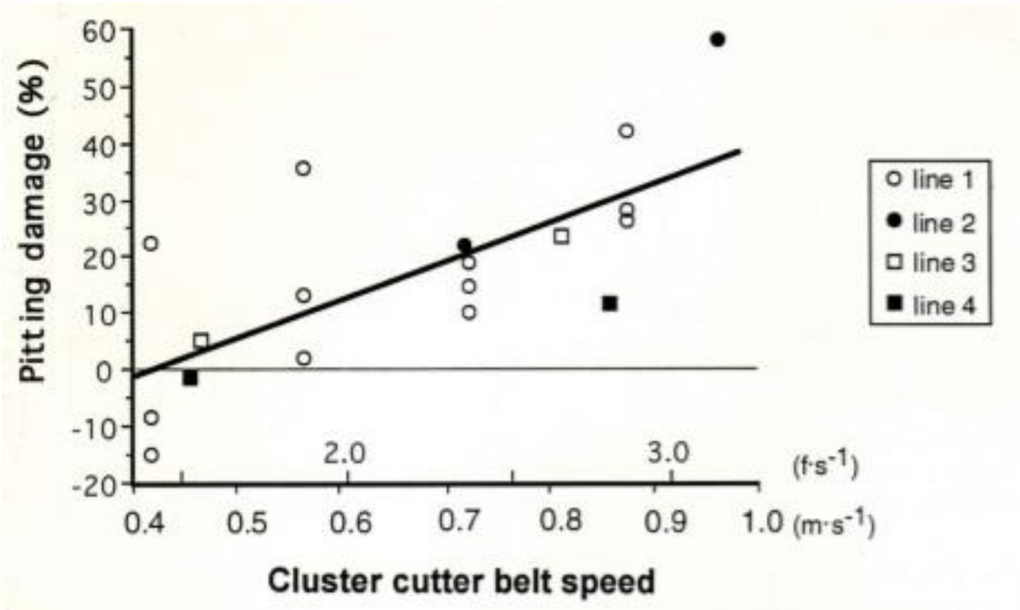

Figure 9: Relationship between cluster cutter belt speed and pitting damage across multiple packing lines (Thompson, et al., 1997)

As cherries are required to be single fruits for grading, a cherry stem separation system must be in place. Although most Tasmanian growers require pickers to separate cherries into singles in the field, and several other packhouses utilise a hydraulic stem separation system, metal blade saw type cluster cutters are most commonly found. These machines consist of a large belt to feed cherries, plastic tines to catch and lift joined stems, and a series of high-speed saw blades to cut those joined stems.

In Australian systems, these saw type cluster cutters have been shown to be the single biggest contributor of fruit pitting. Research by Golding (2017) found that up to 20% of all fruit was being damaged by cluster cutter operations. Since it has long been hypothesised that fruit impacting on the plastic tines of the cluster cutter causes pitting, slowing belt speeds to reduce this impact force unsurprisingly results in less pitting. It is unclear how much pitting is reduced by limiting impact force, and how much is reduced by increased fruit density on the belts causing a lower percentage of fruit to directly impact the tines. Regardless, studies such as these show time and again that any machinery on a packing line that physically impacts the cherries must be designed to handle the fruit with the gentlest care possible.

All packhouses of commercial size utilise electronic graders to individually size cherries and sort defects into various grades. Historically, fruit was mechanically sized with stepped rollers and defects individually sorted by humans. Continuously evolving high-definition camera and software technology of graders has made hand sorting virtually obsolete. With all cherries sold by size, the precision achievable with optical sizing allows producers to present a more visually appealing final box, as well as improving final packouts by removing the need for oversizing.

Defect detection has also improved, with modern machines claiming to remove almost all defects as well as sorting by firmness and detecting internal bruising. Packing lines still using humans to manually sort do not have this ability to sort fruit by firmness and efforts to do so will generally result in even more bruising to the fruit. Considering also that fruit with internal bruising has a higher respiration rate and as such will begin to decay earlier, having the ability to cull this fruit will extend the shelf life of the final product.

