Persimmon Postharvest Manual

Queensland Government

Persimmon postharvest manual

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Contents

INTRODUCTION TO THE MANUAL

The main objective of using postharvest technology is to;

- Maintain the appearance, texture, firmness and flavour of the fruit
- Maintain food safety
- Reduce losses between harvest and consumption.

Understanding changes in maturation of the fruit during development is discussed in Chapter 2.

Pre-harvest harvest factors such as nutrition and climate can greatly influence the potential storage life of fruit and are discussed in Chapter 3. Soft fruit disorder (SFD) which is characterized by rapid softening of fruit less than 7 days after harvest is discussed in Chapter 4. Picking at the correct maturity can optimize postharvest storage life and when combined with correct harvesting procedures can result in a high proportion of class 1 fruit. Maturity standards and harvesting methods are discussed in Chapters 6 and 9.

Persimmon fruit are particularly susceptible to blemishing and it is the major cause of non-marketability, followed by factors such as fruit size. In the past, the percentage of marketable fruit has been reduced by as much as 60%. This is due to blemish marks (wind rub, water marks, petal adherence marks, sunburn, spots and speckles), calyx separation and apex cracking. The causes of blemishing are varied and are detailed in Chapter 7 including:

- environmental (e.g. sunburn)
- nutritional (e.g. green blotch)
- pests (e.g. thrips)
- diseases (e.g. anthracnose)
- physiological (e.g. calyx cavity, poor pollination)
- mechanical (e.g. wire rub)

Produce is a living, breathing commodity. Once separated from its plant it continues to live on its own resources and produces energy in the form of heat and gives off carbon dioxide. This leads to:

- Ripening
- Weight loss
- Softening
- Colour and texture changes
- Physical degradation, including bruising
- Attack by rots and moulds

An overview of packhouse procedures, packaging and grade standards are outlined in Chapters 10, 11 and 12.

Cool storage issues such as sensitivity to ethylene and chilling injury are discussed in Chapters 13 and 14 and tools to manage these issues such as pre-conditioning and heat treatments, short and long-tern storage, modified atmosphere (MA) bags, controlled atmosphere, 1-MCP (SmartFresh™) and forced air cooling are outlined between Chapters 15 and 22.

Cooling can eliminate or limit these deterioration factors by slowing the respiration of the fruit, however choosing the correct storage conditions are essential to avoid chilling injury. Recommendations for short- and long-term storage for different growing regions and varieties are discussed in Chapter 21.

There can be up to 20% loss of value of product during transport. Up to one out of every 10 consignments can result in poor product quality out-turn on arrival. In the case of the Australian supply/value chain, persimmons can be moved at least 21 times, involves 9 or more players, and exposes fruit to 15 or more breaks in the cool chain. Cool chain handling and transport are discussed in Chapters 23 and 24.

Quality assurance and food safety procedures which manage factors affecting quality and food safety along the supply chain are discussed in Chapters 25 and 26. Exporting and disinfestation are outlined in Chapters 26 and 27.

This manual gives a broad overview of pre and postharvest issues than can affect quality and storage life. Understanding all of these issues and utilizing available tools and technology will result in a larger proportion of high quality fruit reaching intended markets. Short and long-term storage options give growers the choice to store fruit during oversupply in the market.

FRUIT DEVELOPMENT

2.1 Fruit growth

Fresh persimmon fruit go through several stages of fruit development and maturation (Figure 1). Fruit growth follows a double sigmoidal pattern (Kitagawa and Glucina, 1984; Yakushiji and Nakatsuka, 2007).

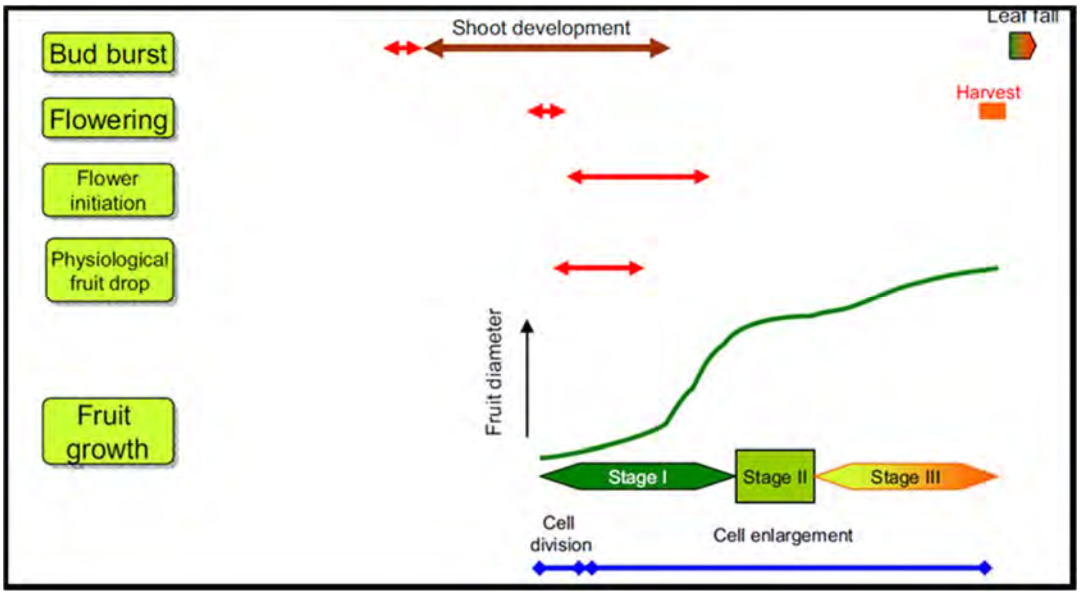

Figure 1. Stages of fruit development and changes in fruit growth (Yakushiji and Nakatsuka, 2007)

2.2 Changes during maturation

Colour

In many fruits, skin colour changes occur during maturation, and/or ripening (Wills *et al*., 1989).

For persimmon, the main colour change occurs during maturation, and is a quick and reasonably reliable indicator of physiological maturity. During maturation, increased carotenoid production and associated chlorophyll reduction causes persimmon skin colour to change from green to yellow through to orange and then red (Ebert and Gross, 1985).

Colour of persimmon skin is usually measured against colour guides developed by industry, such as the Japanese and New Zealand guides. However, to reduce subjectivity in colour research the Hunter Lab colour space model was introduced to quantify colour in three dimensions as L, a and b. (Hunter Lab, 1996). (see Chapter 6 on maturity standards)

Sugar concentrations (Soluble solids)

Sugar concentrations or total soluble solids (TSS) are usually measured as degrees Brix. Generally, persimmon fruits increase in sugar concentration as they mature and the skin colour turns from green to orange/yellow (Figure 2) (Kitagawa and Glucina, 1984).

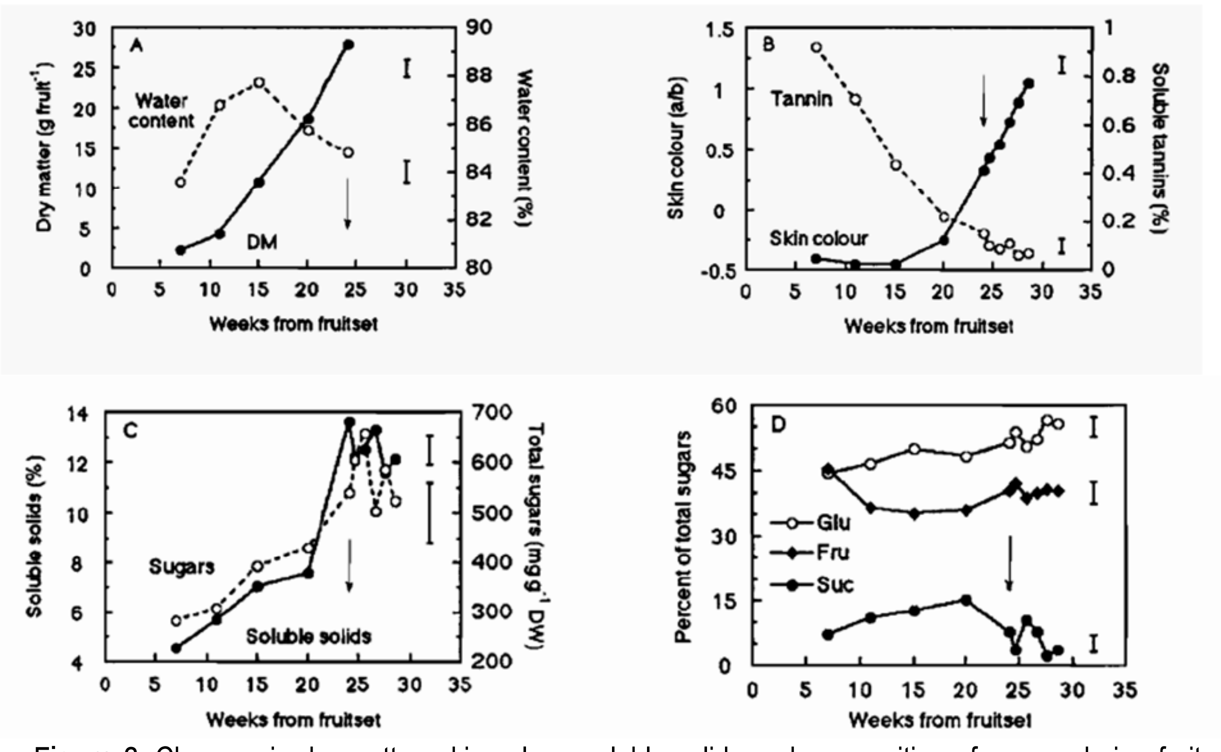

Figure 2. Changes in dry matter, skin colour, soluble solids and composition of sugars during fruit growth and maturation of 'Fuyu' persimmon. Arrows indicate commercial harvest. Data points are the mean of 4 replicates. Error bars are LSDs (P=0.05) based on a pooled estimate of variance. (Clark and MacFall, 2003).

Tannins – astringent varieties
Astringency is the dry sensation in the mouth caused when soluble tannins from the fruit bind to proteins of the saliva, stopping them from 'lubricating' the mouth. This is the same sensation which occurs when drinking strong black tea or red wine, which is also due to the presence of tannins. Soluble tannins are formed during the early stages of fruit development during the cell division stage in the month following fruit set. In the next stage of fruit development, the concentration of soluble tannins decreases as fruit growth occurs and cells expand (i.e. tannin concentration is diluted because of fruit growth). In addition, at higher temperatures soluble tannins form large insoluble polymers that no longer cause the dry mouth-feel (Kitagawa and Glucina, 1984; Jackman *et a*l., 2003).

In astringent varieties, the soluble tannins need to be removed after harvest to make the fruit palatable (Oshida *et al*., 1996; Öz *et al*., 2003; Taira *et al*., 1999; Yamada *et al*., 2002), whereas under most climatic condition, in the non-astringent varieties, soluble tannins disappear through coagulation during fruit maturity (Figure 3) (Kitagawa and Glucina, 1984).

Soluble tannins in astringent varieties, which are responsible for persimmon fruit astringency, are polymerized by acetaldehyde under anaerobic conditions to form an insoluble compound which is non-astringent (Taira *et al*., 1997; Matsuo and Itoo, 1982). Application of high levels of carbon dioxide or nitrogen gas can be effective in removing astringency from the fruit; however, the duration of treatment depends on the cultivar and temperature (Ben-Arie and Sonego,1993).

Tannins – non-astringent varieties
Chujo (1982) found that higher temperatures (25°C-30°C) during fruit development reduced soluble tannin levels in non-astringent 'Fuyu' before harvest, whereas at lower growing temperatures tannins concentrations can be undesirably high at harvest. In Australia, mean daytime temperatures of between 15°C and 22°C are necessary during the autumn fruit ripening period from March to May for non-astringent varieties to completely lose astringency. Mean daytime temperatures of less than 14°C may result in only a partial loss of astringency in normally non-astringent varieties. In contrast to Australia, residual astringency can be a problem in persimmon growing regions of New Zealand due to their cooler summers and autumns.

Soluble solids and tannin concentrations are the two main factors influencing persimmon flavour, and repeat purchase by consumers.

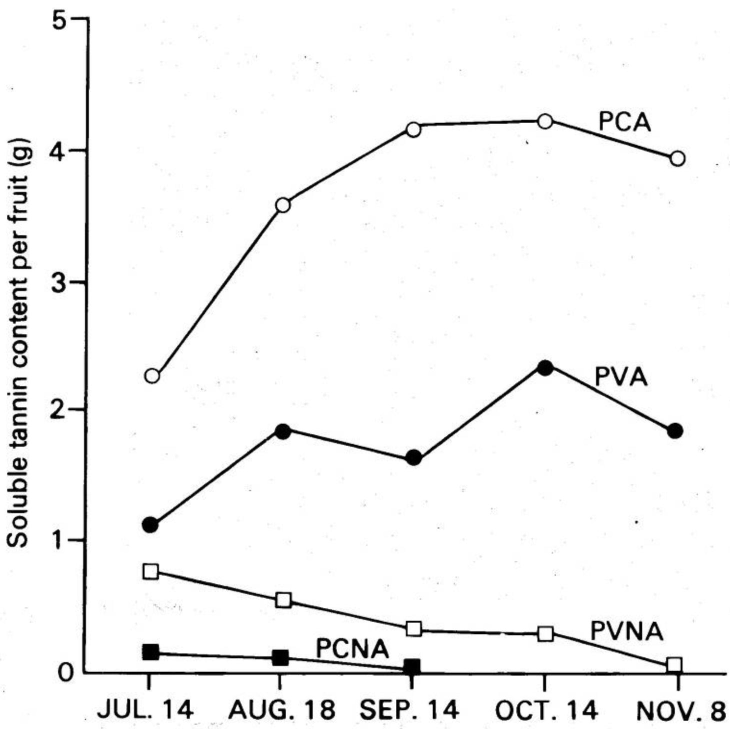

Figure 3. Seasonal changes in soluble tannin content during fruit development of four persimmon varieties in Japan (Itoo, 1980). ○= 'Yokono' (PCA); ●= 'Aizu Mishirazu' (PVA); □= 'Amahyakume' (PVNA); ■= 'Fuyu' (PCNA) (Itoo, 1980). PCA = Pollination Constant, Astringent; PVA = Pollination Variant, Astringent; PVNA = Pollination Variant, Non-Astringent; PCNA = Pollination Constant, Non-Astringent.

