4.3.1

8. Cooling

Cold requirement of Apples and Pears

Certain pears have a cold requirement that must be overcome or met during storage. For most pear cultivars, direct cooling and packing provides adequate cold for the cold requirement of the fruit, as exported fruit normally has a minimum journey of 4 weeks at –0,5°C. The riper the fruit is picked, the less the cold requirement for the fruit to ripen normally. When this cold requirement is met, fruit will ripen normally. For Summer pears, such as Bon Chretien, this cold requirement is as little as 3 weeks. Red D' Anjou pears for instance have a high cold requirement of up to 8 weeks, and Forelle pears as much as 12 weeks. There are special arrangements in place in the South African Industry to manage this requirement of Forelle. Fruit is sampled and analysed in the various production regions to identify harvest release dates per region. First shipping dates are set eight weeks after the release dates. The remaining four weeks cold requirement is achieved during the shipping and marketing period.

There are two ways of cooling the fruit:

- Pre-cooling in forced-air tunnels: Fruit can be forced-air cooled in cooling tunnels. This method shortens the normal cooling down time of 5 days down to 48 hours. Heat is removed rapidly in this way; moisture loss is kept to a minimum and respiration of the fruit is slowed down. When the correct temperature is reached, fruit can be placed in a normal cold room.
- Room cooling: Fruit is placed in a cold room and stacked in front of the cooling fans in such away that the bins form a barrier to the path of the air. Air is forced through the barrier.

Cooling to –0,5°C should be accomplished in 24 to 48 hours (for Summer pears) to a maximum of 144 hours (for apples only). Any longer cooling periods will result in severe moisture loss and risk of wilted fruit. All Summer pears should be cooled within 48 hours. Research by ARC Infruitec-Nietvoorbij has shown that in the case of CA storage on pears, the attainment of the temperature requirement is of greater importance than the gas regimes. While attaining the correct temperatures for apples within the required period is important, research has shown that the attainment of the required gas regimes is more important. Details of CA storage can be obtained from the SAAPPA CA Operators Manual, available from DFPT Research.

Cooling Guidelines:

- Cold rooms should be prepared (disinfected) and switched on before the commencement of harvesting. This will ensure that cold room walls and floor are cold prior to fruit being loaded in the cold rooms.
- Disinfection: Cold rooms can be cleaned with a chlorine solution of 75 to 100 ppm. Chlorine is a corrosive agent and the necessary precautions should be taken. Other non-corrosive or "softer" disinfectants such as the Quaternary ammonium compounds can be used.
- The cooling capacity of the room should not be exceeded.
- Doors should be kept closed or fitted with a plastic curtain or automatic air curtain to prevent warm air from entering the cold room.
- As soon as the recommended temperature is reached, fan speed can be reduced in order to minimise moisture loss from the fruit.

9. Temperature, Relative humidity (% RH) control and use of the Psychrometric chart.

Fruit contains 85% – 95% water. As soon as fruit is picked, it loses its ability to replenish lost water. Water moves out of the product as a result of certain driving forces such as temperature and humidity. **Always remember: cooling causes drying out, hence the period of cooling must be as short as possible and the air speed as low as possible** (high air speeds are necessary during initial cooling, but as the target temperature of the product is approached, the air speed must be reduced). There are several methods by which moisture loss can be minimised and the effect is ascribed to the minimising of the vapour pressure deficit. The moisture holding capacity of air is measured in units of pressure, and there are two important measurements concerned with figuring out how much moisture a given block of air can potentially absorb. First is the saturation vapour pressure (SVP): think of this as the maximum amount of water vapour a given block of air can hold. Second measurement is the difference between the amount of water vapour actually in a given block of air and its SVP (i.e., the maximum amount of water it *could* absorb). This difference is called the vapour pressure deficit, or VPD. Think of VPD as the water sucking power of the air, because it is actually the VPD that affects your fruit, not the relative humidity.

At face value, VPD (sucking power) seems to be the same as relative humidity - because relative humidity is the ratio of the actual vapour pressure in the air to the SVP. Its not the same, because the SVP of a given block of air increases exponentially as the air temperature rises - the higher the temperature, the greater the amount of water vapour that air can hold.

The primary factors that play a role with the VPD are the temperature of the produce and environment, speed of harvesting, packing and cooling. The following is an example of how the Psychrometric chart is used to determine relative moisture loss.

Example:
This example shows that it is important to move fruit to the cold rooms as fast as possible.