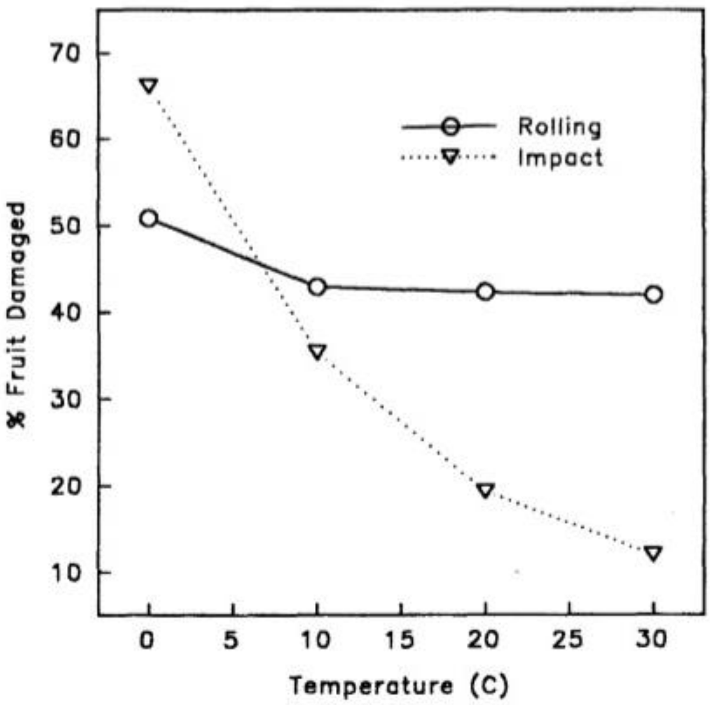

Figure 10: Effects of fruit pulp temperature on bruising susceptibility (Crisosto, et al., 1993)

Once fruit has passed through the electronic grader, individual cherries are dropped off at designated drop points depending on size, colour, and presence of defects. From these drops, cherries are transferred to sorting tables and finally box filling stations. Cherries can be transferred by rubber or plastic belts but water flumes are generally preferred for several reasons. Water flumes are much narrower than solid belts and can be fitted to take corners giving packhouses much better flexibility to transfer fruit in often confined areas. This water is also usually chilled to 0-4°C, as fruit moving through the packing room will begin to warm. Maintaining a chilled water flume will result in a lower fruit pulp temperature at box filling as opposed to dry belts. The greatest single advantage to water flumes is the reduction of bruising and pitting when compared to fixed belts. Every time a cherry falls on to a hard surface, the chance of causing physical damage increases, especially when fruit pulp temperature is cooler (Figure 10).

With pitting and bruising being two of the greatest detriments to shelf life and fruit quality, care must be taken when designing a packing line to isolate or minimise all physical impacts on fruit. Using water flumes as opposed to firm belts is a viable way to achieve this. Where belts must be used, reducing the drop height as much as possible will in turn reduce impact force and presumably lower the overall percentage of damaged cherries. Research has shown that when cherries are handled between 2 and 10°C, drop heights should be limited to 5cm (Candan, et al., 2014). Packing fruit warmer than 10°C carries with it a great deal of impracticality as produce will need to be re-cooled to a much lower temperature after box filling. Current sealed box designs used by Tasmanian producers do not allow such cooling after fruit has been palletised. To achieve acceptable storage potential with minimal pitting whilst using this box design, packers must maintain a low fruit pulp temperature throughout the grading process and reduce fruit drops to as low as possible.

Despite hefty initial set up expense, modern optical graders, such as the Unitec Cherry Vision 2.0 observed at Orchard View, Oregon (Figure 11), provide an unmatched capacity to provide the end consumer with a consistent quality of fruit. Combined with the ever-increasing cost of wages, difficulty in finding packing staff, and increasing fruit volumes, the vast improvements on efficiency and reduction in packing cost make these machines affordable and quite possibly necessary for all but the smallest packhouses.

Figure 11: Unitec Cherry Vision 2.0 optical grader, Orchard View, Oregon, USA (Author, 2019)

Fungicide application

Storage life potential of packed fruit is also challenged by development of post-harvest rots. Local studies of post-harvest rots in Australia showed that Botrytis cinerea (grey mould) was the dominant pathogen in Tasmania, whilst Alternaria alternata was the dominant pathogen in Orange and Young, NSW (Barry, et al., 2016). Alternate pathogens are responsible for rot across different production regions although treatment remains similar.

Pre-harvest fungicide applications and orchard hygiene practices typically reduce the number of spores present on the fruit and decrease latent infections by the time cherries reach the packhouse. Infections can be caused by contaminated water or humid conditions during storage. Most commercial producers pack fruit into specialised polyethylene box liners. These liners create a controlled environment in which humidity remains high and gases transpired from fruit can be removed. Although this high humidity decreases water loss in fruit and prevents stem browning, rot development can be exacerbated if storage temperatures are too high.