Firmness

During persimmon ripening, softening is caused by the activity of the hydrolytic enzymes of the cell wall and by proteins that facilitate these activities such as expansins (Nakano *et al.*, 2003).

Changes in firmness can be used to monitor progress of persimmon ripening (Luo, 2007). Harvested persimmon usually have a firmness >2.3kg of force (using an Effigi penetrometer with a 8mm tip), which then decreases during storage (George *et al.*, 2005).
However, persimmons can soften rapidly within days, sometimes even hours. This softening is initially triggered by ethylene (a natural plant hormone), which is the initial trigger for a range of fruit softening enzymes such as polygalacturonase (PG) and pectinesterase (PE) (Luo, 2007; Niikawa *et al.*, 2005)..

2.3 Persimmon calyx

Persimmon possesses a relatively large calyx compared with other fruits. The calyx contains chlorophyll and shows high photosynthetic ability equivalent to leaves (Nakano *et al.*, 1997). Moreover, unlike the fruit skin, the calyx has many stomata and is considered to be the "gas exchange organ" of the persimmon (Kitagawa and Glucina, 1984). Removal of calyx lobes reduces the fruit carbon dioxide exchange rate markedly, which results in a remarkable inhibition of fruit development (Plate 1) (Yonemori *et al.*, 1996; Nakano *et al.*, 1998). In addition to these functions, the calyx may have a role as stress sensor for the fruit as shown in this study. It seems that calyx has a higher sensitivity to the water stress than the other parts of persimmon fruit and thus acts as a water stress sensor for the fruit.

Besides sensing water stress, the calyx may also sense other environmental stresses. Ethylene produced in the calyx can diffuse into other parts of the fruit where it induces autocatalytic ethylene biosynthesis, resulting in a burst of ethylene production. In some cultivars of Japanese persimmon, such as 'Tonewase' and 'Saijo', even fruit harvested at optimal maturity retain the characteristics of young fruit and thus produce ethylene in correlation with water loss, which in turn causes rapid fruit softening, a major problem in marketing of these cultivars in Japan (Nakano *et al.*, 2001, 2002).

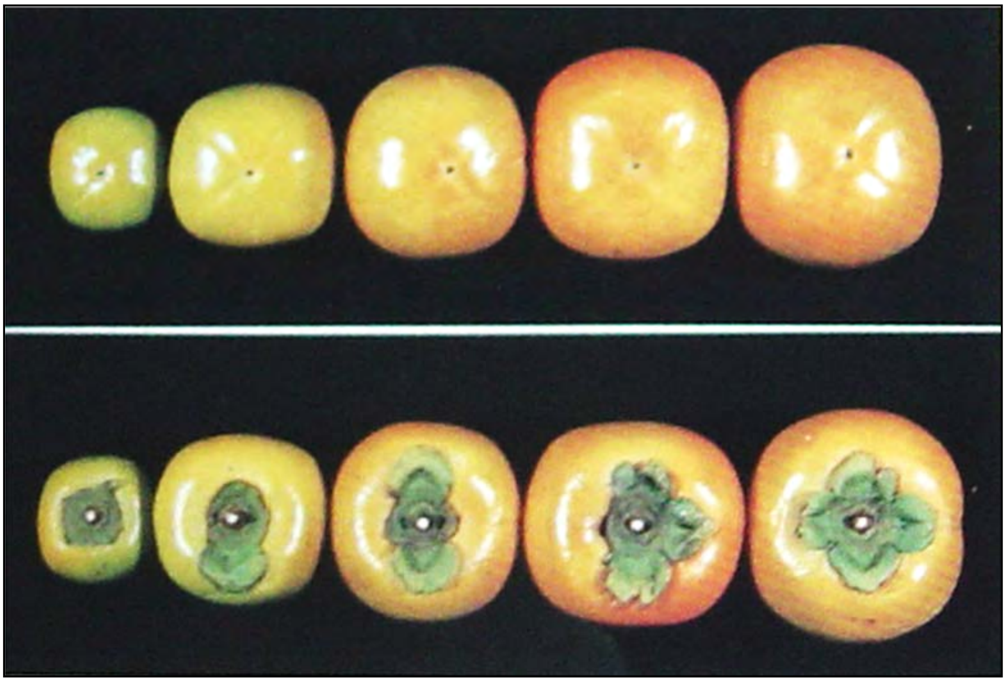

Plate 1. Effects of calyx removal on fruit size. Loss of photosynthetic capacity of the calyx due to sooty mould or loss of calyx area due to chewing caterpillars or disease can have the same effect

2.4 Ripening characteristics of persimmon

The rate of deterioration (perishability) of harvested horticultural fruits is proportional to the respiration rate. Horticultural fruits are usually classified according to their respiration rates and ethylene production patterns during maturation and ripening.

Fruit are either climacteric or non-climacteric (Kader, 2002). Climacteric fruits undergo a rapid ripening phase, in which they soften, colour, and develop desirable flavour and aroma in contrast to a non-climacteric fruit which matures slowly while attached to the parent plant and usually picked when they are sweet and ready to eat (Coates *et al*., 1995).

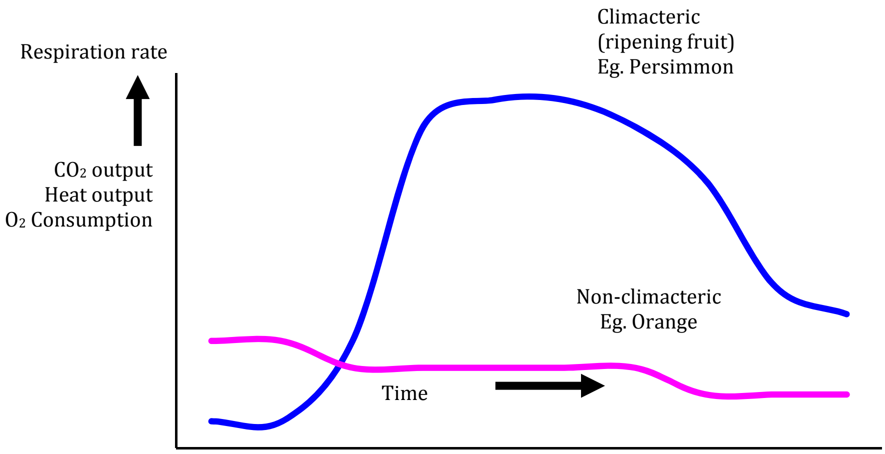

Figure 1. Respiratory patterns of fruit during ripening

Persimmon fruit are classified as climacteric because they produce a small but significant amount of ethylene during ripening (Table 1) (Luo, 2007, Oz, 2011) and are induced to ripen with autocatalytic ethylene production by exogenously applied ethylene (Wills et al., 1998; Kubo *et al*., 2003).

TABLE 1.
Typical ethylene and carbon dioxide emission rates for several kinds of fruit
(Adapted from da Silva *et al*., 2001).

Fruit species	Ethylene emission rate ($\mu L.kg^{-1}.h^{-1}$)	CO_2 emission rate (% in $L.h^{-1}$)
Sugar apple	2.77	1.42
Guava	17.38	2.22
Barbados Cherry	1.52	0.14
Cashew	0.011	-
Papaya	2.24	0.63
Avocado	133.12	3.30
Banana	3.58	0.95
Persimmon	0.19-0.50	0.14

Ethylene production rates vary with persimmon variety but all varieties are very sensitive to ethylene (Kader, 2002; Luo, 2007, Oz, 2011) (See Chapter 13). However, unlike other climacteric fruit species, ethylene production in persimmon is substantially greater in fruit harvested at younger stages (Takata, 1983) and is induced only when fruit are detached from the parent tree (Nakano, 2002).

For example, in persimmon cv. Hiratanenashi, detached young fruit produce more than 10 $\mu L.kg^{-1}.h^{-1}$ of ethylene within a few days after detachment accompanied with rapid softening and calyx abscission. Whereas fruit harvested at the mature stage do not always produce ethylene soon after harvest. They produce as little as 0.2 $\mu L.kg^{-1}.h^{-1}$ of ethylene when they are held in ambient condition for more than 25 days.

In Korea and New Zealand, researchers have found that ethylene concentrations as low as 1 ppm can initiate fruit softening and ripening in cv. Fuyu. Techniques to counter-act the negative effects of ethylene are discussed later.

2.5 Optimum climatic conditions for fruit development

A summary of the most important climatic factors affecting fruit development of non-astringent persimmon are presented in Table 1.

TABLE 1

Optimum climatic conditions for fruit development of sweet persimmon in Australia (George et al., 2005).

Climatic factor	Explanatory notes
At least 1400 hours of sunshine are required during growing season from October to April	This amount of sunshine produces fruit with the best colour and sugar levels
Mean daytime temperatures of between 15°C and 22°C are necessary during the autumn fruit ripening period from March to May	Mean daytime temperatures of less than 14°C may result in only a partial loss of astringency in normally non-astringent varieties. Daytime temperatures above 25°C may affect fruit quality, and temperatures above 35°C may produce severe sunburn of fruit. Lower autumn temperatures increases red skin colour pigments.
Winter chilling of at least 100 chill units is required (preferably 350–550 chill units)	Although persimmons are deciduous plants, and enter a rest period in winter, they appear to have a low chilling requirement for even bud break. They break bud in September, flower in October and are therefore less likely than other deciduous fruits to suffer flower and fruit damage from late spring frosts. Although low chill areas provide an opportunity for slightly earlier crops, high chill areas produce the best quality fruit
Minimal rainfall during the main fruit development and ripening periods is desirable	This minimises disease problems and other blemishes on the fruit. Waterlogging and soil hypoxia can cause soft fruit disorder (SFD).
Protection from strong prevailing winds is essential	Fruit is very susceptible to wind damage and blemish. Wind protection is essential on all sites. Trellising and good pruning greatly reduces blemish.
Absence of frost at flowering time (mid-October) is required	Plant damage is avoided

PRE-HARVEST FACTORS AFFECTING STORAGE - CLIMATE

3.1 Overview

Both climate and nutrition can have large effects on fruit quality and storage life of persimmon. For this reason, climatic effects on storage life are discussed in this Chapter, soft fruit disorder (SFD) in Chapter 4 and key nutritional factors in Chapter 5.

3.2 Temperature effects on fruit development period

In Australia, there are large regional differences in fruit quality and rates of fruit development of persimmon which affect post-harvest storage and shelf life.

In Australia-wide surveys, we have found that the shelf and storage life of persimmon fruit harvested in Victoria and South Australia was much longer than it was for fruit harvested in Queensland or northern NSW (Figure 1).

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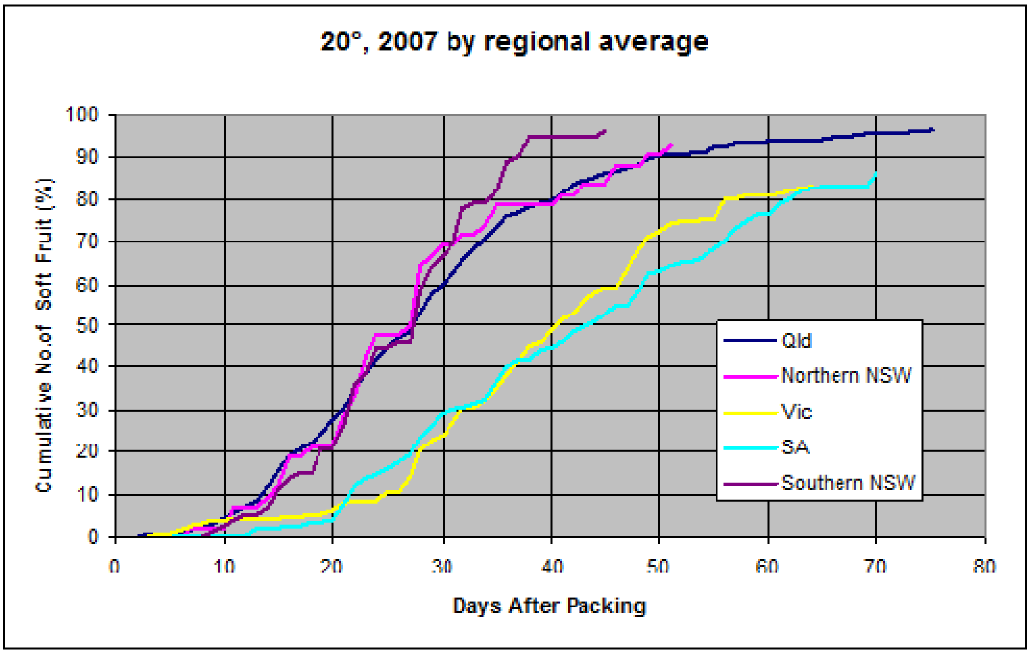


Figure 1. Cumulative softening of cv. Fuyu fruit for regions/States. Fruit stored at 20°C and assessed for first detectable softness every two days.

The reasons for these regional differences in cool storage and shelf life appears to be due primarily to the longer fruit development periods (FDP) of fruit grown in South Australia or Victoria (Figure 2). For example, fruit from Victorian orchards had a 42 day longer FDP than fruit harvested in coastal Queensland.