Driving force for Moisture loss when fruit is kept outside	**Driving force for Moisture loss when warm fruit is initially placed in the cold room**	**Driving force for Moisture loss when fruit is cooled to 0 ^{0}C**
Fruit harvested at 30°C and 30% RH	Fruit harvested at 30°C and 30% RH	Fruit temperature is 0°C
	In cold room at 0°C and 90% RH	Cold room at 0°C and 90% RH
Fruit RH is 100%	Fruit RH is 100%	Fruit RH is 100%
VPprod – Vpatmos = VPD	VPprod - VPatmos = VPD	VPprod - VPatmos = VPD
VPD = 43 –14 = 29 mbar	VPD = 43 - 6 = 37 mbar	VPD = 6.5 - 6 = 0,5 mbar

The example illustrates that more fruit moisture is lost due to large differences in VPD. It is thus important to minimise the periods of large differences in VPD.

Figure 3. The relative (potential) moisture loss during slow and optimally cooled fruit

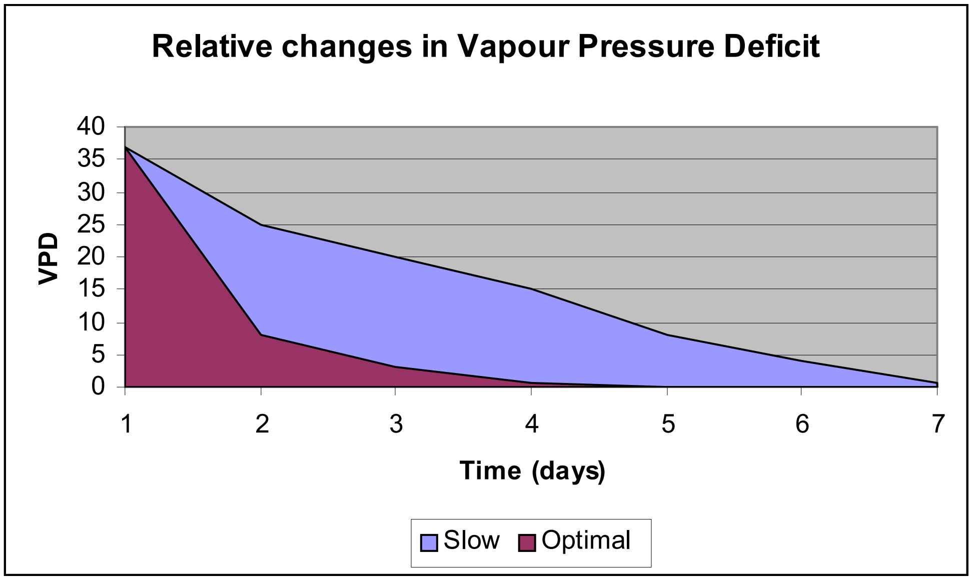

Figure 3 depicts the relative changes in VPD during cooling. The area under each line represents the potential moisture loss of the fruit. The graph shows that fruit loses relative less moisture during the shorter cooling period.

Warm fruit (coming from the orchard) is exposed to a high VPD due to the temperature of the fruit versus that of the room. It is therefore necessary to cool the fruit as fast as possible in order to minimise the VPD. Fruit will lose moisture during any cooling process but the idea is to shorten the period of high exposure to a large VPD. Therefore forced air-cooling is a much more effective method of cooling fruit than room cooling – especially for the high-risk cultivars.

Moisture loss is cumulative, and relative more moisture is lost on day one than on day 4 of cooling, although the VPD changes during the cooling period as the temperature changes. When the fruit and the room temperature are the same the VPD stays low and constant and RH plays a major role in moisture loss during this extended time.

Relative moisture loss can be calculated under various conditions by using the Psychrometric chart (Figure 4). To use the chart, find the vertical line for the dry bulb temperature at the bottom of the chart, and the slanted line for the wet-bulb temperature at the curved top-left edge. Find the intersection point of these two lines, and read the percent relative humidity from the curved lines nearest that point.

The purpose of cooling fruit is to significantly slow down respiration, moisture loss, ethylene production and pathogenic decay.

A good cold room design should ensure that high humidity is retained; good insulation is assured; enough air can circulate over the coil and unnecessary high air speeds are avoided.

15. Defects of Apples and Pears after poor cooling.

- Over-ripe fruit (low firmness)
- Wilted fruit, especially pears
- Yellowing of fruit, especially Bon Chretien, Royal Gala and Golden Delicious
- Bitter pit development, especially Golden Delicious and Braeburn. This however is linked to the bitter pit potential of the fruit.
- Reduced storage potential and shelf-life.
- Mealiness in Red Delicious types.
- Greasiness in Granny Smith and Cripps' Pink (Pink Lady®) - linked to over maturity