To prevent post-harvest infections, most packing lines will have a fungicide dip installed. This dip sees fruit dropped into a small tank of chilled, fungicide-treated water before excess water is recycled to the tank and cherries are transferred to final sorting belt (Figure 12). This treated water is usually separate to flume transfer water to avoid excessive costs of treating the large volume required to run flumes.

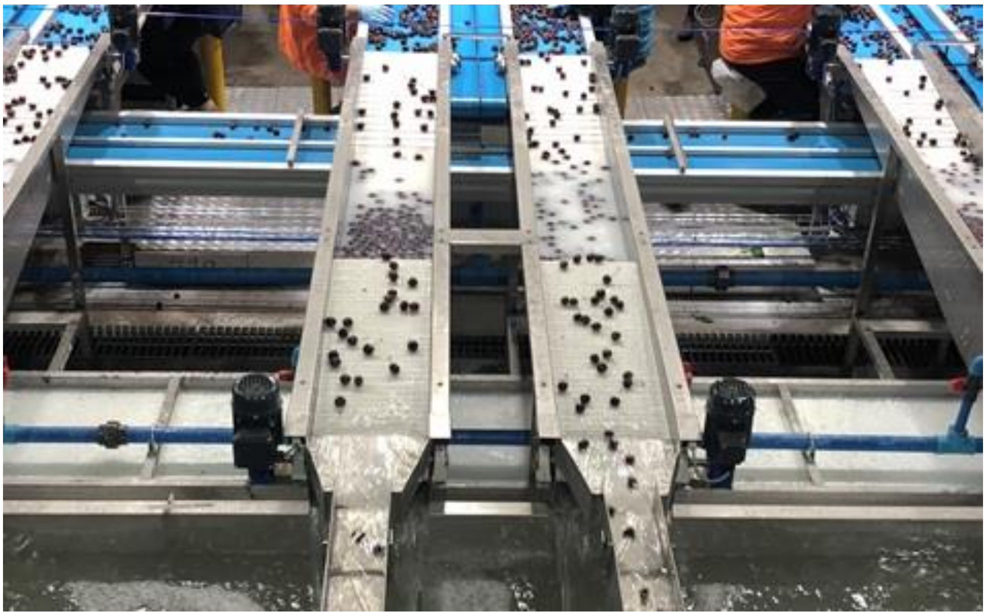

Figure 12: Cherries dipped in fludioxonil before boxing, Curico, Chile (Author, 2018)

There are currently two fungicides registered for post-harvest use in cherries in Australia:

- **Fludioxonil,** sold under the tradename Scholar, is registered for control of *Monilinia spp., Botrytis cinerea, and Rhizopus stolonifera*.
- **Iprodione**, sold under the trade name Rovral, is registered for control of *Monilinia spp., and Rhizopus stolonifera*.

Matias Heitzer, of GP Graders, advised that almost all Chilean producers utilised post-harvest fungicide dips to some degree and that "*If the crop has been affected by rain, then Scholar is a must*" (Heitzer, pers. comm., 2018).

Botrytis cinerea has been found to reproduce, albeit slowly, even at the low temperatures associated with cherry storage. Considering the high likelihood of spores being present in packed produce and high humidity storage conditions, fludioxonil treatment represents the best fungicide treatment for producers in Tasmania to lower the risk of post-harvest rots developing in storage. Studies have shown however that dominant pathogens can vary from region to region and as such, fungicide treatments may need to vary to ensure effectiveness (Barry, *et al*., 2016).

Many importing counties (particularly in the European Union and Asia) have tight restrictions on the use of synthetic post-harvest fungicides. Producers must be aware of regulations in place for all prospective trade partners and find a balance between potentially limiting market access and packing cherries with a potentially greater shelf life.

Chapter 4: Cooling and Packaging

Post packing cooling

The linear relationship between temperature and cherry respiration rate, and the associated link between respiration rate and rate of fruit deterioration, indicates that the longest possible shelf life is achieved when fruit is stored at as low a temperature as possible. The relationship between sugar content and freezing temperature has shown that fruit with high sugar content (22.5% brix) freezes at -2.5°C, while fruit with low sugar content (16.7% brix) freezes at around -1.8°C. With these factors in mind, it is recommended that sweet cherries be stored between -0.5°C and 0.5°C (Golding, 2017).