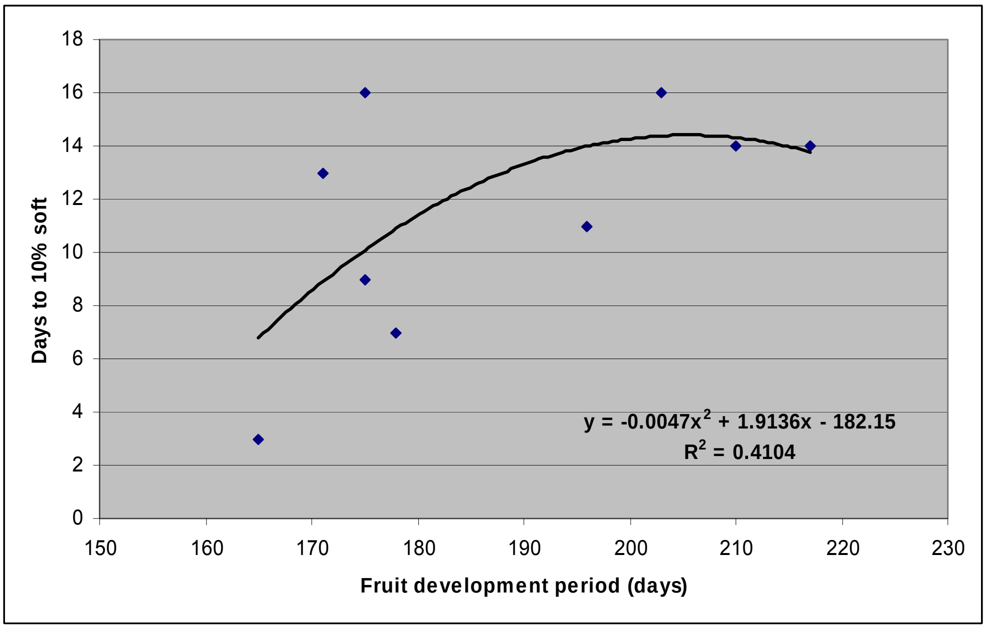


Figure 2. Relationship between fruit development period (FDP) and days to 10% softening for cv. Fuyu in 2008.

We have set a maximum standard of 10% of fruit softening within 7 days after harvesting to be used as an industry standard for domestic retail marketing.

The significantly longer FDPs of fruit grown in Victoria and South Australia appear to be due to cooler soil and minimum air temperatures during fruit development (Figure 3).

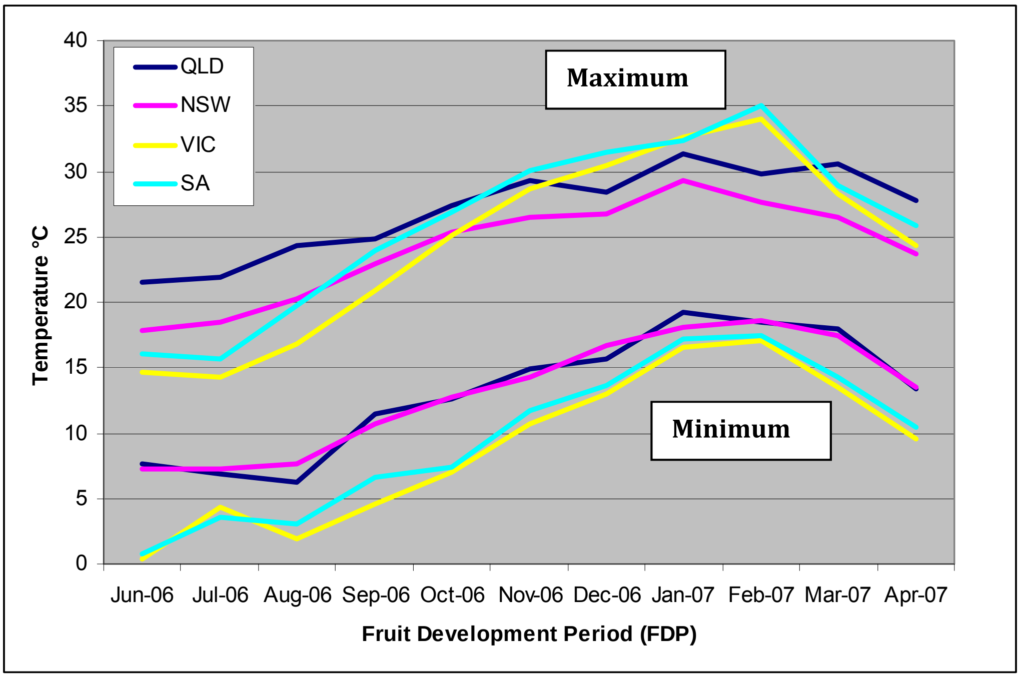


Figure 3. Average maximum and minimum temperatures in the major persimmon production regions of each State.

Fruit softening increased with increasing mean minimum temperatures (r^2 = 0.49, P<0.05) and mean temperatures (r^2 = 0.56, P<0.05) during the FDP and during October (Figure 4). There was no relationship between maximum temperatures and softening.

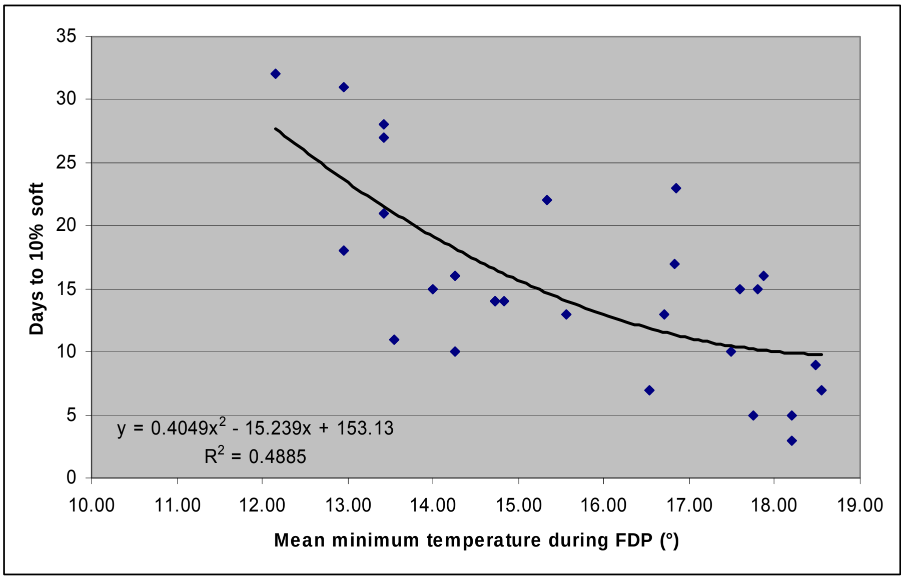


Figure 4. Effects of temperature on days to 10% soft for cv. Fuyu.

This temperature response may be due to:

- slower rates of fruit development under cooler spring growing conditions leading to greater cell division, thicker cell walls, less cell expansion and less carbohydrate resource limitation
- slower rates of shoot extension growth under cooler spring growing conditions leading to less competition between developing fruit and shoots and therefore less carbohydrate resource limitation
- increased net carbon assimilation, lower maintenance respiration and greater dry matter accumulation under lower spring temperatures
- cooler conditions during FDP may slow skin colour development, so that fruit are left longer on the tree and allowed to accumulate more dry matter/Brix. After harvest, higher Brix may provide more resources for respiration and for maintaining longer cell viability.

Minimum air temperatures are 3-4°C lower in the southern Australian States (Victoria and South Australia). Mean minimum air temperatures, and more likely soil temperatures, control the timing of budbreak, rate of fruit development and the length of the fruit development period.

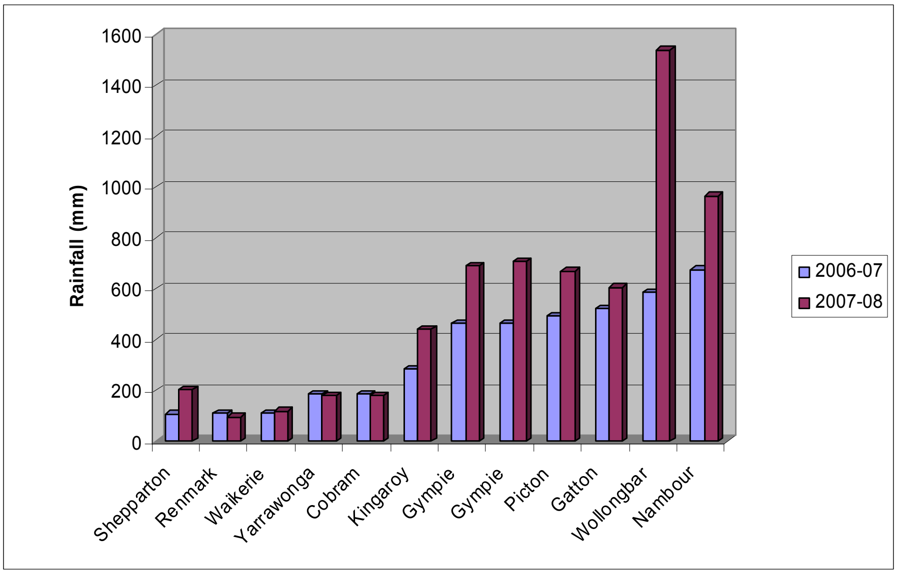
3.3 Rainfall effects on storage life

Other factors besides FDP may also account for the large regional differences in shelf and storage life. These factors may include:

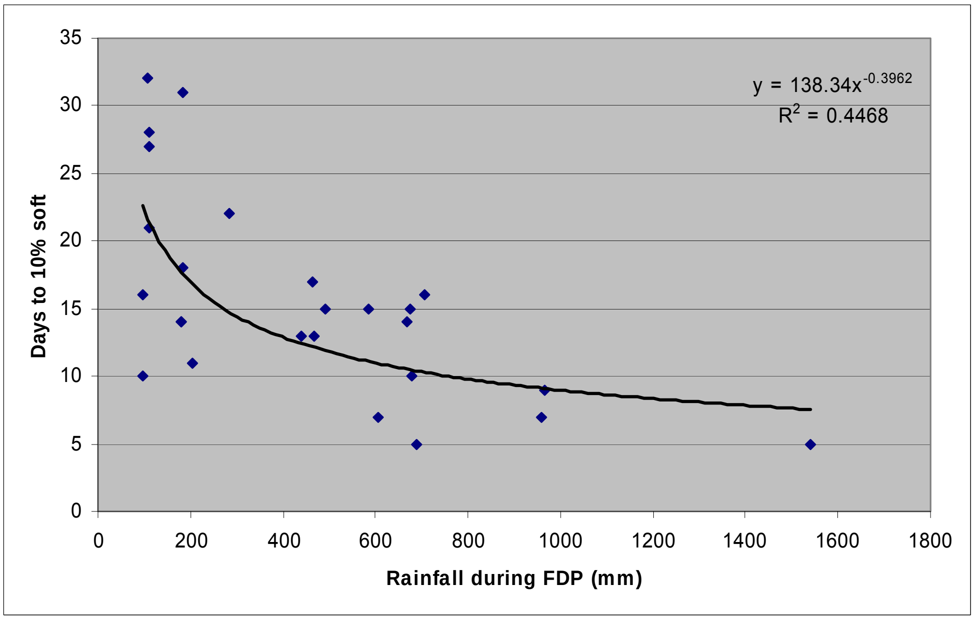
- greater calcium uptake during fruit set and for 2-3 months after flowering on highly calcareous soil types.
- higher rainfall during FDP (Figure 5) which may trigger ethylene release (only 1-2 ppm needed for response) which initiates premature ripening (Wolfe, 2007; Ben-aire *et al*., 2009).

Rainfall in the southern states is 4 to 5 fold less than in Queensland (Figure 5). In some growing seasons, rainfall during FDP in South Australia may be <100mm. Higher rainfall during FDP is moderately related to earlier softening (Figure 6). We found that fruit softening was greatly exacerbated during a wet season.

The Japanese researchers found that waterlogging from flooding increased fruit softening after harvest (Matsumoto *et al*., 2007). Waterlogging from continuous rainfall increased a precursor to ethylene production in the fruit (Mochida and Itamura, 2007). If water stress occurs soon after due to hot windy days, this precursor can be converted into sufficient ethylene to cause on-tree ripening.



Using multiple linear regressions, we can explain that about 50% of the variation in fruit softening is due to two factors, temperature and rainfall.



3.4 Israeli studies

Israeli studies found that fruit with soft blossom end rot (SBE) produced more ethylene.

- They found a lower incidence of the disorder on well drained volcanic tuff compared with regular soil and where there was water saturation in the lowest soil layers.
- Based on the well-known effect of flooding on ethylene accumulation in soil (Jackson, 1985) and the effect of root hypoxia on ethanol accumulation and transport to the fruit, thus inducing storage breakdown of 'Jonathan' apples (Gur and Meir, 1987), these findings led the Israelis to hypothesise that SBE may result from the formation of hypoxic conditions in the vicinity of the root system.
- Ben aire *et al*. (2009) found that in addition to ACC accumulation (a precursor to ethylene production) in SBE fruit, ethanol content was also higher.
- Both ethanol and ethylene (produced from ACC) are known to accelerate fruit softening following removal of astringency (Itamura, 1986).

3.5 Possible control measures

We found that application of 20g/L of calcium nitrate and 10 ppm gibberellic acid (GA_3) about 1 month prior to harvest delayed fruit maturation and extended storage life. Further investigations are warranted. Note: gibberellic acid is not registered for use on persimmon in Australia.

The effects of heavy rainfall and waterlogging can be mitigated to some extent. (See Chapter 4 on the Soft Fruit Disorder for more details).

<u>Key points</u>

Within Australia, there are large regional differences in cool storage life

Fruit with longer FDPs store better than those with shorter FDPs

Fruit from drier inland regions and southern States store longer than coastal Queensland fruit

Heavy rainfall during the FDP reduces coolstorage life

SOFT FRUIT DISORDER

4.1 Definition of soft fruit disorder

The soft fruit disorder (SFD) is a post-harvest disorder affecting persimmon in Australia. The soft fruit disorder can be defined as:

- rapid softening of fruit within 7 days after harvest
- fruit ripening in less than 3 days.

Up to 30% of the fruit within a consignment can collapse within a few days, or the percentage affected can gradually increase over time.

SFD can have negative effects on wholesaler and consumer confidence (Redpath *et al.* 2007). Similar soft fruit disorders have been reported for glasshouse grown persimmon in Japan (Harima *et al*., 2001) and persimmon in Israel (Ben-aire *et al*., 2008).

In Australia, SFD should not be confused with natural ripening; however, the boundaries are not clearly defined. It is suggested that in SFD, the fruit goes directly from the mature phase to the senescent phase, possibly missing the natural ripening phase.

Softening in fruit is triggered by ethylene production, which binds to receptors on enzymes that disrupt cell wall cohesiveness (Wills *et al*. 1989).

Early-season fruit from coastal regions of Queensland northern NSW tends to be the most susceptible to SFD. This is possibly because the fruit has reached maturity faster as a result of either (a) natural variability, or (b) induced effects, for example, by environmental stress, pests, disease or physical damage.

Apart from internal factors that regulate ethylene biosynthesis developmentally in persimmon plant tissues such as ripening fruit, a variety of biotic and abiotic external factors induce ethylene production and fruit softening.

In Australia, the soft fruit problem is linked to the commercial non-astringent varieties of 'Fuyu', 'Jiro' and 'Izu'.

4.2 Possible causes of the soft fruit disorder

Waterlogging and soil hypoxia

Water logging from flooding resulted in a high occurrence of fruit softening after harvest (Matsumoto *et al.*, 2007). Ethylene may be involved here. Water logging from continuous rainfall increased precursors (ACC) to ethylene production in fruit. (Mochida and Itamura, 2007). If water stress occurs soon after due to hot windy days, these precursors can be converted into sufficient ethylene to cause on tree fruit softening (Mochida and Itamura, 2007).

The above findings may be supported by recent evidence that the incidence of fruit going soft in Queensland increases with increasing rainfall (Figure 1) (Redpath *et al*., unpublished data). It is unlikely that water logging was involved here, and it is more likely that more (but not excessive) rainfall stimulated fruit growth at the expense of "robust" cells.

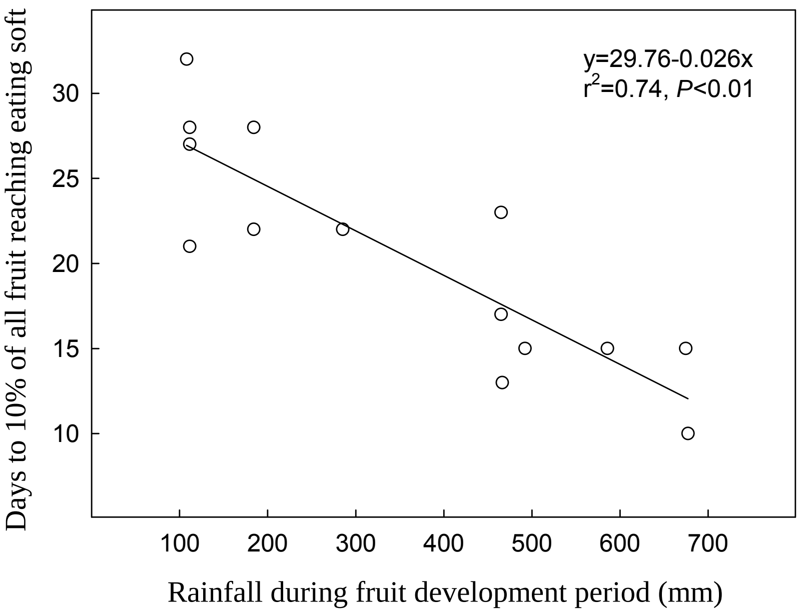


Figure 1. Relationship between rainfall during the fruit development period and days to 10% of fruit reaching eating soft for cv. Fuyu stored at 20°C.

In Japan, Mochida and Itamura (2007) concluded from their studies that pre-harvest fruit softening was induced mostly through the following two-step process;

- at the late stage of fruit maturity, flooding by continuous rainfall blocks aeration in root, and the ethylene precursors (ACC) are accumulated in fruit
- moisture in the fruit is rapidly vaporized by exposure to high temperature during the following fine and windy days, and ethylene release in fruit under water stress, resulting in rapid fruit softening.

Persimmon fruit grown in plastic houses in Japan (simulating conditions in south-east Queensland vs. Southern States) is usually harvested in summer, 1.5 months earlier than field-grown fruit. However, the main drawback of plastic-house fruit is its short postharvest life due to rapid softening (Harima *et al*., 2001; Ito *et al*., 2005). Nakano *et al*. (2001, 2003) suggest that this fruit softening is caused by water stress-induced ethylene production even at rates as low as 1 ppm.

Similarly, in Israel, Ben-aire *et al*. (2009) found that fruit with soft blossom end rot (SBE) produced more ethylene. They found a lower incidence of the disorder on well drained volcanic tuff compared with regular soil and where there was water saturation in the lowest soil layers. Based on the well-known effect of flooding on ethylene accumulation in soil (Jackson, 1985) and the effect of root hypoxia on ethanol accumulation and transport to the fruit, thus inducing storage breakdown of 'Jonathan' apples (Gur and Meir, 1987), they concluded that SBE in persimmon may be caused by root hypoxia.

These findings lead the Israelis to hypothesise that SBE may result from the formation of hypoxic conditions in the vicinity of the root system. Ben aire *et al*. (2009) found that in addition to ACC accumulation in SBE fruit, ethanol content was also higher. Both ethanol and ethylene (produced from ACC) are known to accelerate fruit softening following removal of astringency (Itamura, 1986).

We suggest that there is a major advantage in growing fruit under drier inland conditions. Management techniques may also reduce severity. Water may be shed into the inter-row due to the use of Extenday® mulch, consequently root systems may experience slight to mild stress levels. Mounding of rows and improved soil drainage may also greatly reduce SFD.

Low Calcium

We found that the rate of fruit softening was exacerbated by lower calcium concentrations at fruit set (Figure 2). Fruit from orchards located on highly calcareous soil types have a lower incidence of SFD.

Water logging from rainfall events during fruit set and initial fruit growth may also have an effect on soft fruit by reducing fruit calcium uptake at this critical stage of development (George *et al*., 2005).

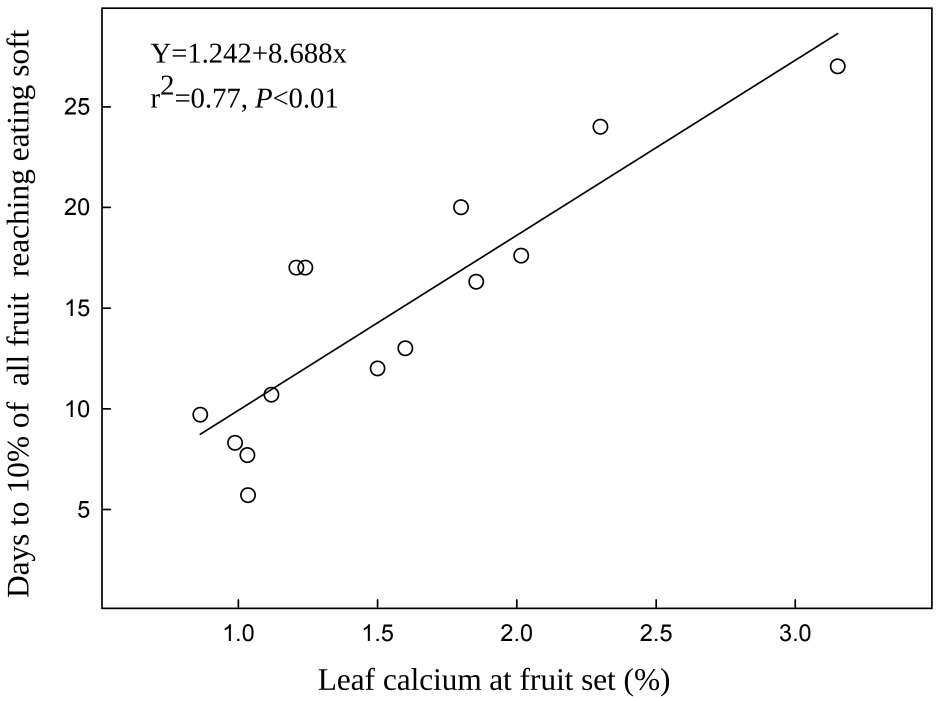


Figure. 2. Relationship between leaf calcium at fruit set and days to 10% of fruit reaching eating soft for cv. Fuyu stored at 20°C.

Fruit development period (FDP)

Fruit with longer fruit development periods appeared to have better shelf life perhaps due to higher dry matter accumulation, higher Brix concentrations, greater cell numbers and greater calcium uptake during flowering and for 2-3 months after flowering.

Calyx health and calyx cavity

Poor calyx health and calyx cavity may also reduce storage life. Calyx health may be improved through:

- regularly-applied fungicide sprays
- foliar fertiliser spray program, particularly potassium
- foliar application of anti-transpirants

Previous reports have shown that calyx cavity is related to high rates of fruit growth and low fruit numbers on young trees (George *et al*., 2003). The calyx contributes significant photosynthates to the developing fruit and if damaged, fruit growth is retarded (Choi *et al*., 2006). Calyx health also deteriorated with increasing calcium/potassium ratio suggesting nutrient fluxes between the calyces and developing fruit. These fluxes need further elucidation.

We have recorded better calyx health in very low rainfall regions <300 mm during FDP indicating that a better fungicidal or foliar fertilising program may be needed to control calyx diseases and to maintain calyx photosynthetic activity under wetter subtropical conditions.

4.3 Control measures

The soft fruit disorder (SFD) appears be caused by short-term waterlogging and soil hypoxia in warmer coastal production regions leading to ethylene release and on-tree ripening. Some possible solutions to SFD are presented below:

Pre-planting

- mounding of rows
- improved soil drainage though use of agricultural pipe (Ag pipe), trenches, diversion drains etc.

Pre-harvest

- mulching to improve fine root development in upper regions of the soil
- use of reflective mulch (Extenday®) to exclude water
- selection of rootstocks tolerant of waterlogging
- restricted irrigation during the final stages of fruit development
- maintain soil calcium levels at >10meq through annual applications of gypsum
- restrict nitrogen during fruit set period

Post-harvest

- pre-conditioning of fruit at a moderate temperature (23°C) before long term storage
- application of antitranspirants/waxes to fruit
- use of perforated bags to maintain humidity around fruit
- use of ethylene scrubbers and absorbents in cool rooms and in trays
- treatment of fruit with ethylene inhibitor 1-MCP after harvest

We found that rate of fruit softening was reduced with increasing fruit and leaf calcium, leaf boron at fruit set and harvest and potassium concentrations at fruit set and at harvest.

The optimum calcium concentrations at fruit set are 30-40% higher than the current standards recommended by George *et al*. in the "Sweet Persimmon Growers Handbook" (2005). Based on the findings of this study, leaf nutrient standards set by George *et al*., 2005 should be revised as follows:

Leaf calcium at fruit set	>1.5%
Leaf potassium at fruit set	2.5-3.0%
Leaf potassium at harvest	1.6-2.2
Leaf nitrogen at harvest	1.8-2.2%
	>2.5%, increases SFD
Leaf boron at fruit set	70-100 mg/kg
Leaf boron at harvest	150 mg/kg

Depending on soil pH, growers should apply gypsum regularly to maintain soil calcium concentrations greater than 10meq/100g.

Excessive nitrogen application will also increase SFD. We suggest maintaining leaf nitrogen, at harvest, at less than 2.2%.

To date, we have found little or no benefit in applying foliar calcium. A wider range of formulations and concentrations is currently being trialled.

Key points

Soft fruit disorder (SFD) is rapid ripening and softening of fruit within 7 days after harvest

SFD is mainly a problem in coastal Qld and northern NSW

SFD appears to be exacerbated by waterlogging

Improved soil drainage and increasing fruit calcium concentrations reduce SFD

STAGE OF FRUIT MATURITY

5.1 Overview

Amongst the many factors that determine the storability of persimmons, fruit maturity at the time of harvest is one of the most important (Öz and Ergun, 2010). Higher flesh firmness at harvest increases storage and shelf-life (Salvador *et al*., 2007).

Japanese studies

In Japan, Takata (1983) showed that ethylene rates for detached fruits decreased as fruit progress from stage I to Stage III of growth. Cv. 'Tonewase' fruit harvested very early (89 and110 days after full bloom) or very late (170 days after full bloom) showed a 100% and 60% softening rate respectively, within 10 days after harvest when stored at 25°C (Harima *et al.,* 2002). There was a 6 to 10 fold increase in softening rates for either very early- or very late-harvested fruit compared to fruit harvested at intermediate dates between 121-159 days after full bloom (Harima *et al.*, 2002). Similar findings have been reported for 'Saijo' persimmon (Kurahhashi *et al*., 2005). Decline in fruit firmness with later-harvested fruit may due to polgalacturonase activity that causes breakdown of pectic substances in the middle lamellae and cell wall (Taira *et al.,* 1987).

Korean studies

Korean researchers have found similar findings to Japanese researchers. Kim *et al*. (2010) found that very early-season and very late-season harvested fruit have higher rates of respiration. Kim's findings have implications for long-term storage and use of MA bags for cool storage (see Chapter 18).

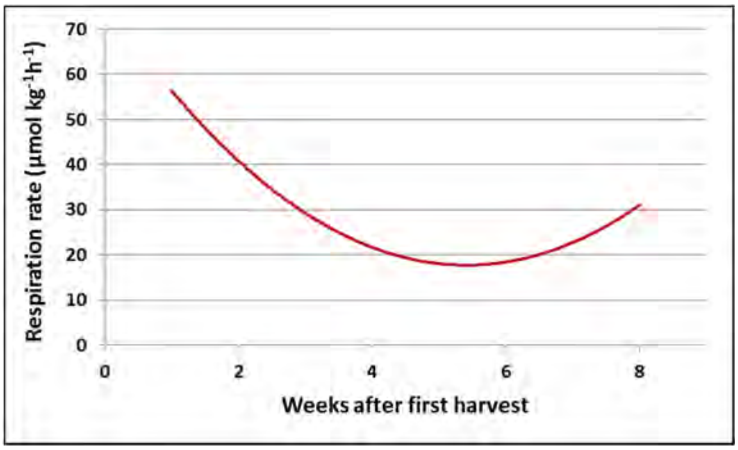


Figure 1. Respiration rate of ‘Fuyu’ fruit stored at 0ºC according to harvest date (adapted from Kim *et al*., 2010).

Brazilian studies

Krammes *et al*. (2007) and Giehl *et al*. (2008) found that rates of ethylene production and respiration rates of cv. Fuyu increased significantly only in fruits harvested in the ripe or overripe stage.

Spanish studies

In Spain, Salvador *et al*. (2006) found that although early-harvested “Rojo Brillante” exhibited higher fruit firmness during cool storage at 1 °C, but fruit showed higher chilling sensitivity after removal from storage. Symptoms of chilling injury in early-harvested fruit could be alleviated by 1-MCP.