Most Australian cherry packing follows a similar procedure:

- Full bins or totes of fruit are received from the field.
- Bins are hydrocooled to remove field heat.
- Bins are stored in 0-1°C cool rooms for 1-3 days.
- Fruit is graded with chilled water flumes to transport fruit to sorting tables within an insulated packing room.
- Fruit is packed into sealed boxes, random weight bags, or punnets and palletised.
- Palletised fruit is held in cool rooms between 0-1°C prior to dispatch.

Fruit handled in this manner is highly unlikely to have a pulp temperature lower than 3-5°C at time of palletisation. Using these systems, cherries can only effectively be cooled through initial hydrocooling and passive room cooling during pre-packing storage. Chilling of fruit with transfer flumes will most likely maintain current fruit pulp temperature without significant further chilling. Several cherry packing lines have in-line hydrocooling systems installed which allow fruit to experience most of the earlier, rougher packing procedures at a warmer temperature (6-10°C) before entering a submerged or shower-type hydrocooler immediately before de-watering and box filling. Packing fruit under these conditions offers several advantages, the main one being the increase of fruit pulp temperature during the earlier packing processes will result in less fruit sustaining pitting and bruising damage (Crisosto, *et al*., 1993). However, most in-line hydrocooling systems will fail to have the cooling capacity to remove this excess heat and thus final pulp temperatures at box filling will still be in the range of 2-5°C. A recent survey of six pack houses in British Colombia, all of which were utilising in-line hydrocooling, found that the most consistent systems were producing fruit pulp temperatures of 2.1-3.2°C at box filling (Toivonen, 2014). The same study found that pulp temperature in palletised boxes showed little to no further decrease when held in 0°C cool rooms for 20 hours. In fact, only when pallets were held in very cold rooms (-1.7°C) and placed directly in the path of cool air from the refrigeration coil was any serious lowering of pulp temperature observed in the first 20 hours. This further cooling was only measured in boxes on the outside of pallets, with internally stacked boxes showing no further cooling, even under these colder conditions.

The Australian and Tasmanian cherry industries rely heavily on (relatively) cheap air freight and a developed domestic transport system to deliver fruit to international markets within days of packing. When the cool chain is managed correctly and cherries reach the final consumer within a week of packing, fruit pulp temperatures of 2-4°C on dispatch are sufficient to ensure fruit quality is maintained. These ideal conditions are not always a reality though when many producers rely on having fruit in certain markets at specific times or when market prices are high. Volatile relations between trading partners and the potential for unforeseeable events means having the ability to hold fruit in storage for any increased length of time could be priceless. Achieving lower fruit pulp temperatures at dispatch through current packing processes is challenging as any further reduction in temperature prior to packing will raise incidence of pitting and bruising damage. Paired with Toivonen's findings that passive room cooling does not significantly cool fruit once it has been palletised, one of the most commonly utilised methods to achieve such results is forced air cooling (FA cooling).

FA cooling, also known as pressure cooling, is a post-packing process in which chilled air in a cool room is sucked through vent holes in the sides of palletised boxes. FA cooling systems vary depending on produce being cooled, floor space, and produce packaging but the most common system found in cherry pack houses is tunnel-style. A standard tunnel cooling system will consist of two rows of palletised produce stacked against the cool room wall. Built into the wall between the rows is a large suction fan. The top of the aisle created between the two rows of pallets, and the end opposite the fan are sealed by tarps. Once this fan is turned on, negative pressure is created in the aisle between the pallets. Cold air in the cool room must then travel through the side box vents and around individual cherries to reach the low-pressure area in the aisle (Figure 13). Once it has been sucked through the pallets, this warmed air will be cooled with a refrigeration unit and recycled back into the cool room.

Figure 13: Tunnel-style forced air cooling of stone fruit, HMC, California, USA (Author, 2019)

When cooling any produce, it is important to keep the concept of 7/8 cooling in mind. This concept refers to the amount of time required to remove seven eighths of the temperature difference between the temperature of produce, and the temperature of the cooling medium, in most cases refrigerated air chilled to 0°C. Regardless of the cooling method (FA, hydrocooling, passive room cooling), produce cools quickly at first, then slowly over time. 7/8 cooling aims to bring the fruit pulp temperature as close as possible to optimum storage conditions, while avoiding the excessive cost and time of fully chilling cherries to the temperature of the cooling medium. In theory, ¾ cooling time is twice the ½ cooling time and 7/8 cooling time is three times the ½ cooling time. This is almost never completely true as storage temperatures generally fluctuate. The cooling curve however is a useful tool to predict when produce will reach a certain temperature. For example, should cherries with a pulp temperature of 6°C and a cooling medium of 0°C take two hours to reach ½ cool temperature of 3°C, it can be extrapolated that a pulp temperature of roughly 0.75°C can be achieved after a further four hours.