Taiwanese studies

In Taiwan, Lin ShinBong and Chen RuYin (2007) found that, to obtain maximum storage life, fruit must be picked when mature but not fully ripe.

Vietnamese studies

In Vietnam, Lan and Xuan (2007) showed that for cv. Thachat, the leading persimmon cultivar grown in Vietnam, fruit harvested at an earlier stage of maturity could be stored for significantly longer times than those harvested at a later stage of maturity. Using colour-based maturity standards, they found that the maximum shelf life was 60-80 days for early-harvest fruit compared with 15-30 days for very late- harvested fruit.

Iranian studies

In Iran, Ramin *et al*. (2003) found that early-harvested fruit of cv. Natanz (breaking colour to yellow) stored significantly longer than orange, ripe fruit. These differences may be related to the level of free water content, which was higher in ripe fruit than unripe ones.

5.2 Date of harvest in Australia

In studies on ‘Fuyu’ grown in coastal regions of Queensland we found that, provided damaged fruit were removed, later-harvested fruit ripened up to twenty days faster than early-harvested fruit even though they were harvested at the same visible colour (4.0) on the Japanese colour chart (Figure 2) (George *et al*., 2009). Our findings contradict Japanese and Korean studies, a summary of which is presented in the previous sections. However, our Australian study was conducted only on very early-season coastal fruit which are not representative of fruit harvested in cooler, drier regions. We suggest that very early-season fruit may be physiologically over-mature due to rapid growth and ripening under warm, subtropical conditions. In coastal regions more damaged fruit occur earlier in the season. Therefore, harvest date may have significant effect on fruit quality and maturity and subsequent storage.

Summarizing all studies, there appears to be an optimal fruit development period for each region where storage life is maximised.

5.3 Flavour and sugar concentration

Provided fruit are harvested at a Japanese colour chart rating of 4.0 or greater, they reached the minimum acceptable level for eating quality and a minimum desirable flavour rating of 6.0 on the hedonic scale. Depending on whether a minimal, acceptable flavour rating of 6.0 or 6.5 was set on the hedonic scale, a minimum Brix concentration of >14° or >15.0°, respectively, would be needed to satisfy these standards.

Many growers in south-east Queensland harvest their fruit at less than 4.0 on the Japanese colour charts to increase dollar returns for early-harvest fruit. This is a highly undesirable practice because it potentially reduces eating quality and consumer acceptability.

5.4 Fruit colour predicts storage life

Fruit with greater colour development store for shorter periods than those which are harvested 'greener' (Plate 1). This is in agreement with the findings by Besada *et al*. (2009) and Bill (2012) who found that loss of firmness during storage is lower in fruit picked less ripe compared to fruit picked more ripe (Figure 3).

Skin colour generally seems to be a good external parameter for use in predicting the storability and shelf life potential but there is a compromise between storing 'greener fruit' which stores longer and better eating and external quality of more highly coloured fruit (Ahn, 2012) (Plate 2).

Plate 1. In a South African study, 'Triumph' fruit picked semi-green stored better than more high coloured fruit but fruit quality was compromised (Bill, 2012).

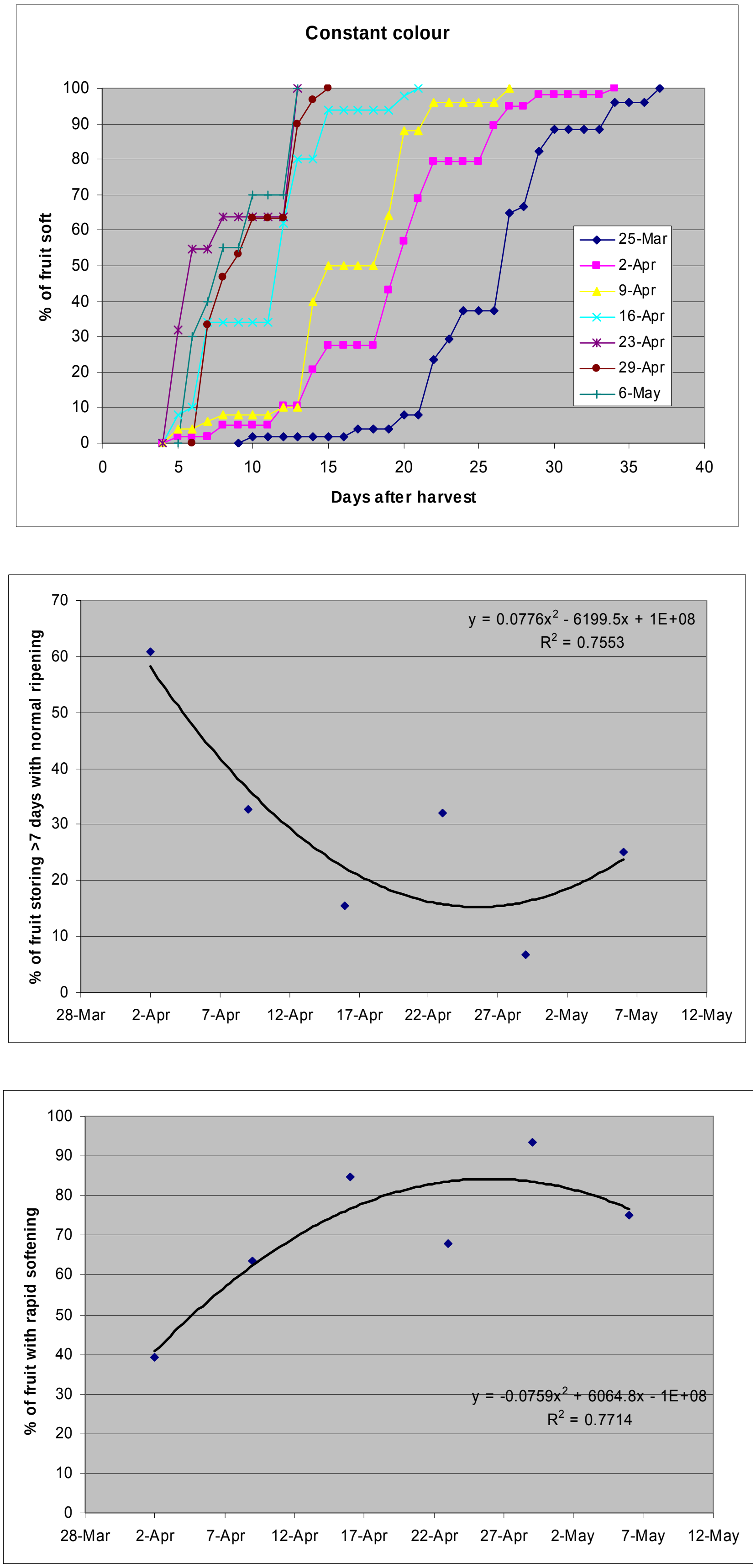


Figure 2. Rates of fruit softening for cv. Fuyu harvested on different dates at a constant colour of 4.0 on Japanese Colour Chart at a commercial orchard at Woombye, Queensland. After harvest, fruit were held at 20°C.

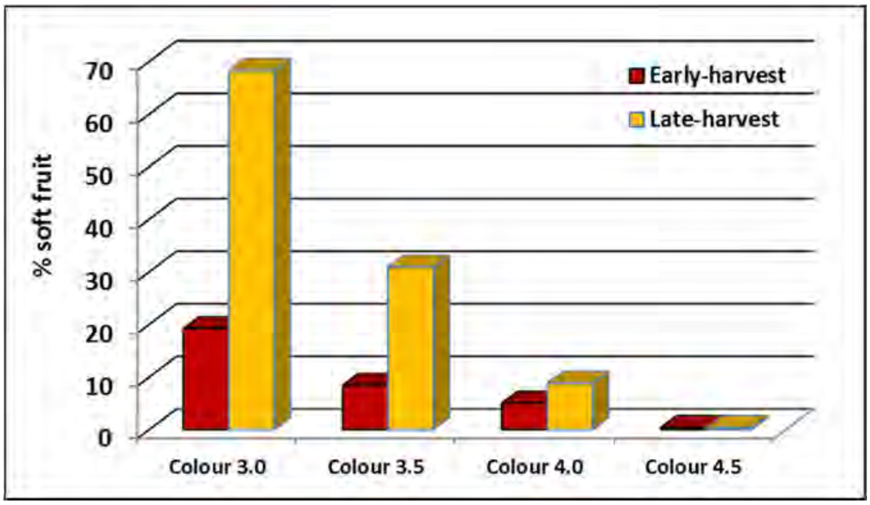


Figure 3. Effects of harvest date and fruit colour of 'Triumph' persimmon stored for 6 weeks at -0.5°C for 6 weeks. Adapted from Bill (2012).

5.5 Summary

Most studies show that within an orchard either very early-season (physiologically immature) or very late-season fruit (physiologically over-mature) store more poorly. Irrespective of harvest date, more highly coloured fruit, with greater Brix and dry matter accumulation, ripen more rapidly and store for shorter durations.

Color	Soluble solid(Brix)	Firmness (N/5mm)	Fructose(%)
3.5	13.7	23.1	2.5
4	14.5	22.4	2.7
5	15.5	21.7	2.8
6	16.2	20.2	3.5
7	17.7	15.7	5.3

Plate 2. Changes in fruit quality variables for Korean ‘Fuyu’ persimmon with increasing colour of fruit at harvest (Ahn, 2012).

Key points

Damaged fruit breakdown quickly and should be removed before storage

Most studies have shown that both very early- (physiologically immature) and very late-season fruit (physiologically over-mature) have shorter storage life compared with mid-season fruit

There is an optimal harvest period for each farm/region

‘Greener fruit’ store longer but flavour, sugar, eating quality and external colour are compromised

FRUIT MATURITY STANDARDS

6.1 Definition of fruit maturity

Maturity can be considered the stage of development of the fruit that after harvesting and ripening, its quality will be at least the minimum acceptable to the ultimate consumer (Kader, 2002). This definition implies a measurable point in the commodity's development and it also implies the need for techniques to measure maturity.

A maturity index for a fruit is a measurement or a set of measurements that can be used to determine whether the fruit is mature (Kader, 2002). The most accurate maturity indicator (or maturity standard) is to harvest the fruit, allow it to ripen if appropriate, and determine quality. However, commercial maturity standards need to be cheap and easy to use, so that most of them are indirect, not always accurate indicators of horticultural maturity.

Possible maturity (harvest) indices include:

- soluble solids content (Brix)
- acidity,
- dry matter
- skin or flesh colour
- firmness
- flavour
- biochemical or molecular markers.

The indices used to determine maturity vary by fruit but must be relatively simple and rapid to obtain and analyse. Examples of current indices used for fruit crops include:

- Apple: starch pattern indices, background skin colour, firmness
- Pear: firmness and starch pattern indices
- Avocado: dry matter (which correlates strongly with oil content)

Various maturity indices for Australian persimmon are discussed below.

6.2 Colour

Overview

In many fruits, skin colour changes over time, and/or ripening (Wills *et al*., 1989). For persimmon, the main colour change occurs during maturation, and is a quick and reasonably reliable indicator of physiological maturity. During maturation, increased carotenoid production and associated chlorophyll reduction causes persimmon skin colour to change from green to yellow through to orange and then red (Table 1) (Ebert and Gross, 1985).

Colour charts

Colour of persimmon skin is usually measured against colour guides developed by industry, such as the Japanese colour guides (Plate 1). Other countries such as South Korea have their own colour standards (Plate 2). In Australia we mainly use the Japanese colour charts.

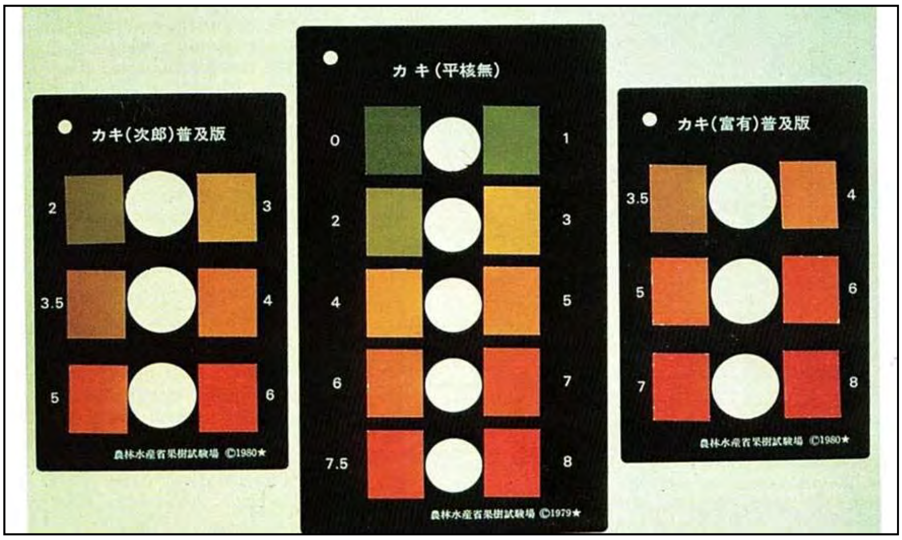


Plate 1. Japanese colour chart used to determine maturity. Separate charts are used in Japan for each variety. Left 'Jiro', Centre 'Hiratanenashi', Right 'Fuyu', 'Matsumoto Wase Fuyu', 'Izu','Nishimura Wase'.

Plate 2. Korean colour chart for determining maturity of ‘Fuyu’. Fruit are harvested at a colour rating of 3.5 to avoid frosts. Optimal colour is considered to be 5.

Many growers pick fruit which are immature (Plate 3) either to:

- capture early-season markets
- escape problems with pests such as fruit fly
- avoid or reduce severity of soft fruit disorder (SFD)
- improve storage life

Fruit with greater colour development store for shorter periods than those which are picked ‘greener’ (see Chapter 6). This is in agreement with the findings by Besada *et al*. (2009) who found that loss of firmness during storage is lower in fruit picked less ripe compared to fruit picked more ripe. Skin colour generally seems to be a good external parameter for use in predicting the storability and shelf life potential but there is a compromise between storing ‘greener fruit’ which stores longer and better eating and external quality of more highly coloured fruit. Persimmon fruit should be picked at a minimum colour development of 4.0 on the Japanese colour charts (Plate 4).