All FA cooling systems are most effective when operating in a dedicated cool room, separated from the temperature fluctuations of doors opening and closing and new batches of warmer produce arriving. This style of cooling and operating set-up was viewed at numerous sites across Chile and the United States and clearly appears to be the preferred method to cool cherries after packing. Portable tunnel cooling units can be utilised in existing cool rooms although this often requires an upgrade of refrigeration to handle the increased heat load.

Currently, all cherry producers in Chile use FA cooling to lower cherry pulp temperature as much as possible before dispatch. For these pack houses, this is a minimum requirement for fruit to withstand the 20+ day sea journey to be marketed in China. Achieving such a low pulp temperature requires palletised cherries to be cooled in purpose-built FA rooms for 10-24 hours with -0.5°C chilled air. Shipping fruit any warmer than this from Chile would not enable it to survive the journey to Asia in acceptable, marketable condition.

Renown cherry researcher, Prof. Juan Pablo Zoffoli, is a vehement believer that packing fruit at a warmer initial temperature and removing heat after box filling has been the key to increasing shelf life of cherries grown in Chile. Speaking to cherry growers around the globe, Prof. Zoffoli has not only continued to stress the importance of this shift in mindset but has himself undertaken research to justify this considerably different concept (Zoffoli & Rodriguez, 2014). When asked to comment on current packing systems used in Tasmania, Prof. Zoffoli was adamant that “packing cherries at such a cool temperature was most likely causing considerable damage” with his research indicating that fruit packed at 6°C suffers less than half the pitting of fruit packed at 3°C (Zoffoli, pers. comm., 2018).

With considerable government and industry body funding which has fuelled cherry handling research in the country, many believe that a cherry shelf life of 60 days can soon be achieved (Jara, pers. comm., 2018). Although this time frame would be considered overkill for Tasmanian producers, the successes of the Chilean industry largely prove that these cherry handling techniques and procedures lead to the greatest extension of shelf life currently seen in the world.

Although not always heavily export focused due to high domestic consumption, the majority of large-scale packing sheds in the Pacific north-west of the USA also utilise FA cooling post-packing. This is especially true at Stemilt Growers in Wenatchee, Washington where production manager Steven Bowden describes their core dispatch procedure as "*no fruit leaves the shed warmer than 34°F (1°C)*" (Bowden, pers. comm., 2019).

Box design

FA cooling does not require produce to be packed in water-resistant containers although it can cause water-loss and dehydration in some situations. Since almost all cherries are sealed in polyethylene bags, this potential water loss is usually not an issue. One of the greatest advantages of tunnel style cooling is that most container types are suitable so long as there are enough side vents, and these vents line up through the pallet.

There are many factors that affect the rate of cooling in a FA system, including fan size, air leakage, density of produce in pallet and the packaging container used. Fruit cools faster if the air can pass uniformly through the pallet. Thompson, et al. (2002) advise that produce to be cooled using tunnel style forced air should be designed with several factors in mind:

- Vent size and shape should not allow vents to be blocked by produce (avoid small and round vents in the case of cherries).
- Use few large vents as opposed to many small.
- Vents should be at least 1cm wide.
- Vents should be 4-7cm away from box corners.
- Total vent area should be at least 5% of the side area of the pallet.

With these factors in mind, current boxes used by the Tasmanian cherry industry are completely unsuitable for any style of post-packing cooling. Most producers use a solid two-piece box where fruit is packed into a modified atmosphere (MA) bag within a 1, 2 or 5kg sized cardboard base. The bag is then sealed and a cardboard lid is placed over the top with these boxes then placed inside a larger cardboard outer (Figure 14). As well as providing good structural strength, these boxes are predominantly designed for the gift market. Due to the close proximity of the Tasmanian harvest season to Chinese New Year, this gift market is a lucrative one as many Chinese consumers purchase Tasmanian cherries in these 1 or 2kg boxes to give to friends and relatives. Packing directly into this packaging means that fruit will not need to be repacked in Asian markets and helps to maintain the consumer perception of Tasmanian cherries being of a premium standard and quality.