Plate 3. Left: Persimmon fruit showing green tinges. They are obviously immature. Right: fruit picked at the correct colour – about 4.0 on the Japanese colour chart.

Plate 4. Excellent quality fruit picked at the correct colour of 4.0 or greater on the Japanese colour chart.

Regional differences

We have also found significant differences between growers and states in fruit colour ratings using Japanese colour charts. Fruit from southern states develop a deeper red colour than those grown in coastal and inland Queensland (Plate 5).

The presence of chlorophyll at harvest can mask the full colour of the carotenoids and is probably the case in south-east Queensland. Under cooler climates, fruit that are exposed to lower night temperatures (<14°) during the final stage of fruit growth undergo rapid chlorophyll degradation of the peel, unmasking the carotenoids that produce the typical orange/red colour of mature fruit (Suguira *et al*., 1991). However, most fruit grown in coastal Queensland and NSW do not undergo this intense colour change and are physiologically mature at lower colour intensity than southern fruit.

In contrast, fruit from Victoria and South Australia can be picked at colour chart ratings >4.5 being physiologically mature but not ripe (Plate 6, Figure 1). Jiro and Fuyu from different regions are shown in Plate 7,8,9,10 and 11.

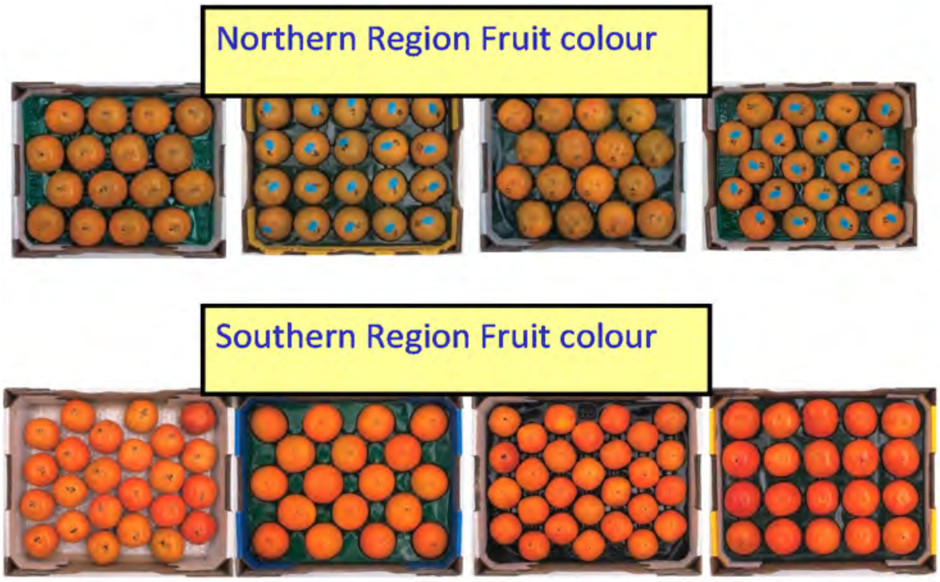
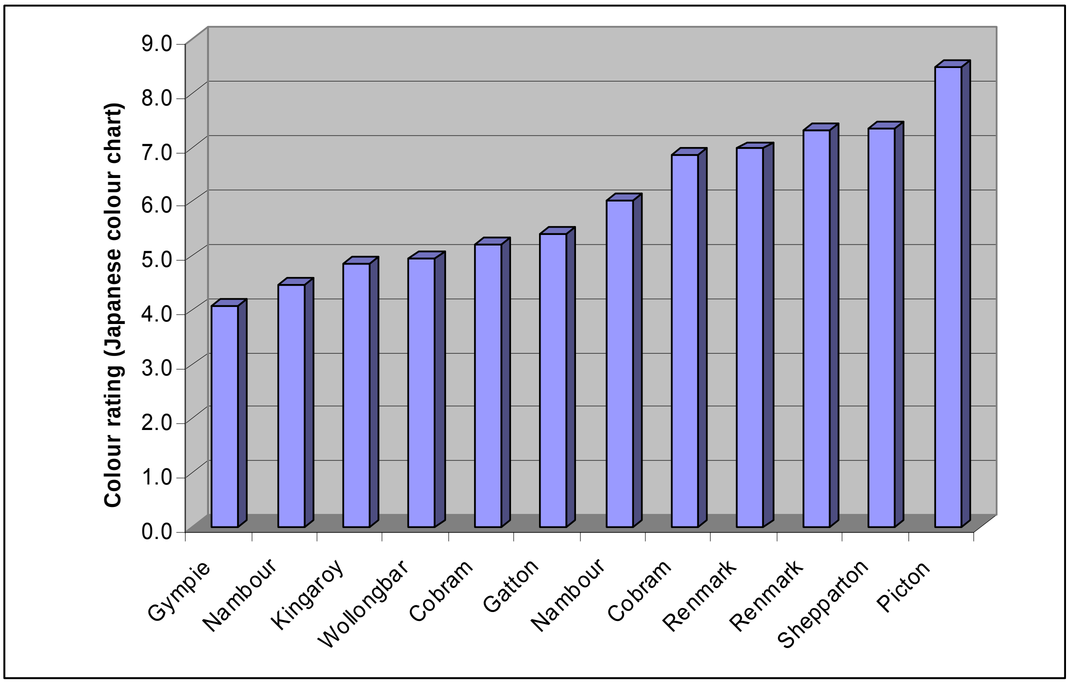


Plate 5. Fruit of cv. Fuyu from southern states showing more intense red skin colour at harvest than those from coastal Queensland or northern NSW. These fruit can be harvested at colour chart ratings >4.5.

Plate 6. Fruit from cooler regions of Victoria and SA has a deeper orange skin colour due to lower night temperatures in autumn increasing carotenoids.



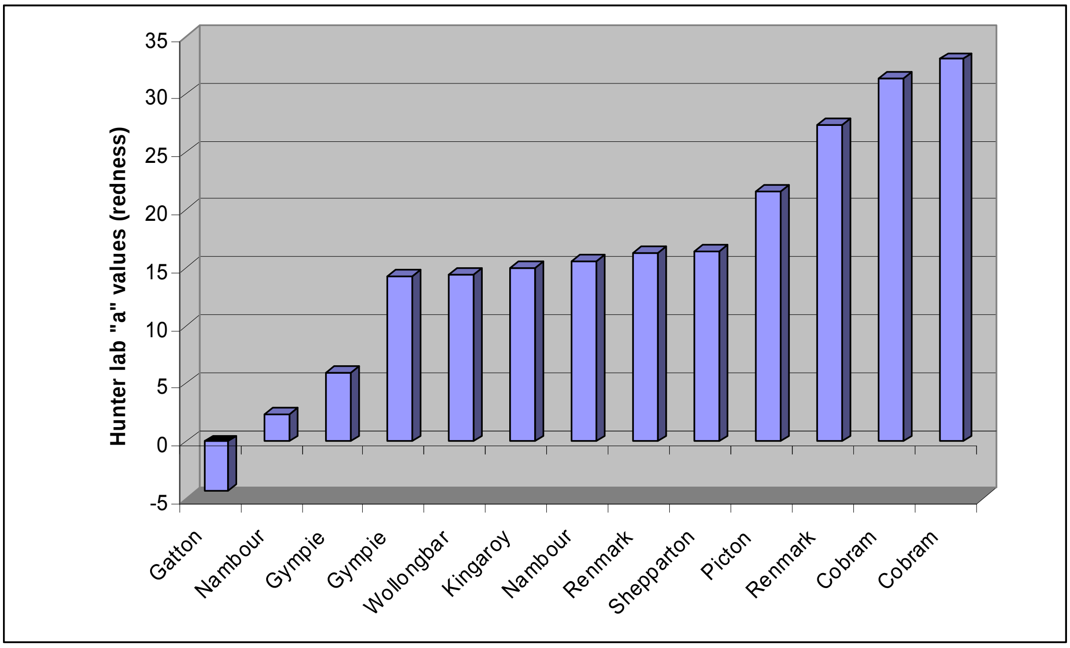


Figure 1. Regional variation in fruit colour of cv. Fuyu as measured by Japanese colour charts and by Minolta CR-200 chromameter ‘a’ (red) values (Hunter *L.a.b* values).

Plate 7. Jiro from three coastal growers

Plate 8. Fuyu from three coastal region growers.

Plate 9. Jiro from three inland region growers.

Plate 10. Fuyu from two inland region growers.

Plate 11. Fuyu from three southern region growers.

Chromameters

Colour can also be measured more accurately than colour charts using chromameters. They measure colour using the HunterLab model. The Hunter Lab colour space model quantifies colour in three dimensions as L, a and b values (HunterLab, 1996) (Plate 12).

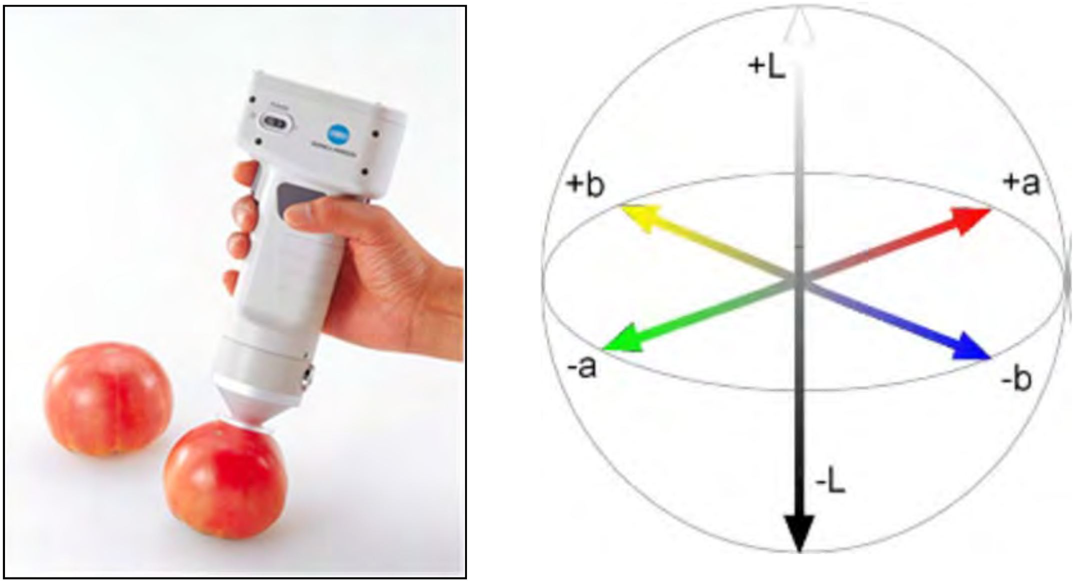


Plate 12. Left: a Minolta CR-200 chromameter used for accurately measuring fruit colour. Right: Hunter Lab *L.a.b* colour ranges. The "L" value for each scale indicates the level of light or dark, the "a" value - redness or greenness, and the "b" value - yellowness or blueness. All three values are required to completely describe an object's colour.

From an Australia-wide survey, it was only the Hunter "b" values (degree of yellowness) which were most highly correlated with days to softening (George *et al*., 2008). Despite fruit being harvested at a set colour (4.0 on Japanese colour chart), days to softening was reduced by only slight and visually indiscernible increases in the "b" values which measure the yellowness of the skin (Figure 2).

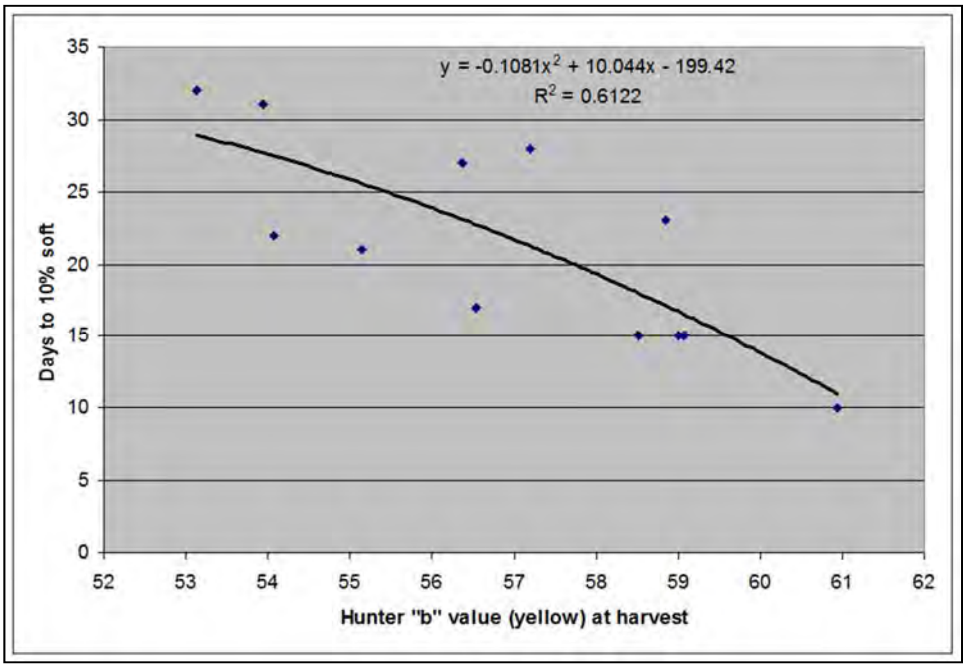


Figure 2. Relationship between Hunter "b" value and days to 10% softening for cv. Fuyu. This figure shows that as the fruit become more yellow, the shelf life drops quickly.

Although colour charts are useful for determining maturity, we suggest that the use of colour chart ratings alone may not be reliable by itself to be a suitable index of fruit maturity.

Orchard management

Although autumn night temperatures are the main determinant of fruit colour, training systems which produce open canopies and use of reflective mulch (Plate 13) which increases light transmission into the tree canopy may also improve both depth and evenness of fruit colour. Even in coastal regions of Queensland, uniformity of colour and bloom can be greatly improved using reflective mulch. Light exposure stimulates carotenoid production which is responsible for the orange/red colour of the fruit at harvest (Chujo, 1971).

If fruit are heavily shaded during the growing season, this can result in fruit at harvest with a yellow rather than orange/red colour. Lower autumn temperatures can stimulate an increase in red pigment carotenoids but very high temperatures can inhibit pigment development (Ito *et al*., 2005).