Figure 14: Generic 2kg two-piece box with generic 6x2kg outer commonly used in Tasmania (Author, 2019)

The issue with this style of packaging is the inability to cool fruit once it has been packaged and palletised. Even vented boxes under passive cooling conditions have been shown to maintain current fruit temperatures for at least 20 hours (Toivonen, 2014). It is most unlikely that sealed, unvented boxes stacked in sealed, unvented outers will show any decrease in fruit temperature once palletised at all in the same period of time.

For Tasmanian cherry producers to achieve a lower pulp temperature, boxes and outers will need to be re-designed to feature vents, allowing for FA cooling. This may well have some implications in regard to specified protocols of importing trade partners but currently it represents the best feasible option to extend shelf life.

Modified Atmosphere (MA) packaging

Cherries maintain quality in storage longer when oxygen levels are low, and carbon dioxide levels are high, lowering the respiration rate of the fruit. The optimum ratio of gasses can be achieved through controlled atmosphere storage, or most commonly through using modified atmosphere (MA) packaging. This practice involves packing cherries into polyethylene plastic bags with specific film permeability to allow carbon dioxide and oxygen gasses to reach a desired equilibrium. There are several different bags used globally, with each designed to be used under certain temperatures, and with a specific volume of fruit. Usually, the high level of carbon dioxide in these bags is generated by the natural respiration of the cherries. This is referred to as 'passive MA packaging' and it can take several days or even over a week in storage until gasses have reached required equilibrium. Alternatively, the bag can be directly filled with desired concentration of gasses before being sealed. This is termed 'active MA packaging' and allows the benefits of MA to be applied immediately.

MA packaging is widely used in the cherry industry, and as suggested by Aliqu, *et al.* (2003), it offers several keys to improving shelf life including:

- Maintain greenness of stems.
- Delaying the change of colour in fruit.
- Minimising losses in firmness and acidity.
- Lowering the rate of total soluble sugar decline.
- Preventing shrivel and water loss by maintaining fruit in a relatively high humidity environment.

Levels of carbon dioxide and oxygen in the bag need to be monitored and maintained as an excess of carbon dioxide can be detrimental to the fruit and result in an 'off-flavour', usually affecting returns. Maintaining the cold chain becomes especially critical when using MA packaging as the rate of respiration of the cherries directly influences the levels of gas within the bag. Any break in the cold chain will cause fruit to warm up and rate of respiration to increase beyond that of which the bag is designed for. This will alter the atmospheric composition within and negatively affect or destroy fruit quality.

Recent research by McCrory (2019) showed that although refrigerated trucks used by the Tasmanian industry to transport cherries between packhouses and freight forwarders have set temperatures of 2°C, actual air temperature within said trucks was often closer to 4°C. For any produce to be exported from Tasmania, it is must first be transported by refrigerated truck to Melbourne or Sydney via ferry. Depending on where in the state that fruit has originated from, it will spend up to 20 hours within this truck. While temperatures of 4°C for this period of time is not likely to cause dramatic fluctuations in fruit core temperature of palletised fruit, it is still important to note that this link in the cold chain is not quite operating as producers may have believed. This also further illustrates that once cherries have been palletised, any further reduction in fruit temperature is very unlikely.

Chapter 5: Marketing

Tasmanian cherries exported to Asia are sold through several differing channels, depending on the market. Commonly, large sized fruit is packed directly off the line into 1 or 2kg boxes which are eventually sold to consumers who in turn gift these boxes to their friends or family. These types of sales are especially strong in the period just before Chinese New Year. This sales avenue is extremely important to the industry as natural harvest timing and air freighting allows many of these gift-type boxes of Tasmanian cherries to arrive in good condition when market demand is highest. This style of packaging is also beneficial to producers as it allows for convenient shipping: most box dimensions are designed with freight efficiency in mind and very little air space wasted.

While Chinese New Year represents the peak demand for cherries in Asia, much fruit is distributed before and after this time. The vast majority of this is sold through supermarkets, as also seen in Australia. Marketing cherries has long presented a challenge for retailers with pre-pack bags and punnets much preferred to past methods of consumers selecting individual cherries for themselves. These packs are now sold by practically all major retailers of cherries throughout the world, with most North American pack-houses packing into random weight bags with several of these bags in an 18lb carton. This allows for less double handling as consumers can take these bags direct to the checkout. However, despite this advantage, this style of packing is uncommon when dealing with export as an unacceptable amount of freight space is lost due to inefficiencies in stacking pre-pack containers. More often fruit is bulk shipped in 5kg or larger boxes with final sorting and re-packing taking place at receival. This takes advantage of cheaper labour and packaging in countries such as China, Vietnam and Malaysia. With cherries still being seen as somewhat of a luxury item amongst Asian consumers, these pre-packaged bags/punnets help to increase consumption amongst those who otherwise could not afford to buy cherries by the kilogram.

Figure 15: Pre-packed punnets of Chilean cherries on retail display, Hong Kong (Author, 2016)

Fresh cherries on sales display by retailers in Australia are presented either within a refrigeration cabinet or on a promotional table exposed to ambient room temperature. Research showed that cherries under the latter conditions experience temperatures of up 20°C, as opposed to those in refrigerated cabinets which maintain fruit at a much more reasonable 4-8°C (McCrory, 2019). Given that the respiration rate of cherries directly influences the rate of fruit decay, and respiration rate is directly impacted by temperature, this type of ambient temperature display is undoubtedly negatively affecting the fruit and in turn the consumers' eating experience. Alas, similar types of unrefrigerated displays were seen all around the globe with many poor-quality cherries, with dry, shrivelled stems visible within the packaging (Figure 16).

Figure 16: Poor quality cherries for retail sale on promotional display, USA (Author, 2019)

For the per capita consumption to increase in Australia, cherries simply cannot continue to be marketed this way and communication between producers and major retailers is essential for this to improve. Whether it is overseas or domestically, fresh cherries for many consumers continue to be somewhat of a treat and often an impulse buy. It is clear that selling fruit in punnets or pre-pack bags is an effective tactic to improve sales and reduce wastage although for smaller producers, installing such packaging technology is likely not financially viable. Additionally, packing sheds located in regional areas or in Tasmania will perhaps find difficulties associated with increased freight costs due to less efficient pallet stacking. For those fortunate enough to possess harvest timing that is compatible with Chinese New Year gift box demand, this should remain a strong focus.

Given the rapidly increasing demand for cherries from China, and South-East Asia in general, strong export potential for Australian and Tasmanian growers still exists. The focus of the Chilean cherry industry for several years has been the same – increase volume and increase shelf life. The Chileans are not interested in competing with other southern hemisphere fruit producers, instead employing a marketing campaign to increase Chinese consumer awareness of the 'Chilean fruit' brand.

Ignacio Caballero of ASOEX, a non-profit entity representing 90% of all fruit exports from Chile, perhaps sums it up best: "*Other cherry growers aren't the competition, chocolate is*" (Caballero, pers. comm., 2019). This attitude is common within the Chilean fruit export industry. Rather than increasing their market share within Asia, continuing to increase the size of the market is far more of a focus. To this point, this has been largely successful and has been achieved not only through a vast improvement of fruit handling techniques, but also targeted and intensive marketing direct to Chinese consumers. The most recent marketing campaign of this nature is known as 'Enjoy your red moment.' This campaign is solely focused on marketing Chilean cherries to China and runs with a budget of almost US$5 million a year, utilising online ads, social media, point of sale displays, television ads, and many public advertisements. Most recently, the campaign placed greater emphasis on regional cities in China. This spread across China is likely to continue as an increasingly greater amount of Chilean cherries arrive at Chinese ports.

The sheer production volume of the Chilean cherry industry, and its commitment to China, does not necessary spell disaster for Australian exporters hoping to maintain or improve current returns. Through considerable government and industry investment and unification of growers and packers, it is clear that the Chileans will remain dominant in this landscape for years to come. To remain viable, Australian growers must promote their brand and strive for the premium end of the market as their South American compatriots continue to increase the popularity of counter-seasonal cherries in the South-East Asian region.

Conclusion

Current cherry handling practices of export-focused producers in Australia are consistent with those in Chile and the USA, with a few key points of difference. The vast difference in scale between producers in these countries with those in Tasmania will make much of the current packing technology unviable for many in the state. Modern optical graders will continue replace their mechanical predecessors with this takeover all but complete.

Current cold chain management is acceptable but there is still room for improvement. Cherries should be cooled to a pulp temperature of under 5°C as soon as practical, as much shelf life may be lost between harvest and hydrocooling.

The single biggest contributing factor to shelf life is fruit respiration rate, which itself is directly related to storage temperature. Consequently, fruit should be held between -0.5°C and 0.5°C after packing.

Pitting frequency and severity can differ between seasons and varieties. The cause of this problem, however, is physical impact on the cherry and this becomes more prevalent as cherries are handled at colder temperatures.