Plate 13. Uniformity of colour and bloom can be greatly improved using reflective mulch.

6.3 Sugar concentration

Measurement

In relation to persimmon, a major criterion of horticultural maturity is acceptable sugar concentrations.

A refractometer (Plate 14) directly measures the fruit juice's total soluble solids (TSS) in units called degrees Brix. The TSS is virtually the same as the sugar concentration. A refractometer is not expensive (about $250).

Measurements are made after polishing the fruit to remove the wax bloom and spray residues. A small piece from two sides of the fruit is cut and placed in a garlic crusher. Some juice is extracted and a few drops are placed on the refractometer to read the Brix levels (Plate 14). The refractometer is cleaned with water and wiped with a tissue between samples.

Plate 14. Left: Hand-held refractometer used for measuring sugar concentration. Right: laboratory refractometer

Regional differences

Irrespective of region, the minimum recommended Brix concentration for persimmon is 14º. It can be seen from Figure 3 that most Australian orchards produce very sweet fruit. Only a small percentage of orchards in Australia produce fruit less than 12 º Brix.

However, with few exceptions, orchards with the highest Brix concentrations were located in South Australia and Victoria (Figure 4). Higher Brix concentrations in these states are probably due to a combination of factors including longer FDPs (Figure 5) and drier and cooler conditions during fruit development. Consequently higher, premium grade standards could be set at 16° for these regions.

Studies by Mowat and Collins (2000) showed that Australian fruit had a 29 per cent advantage in market perceived quality over New Zealand fruit in the Singapore market. Presumably much of this perceived quality advantage is due to the higher sugar concentrations and flavour of Australian fruit.

Due to cooler summer growing conditions in New Zealand, it is difficult for NZ fruit to reach 14° Brix. High sugar concentrations of Australian fruit are a major competitive advantage for export markets and needs to be promoted to capitalise on the Australian persimmon fruit competitiveness internationally.

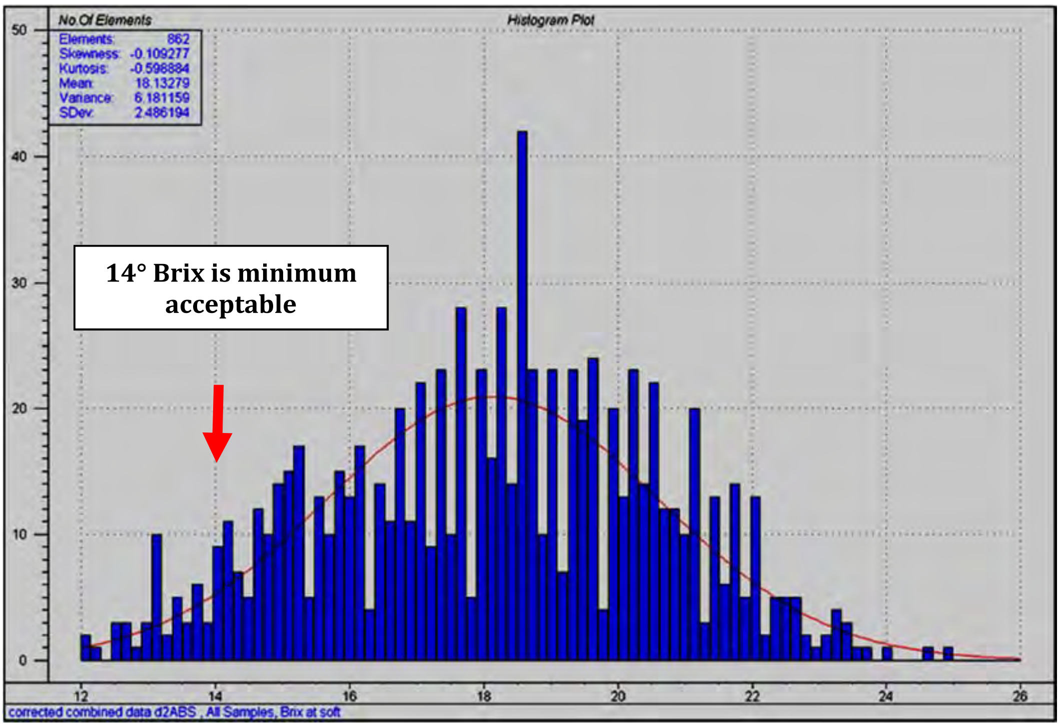


Figure 3. Distribution of Brix concentrations from 14 surveyed persimmon orchards from 5 regions of Australia. The majority of Australian orchards produce fruit with exceptionally high Brix. Horizontal axis is in units of Brix.

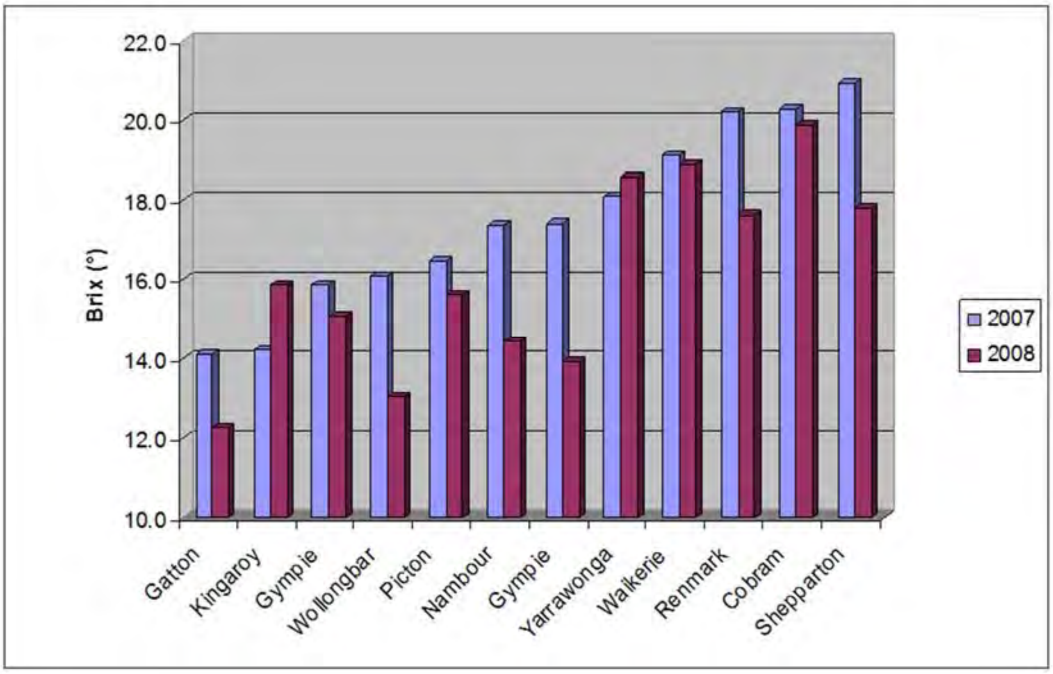


Figure 4. Variation in Brix concentrations for cv. Fuyu for surveyed persimmon orchards. Fruit from Victoria and South Australia exhibit higher sugar concentrations.

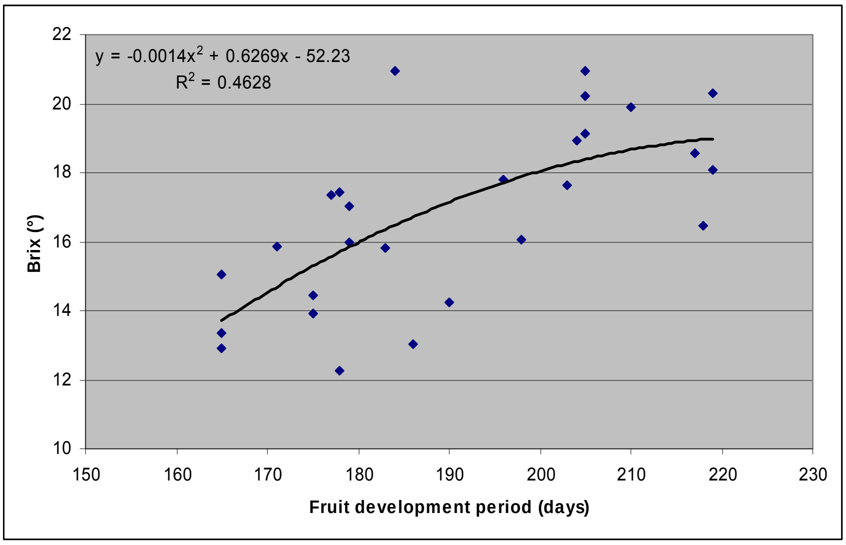


Figure 5. Relationship between Brix and FDP for cv. Fuyu for surveyed orchards.

Time of harvest

Early-season fruit from south-east Queensland orchards exhibit 1 to 3° lower Brix concentrations than mid-season fruit. Brix concentrations at one orchard in Queensland increased from an unacceptable Brix concentration of 12.6° for early-season fruit to 15.8° for mid-season fruit indicating that early-season fruit may have been picked immature.

Rainfall

Heavy rainfall during the FDP can greatly reduce sugar concentrations in the fruit (Figure 6). Therefore, depending on the season, fruit from regions of heavy rainfall such as coastal Queensland will have lower sugar concentrations.

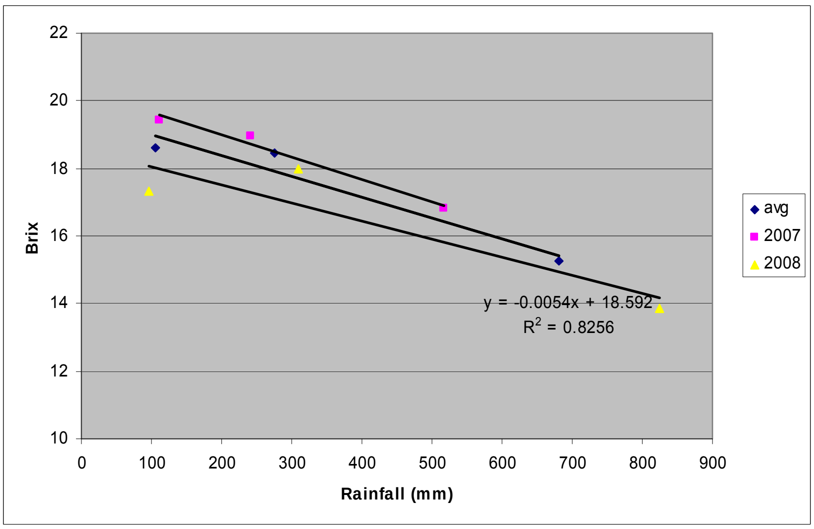


Figure 6. Effects of rainfall during FDP on average Brix concentrations for cv. Fuyu for different states.

In Japan, water stress during fruit growth has been shown to reduce fruit weight and increase soluble solids concentration at harvest (Tanaka and Aoki, 1971). It may be feasible to mildly stress trees near harvest to increase sugar concentrations.

Nitrogen and potassium

Excessive applications of nitrogen can drop Brix concentrations. George *et al*. (2002) found that Brix concentration only dropped once leaf nitrogen concentrations exceeded 2.4%. In contrast to nitrogen, Brix concentrations increased with increasing leaf potassium concentrations up to 3.0% before plateauing.

Near infrared spectroscopy

Brix can also be measured using near infrared spectroscopy (NIRS) (Subedi *et al*., 2007; Redpath *et al*., unpublished data). Results are promising at this stage, but more work is required. NIRS could be used potentially either in the field as a portable unit, or for in-line grading during sorting/packing.

6.4 Flavour

George *et al*. (2008) found that flavour and Brix concentration were highly correlated (Figure 7). Maximum flavour was achieved at a Brix concentration of 18°. If a minimal acceptable flavour rating of 6.5 were set on the hedonic scale (1=highly unacceptable, 9=highly acceptable), a Brix concentration of ≥16° would be needed to satisfy this standard. Flavour is also genetically determined. Some new Japanese and Chinese varieties appear to have better flavour than ‘Fuyu’.

Irrespective of region, a minimum flavour rating of 6.0 should be set. This corresponds with a Brix concentration of about 14°. Most Australian orchards would meet this standard.

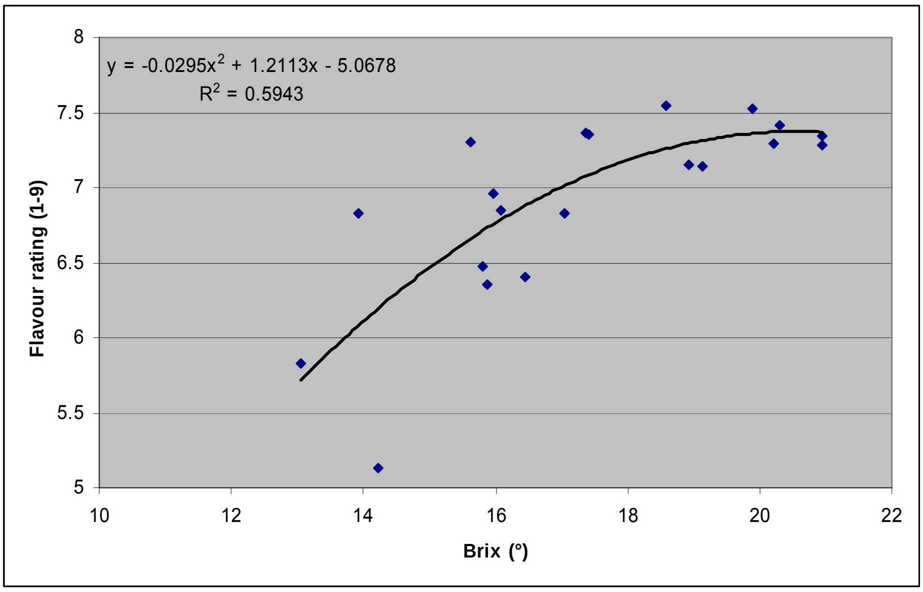


Figure 7. Relationship between flavour and Brix concentration for cv. Fuyu for surveyed farmer orchards.