FA cooling or in-line hydrocooling represent the only viable methods to further reducing fruit-pulp temperature without noticeably increasing damage to cherries. For FA cooling to be effective, current box designs would need to be modified.

Increasing cherry consumption within Australia can only be achieved through collaboration between growers and retailers to improve presentation of cherries and make for a more enjoyable eating experience for the consumer.

Recommendations

The focus on quality over quantity when exporting into Asian markets has been prevalent for some years. This will almost certainly continue as commodity prices for cherries continue to decrease. With several advantages over international competitors, many improvements to existing systems can be made to develop this emphasis on presenting the best cherries on the market. In all likelihood these premium sales opportunities, including the lucrative Chinese New Year gift market, represent the best chance for Tasmanian cherry producers to remain financially viable. Key recommendations from this report are:

- The Asian export markets need to remain a key focus. The Chilean crop is predicted to continue to expand and as such, it has never been more critical to produce the highest quality fruit.
- Australian producers should continue to focus on air freight rather than exploring sea shipping. The ability of Australian producers to air freight fruit quickly and efficiently to China gives a distinct advantage over Chilean producers who will continue to rely on sea shipping due to the financial limitations of air freighting.
- Reduce the amount of time a piece of fruit is handled. This will reduce bruising and improve final quality, although this must be balanced with maintaining transport efficiency and logistical practicality.
- Cherries must be introduced to the cold chain as soon as possible. Design of harvest systems should place emphasis on reducing the time between picking and hydrocooling with inefficiency in this area causing irreversible reduction of shelf life.
- Reduce pitting by slowing cluster cutter belt speeds, reducing hydrocooler shower height and reducing fruit drops to as low as possible. Packhouses should place larger emphasis on monitoring packing lines and making alterations to minimise all fruit impacts. Water flumes provide a better option to transport fruit than solid belts.
- Ensure post-harvest fungicide dips take place to reduce occurrence of rot, especially when used in conjunction with modified atmosphere packaging. Packers must be aware of maximum residue levels of importing countries and make decisions accordingly.
- Encourage modification of box and outer designs to include vents to make FA cooling feasible. This process represents the greatest opportunity to lower fruit pulp temperature and improve shelf life and is used commonly in all major global cherry production areas. With current air freight capacity, improving cherry shelf life through FA cooling may not necessarily improve returns directly, although the greatest benefit would be the ability to hold fruit and allow marketers to better target time periods of greater demand.
- Limit investment for domestic consumption growth to large-scale producers. Increasing domestic consumption would likely not be without significant commitment and servicing this market would not be feasible for all packers due to insufficient scale to invest in punnetising or bagging technologies.

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Plain English Compendium Summary

Project Title:	Improving Sweet Cherry Fruit Quality
Nuffield Australia Project No.:	1908
Scholar:	Jake Newnham
Organisation:	Lowdina Orchard 1321 Colebrook Road Campania, TAS 7026
Phone:	0437710927
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Objectives	This report looks at the changes can be made to produce a better end product. The main objectives are: • Understand the best handling practice to get fruit from the orchard to the packing shed with as little impact on fruit quality as possible. • Find the best practice cold chain management procedures for Tasmania and Australia, given that packing technology is constantly evolving globally. • Understand how the implementation of forced-air cooling could improve cherry fruit quality given the global prevalence of this technique. To compare a variety of packaging types and find what is most commonly used to provide the greatest improvement in shelf life. • Investigate how the current handling practices of domestic retailers compare with those of their global counterparts.
Background	Tasmanian cherry producers are dependent on Asian exports far more than their counterparts on the mainland. International competitors in this market have vastly increased productivity and improved fruit quality. The Tasmanian industry must match these quality improvements to remain viable.
Research	This study was conducted by visiting numerous growers, packers, researchers and marketers across the USA, Canada, Chile and New Zealand. Many published reports in the field of post-harvest handling and fruit shelf-life were reviewed with several being cited within this report.
Outcomes	Tasmanian handling practices are adequate for the current market conditions but still inferior to many producers around the world. The small size and scale of the industry means that international competition will always be more advanced in terms of packing technology. Key areas of potential improvement were investigated with several practical advances highlighted.
Implications	Improving the overall quality of fruit industry-wide is possible but will require investment and commitment from producers. Placing a greater emphasis on initiating the cold chain as soon as possible, and redesigning packing procedures to reduce the pulp temperature of fruit at dispatch will most likely provide the improvements in quality and extension of shelf life the industry desires.
Publications	Nuffield Australia Virtual Online Presentation, March 2021