6.5 Dry matter

George *et al*. (2008) found that the optimum dry matter % for persimmon, to achieve maximum flavour ratings, was 20%, similar to that reported for avocado (Hofman *et al*., 2002). However, if a flavour rating of 6.0 on the hedonic scale is set as an acceptable level, then a lower dry matter % of 16% could be set as the minimum standard.

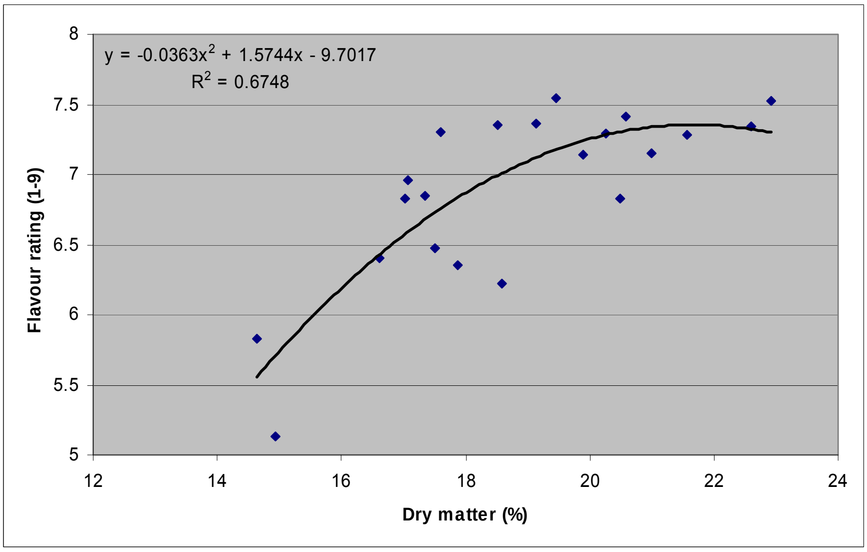
George *et al*. (2008) also found that flavour and dry matter were highly correlated indicating that dry matter may be a better indicator of fruit maturity than Hunter *L, a, b* values or Japanese colour chart readings.

With avocado, dry matter is highly correlated with oil content. Dry matter % is now used routinely as a maturity index for mango and avocado in Australia, Israel, New Zealand and the USA (Hofman *et al*., 2002).

Overall, the South Australian and Victorian orchards had the highest dry matter accumulation for cv. Fuyu (Figure 8) presumably due to a several factors including:

- longer FDPs
- drier growing conditions
- greater net carbon assimilation
- lower maintenance respiration rates

We suggest that it may be feasible to develop a dry matter index for each region which could be used in combination with other indices to determine fruit maturity.



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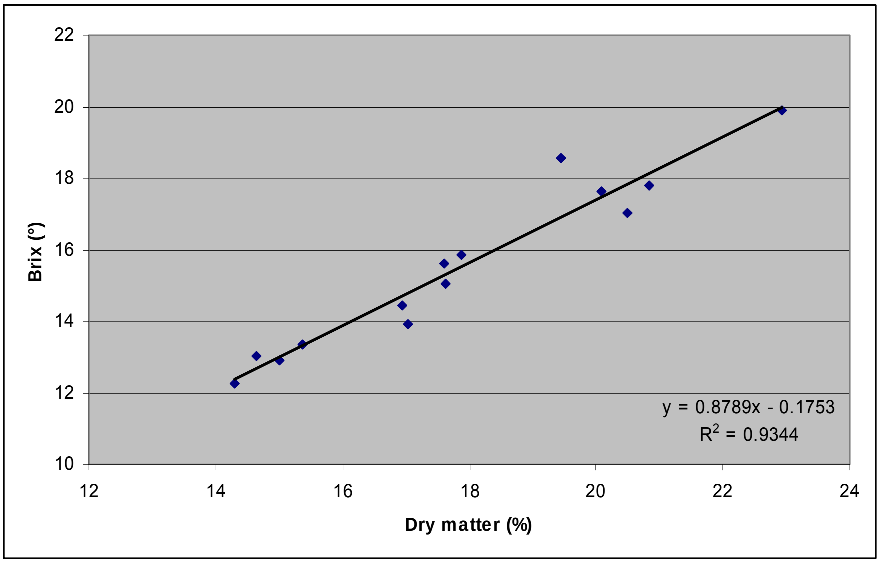

Figure 8. Relationship between flavour, rated on the hedonic scale (1=unacceptable, 9=highly acceptable), and Brix and % dry matter for cv. Fuyu.

6.6 Firmness

Firmness is a useful criterion for ascertaining when fruit have reached maturity, and is ready for harvest (e.g. melon, Sugiyama *et al*., 1998). High flesh firmness at harvest plays a decisive role in the preservation of fruit quality during storage and shelf-life of persimmon (Salvador *et al*., 2007).

The firmness of persimmon fruit and the texture of the flesh can be measured using a penetrometer (Plates 15 and 16). This is done by pushing the instrument's probe into the flesh using steady pressure. The scale shows the force required to push the probe the distance determined by the probe.

Two measuring scales are available (in kilograms or pounds) and two probe sizes. The size of the probe influences the reading, so standard methods for specific products needs to be reported. Fruit should be firm at harvest (>4kg 8mm head). We recommend that fruit of 'Fuyu' and similar cultivars have a minimum penetrometer force (8mm head) of >2.5kg or 10 Newtons (N) three days after removal from cool storage. A penetrometer force of <1.8 kg force is at the limit of marketability and <1.0kg is soft fruit. (Note: 1 kilogram is equal to 9.81 N)

Plate 15. Hand Penetrometer

Plate 16. Testing for fruit firmness using penetrometer with 8mm head. Fruit firmness is quantified on a Shimadzu Autograph AGS-H using a 100N load cell.

6.7 Tannins

Non-astringent varieties (sweet persimmon) should have no residual astringency at full maturity. They should be able to be eaten hard and crisp.

Mean daytime temperatures of between 15°C and 22°C are necessary during the maturation period from March to May for the fruit to totally lose their astringency.

In most regions of Australia, fruit of non-astringent varieties have naturally lost their astringency at least three months prior to harvest. In contrast, non-astringent varieties grown in New Zealand may have low residual levels of astringency at harvest.

6.8 Maturity standards and cool storage life

Stage of maturity can have an effect on length of time in cold storage. Over-mature fruit can have shorter storage life. On the other hand, immature fruit, although it may store longer, is unacceptable to the consumer. (See Chapter 6). Another major problem has been fruit with 'soft fruit disorder' (See Chapter 4).

6.9 Overseas maturity indices

Until recently, there are no recognised maturity standards for persimmon in Australia based on scientific studies relating eating acceptability to fruit quality variables. George *et al*. (2005) suggested in the 'Sweet Persimmon Grower's Handbook' that a minimum total soluble solids levels (TSS) for 'Fuyu' should be 14% and that non-astringent cultivars should have no residual astringency at harvest.

Currently most Australian growers base their time of harvesting on the non-destructive index of fruit colour, using either the Japanese or New Zealand colour charts. Some growers pick fruit at a colour rating of 3.5 whilst others at 5.0.

We suggest that new maturity standards for persimmon in Australia be implemented using a range of indices. For comparison, maturity standards used in various countries are presented in Table 1.

In our surveys, we found little or no variation in fruit quality variables within canopy. Thus, sampling of fruit anywhere within the canopy may give an acceptable measure of fruit maturity.

TABLE 1.
A comparison of fruit quality and maturity indices between different growing regions of the world.

Country	Colour	Fruit weight	Soluble Solids	Soluble Tannins	Reference
New Zealand	Min. 5 on industry chart	>200g for Fuyu	Average of 14%	<0.04%	(Chee and Mowat, 1992)
Japan	Min. 6 on Japanese chart	230–250g for Fuyu	Average of 15.5%	Virtually none	(Kitagawa and Glucina, 1984)
Korea	N/A	210–220g for Fuyu	Average of 15.5%	N/A	Choi *et al*. (2006)
USA	=> 10Y-6/6 Munsell	>200g for Fuyu	18-20%	Virtually none	(Crisosto, 1999)

New Zealand
In New Zealand, the current industry recommendation is to harvest fruit at a colour grade of 5.0 on the Japanese colour chart. More complex maturity indices developed in New Zealand by Mowat and Ah Chee (1992) have not been implemented by the New Zealand industry. Mowat and Ah Chee (1992) developed an external fruit quality index calculated as the average index value of fruit fresh weight and skin colour, and an internal fruit quality index as the average of soluble solids and soluble tannin concentration indices. The maturity index was calculated as the average of all four fruit quality indices.

Woolf *et al*. (2008) showed that harvesting fruit in New Zealand with increasing colour grade from 4.5 to 5.5 to 6.6 led to significant increase in TSS from 12.4 to 13.5 to 14.2, respectively. He suggests that an increase in TSS of 1% is easily perceptible to taste.

Spain
In Spain, Testoni (1981) suggests that firmness cannot be considered a reliable maturity index since, over 12 days of harvesting, the decrease is very slight (4.2 kg vs 4.0 kg). Later studies in Spain by Salvador *et al*. (2006) showed that fruit colour was a good predictor of fruit firmness for the major cultivar ‘Rojo Brillante’. They used a colour index where colour index=1000*a/(L*b).

Brazil
In Brazil, Krammes *et al.* (2007) showed that the rates of ethylene production and the rates of respiration increased significantly in cv. Fuyu only in fruits harvested overripe. Thus, the maturity indices for 'Fuyu' persimmon fruits harvested for storage and/or to transport were determined as 14.6-

15.3% soluble solids content, about 63 and 66 N (~6.4-6.8kg) of flesh firmness, hue angle between 73 and 66 and a visual colour index of 4.

6.10 Recommended maturity standards for Australia

We recommend that a set of minimum maturity standards be set for Australian growers. A combination of parameters e.g. colour and Brix will give a better indication of maturity than one parameter alone. These parameters are presented in Table 2.

We also suggest that higher maturity standards could be set for a premium grade of fruit based largely on the regional differences in fruit quality. Australia-wide surveys have shown that fruit from Victoria and South Australia, and some regions of inland Queensland, have naturally higher sugar concentrations, deeper red skin colour and lower blemish levels than fruit grown in coastal regions of Queensland.

The new standards may be a compromise between eating quality and those that ensure reasonable post-harvest storage life (see Chapter 6). The optimum stage of maturity for post-harvest of persimmons will depend on the relative importance of a range of fruit quality variables (Brix, eating quality, storage life etc). These proposed standards would need to be verified by further longer term and regional studies.

We also suggest that the NIR technique could be used successfully for non-destructive field sampling of fruit for Brix and dry matter estimation. These NIR estimates, if used in combination with fruit colour, could also be used to estimate storage life. However, further studies would be needed to test these relationships within and between regions. Blemish and defect standards are presented in Chapter 7.

TABLE 2.

New maturity standards for non-astringent persimmon varieties

Parameter	Minimum standard	Premium standard
Brix (minimum)	14°	15°
Dry matter (%)	≥16.2	≥17.0
Japanese colour chart rating	≥4.0	>5.0
Hunter "a" value	>2	>2
Hunter "a/b" value	>0.10	>0.25
Minimum flavour rating (Hedonic scale 1-9)*	6.0	6.5
Minimum firmness after storage (8mm head)	>2.5kg	>2.5kg
Firmness after storage	10N	10N
Residual tannin	None	None
Calyx cavity/damage	None	None
Insect pest damage	None	None

*1=highly unacceptable, 9= highly acceptable

Key points

Australia can produce excellent quality fruit with very high sugar concentrations and well-developed colour

Colour alone does not always give a good indication of fruit maturity, consequently measurement of a combination of variables e.g. colour, Brix and dry matter will give a better indication of maturity than one parameter alone

A premium maturity grade standard, based on higher sugar concentrations and colour, could be developed for some regions due to the effects of climate on fruit quality

BLEMISHES, DEFECTS AND DISORDERS

7.1 Overview

Persimmon fruit are particularly susceptible to blemishing and it is the major cause of non-marketability, followed by factors such as fruit size. In the past, the percentage of marketable fruit has been reduced by as much as 60%. This is due to blemish marks (wind rub, water marks, petal adherence marks, sunburn, spots and speckles), calyx separation and apex cracking. The causes of blemishing are varied including:

- environmental (e.g. sunburn)
- nutritional (e.g. green blotch)
- pests (e.g. thrips)
- diseases (e.g. anthracnose)
- physiological (e.g. calyx cavity, poor pollination)
- mechanical (e.g. wire rub)

The major blemishes identified in persimmons in Australia are:

- wind rub
- water marks
- anthracnose
- sunburn

The seasonal incidence of blemishing (excluding sunburn) varies considerably between regions and seasons with more than 80% of fruit affected with more than one blemish type. Blemishing severely reduces the percentage of fruit suitable for exporting. Consequently, considerable research effort has been directed to reducing their incidence by better orchard management.

7.2 Current grade standards for blemish

The current FreshSpec grade standards used by industry were set many years ago. Since then most growers have improved their orchard management practices. In our surveys, some growers have suggested that the maximum blemish levels of 2 sq. cm for domestic markets and 1 sq. cm for exports are currently set too high. They suggest that new blemish standards could be set at a maximum of 0.5 sq. cm for both domestic and export markets. (See Chapter 11).

7.3 Orchard management methods to reduce blemishing

Orchard management practices can have a big impact on reducing blemishing. Some of the more important practices that can be used to reduce blemish are described below.

Training systems

Persimmon trees are best trained onto trellising systems such as open V and palmette. An open canopy reduces shading and maximises fruit temperatures throughout the canopy. New Zealand studies (Jackman *et al*., 2003) have shown that open canopies increase air flow and sun exposure of fruit, consequently reducing "black blotch" (black marking of the fruit). This generally leads to a significant increase in pack-out rates, particularly in seasons with rain during harvest. An additional benefit of increased exposure of fruit is reduction in external disorders following long-term storage (>10-12 weeks).

Plate 1. Leaves have been removed around the fruit to reduce leaf to fruit contact

Summer pruning

New Zealand studies by Jackman *et al*. (2003) showed that orchards which maintained an open canopy by summer pruning in December and February had 5 to 10 % higher export pack-outs before heavy rain, and 10 to 15 % higher after rain than orchards that had omitted autumn pruning. Autumn pruning removes unwanted shoots and shortens shoots that have second-flushed back to the base of that second flush.

Leaf plucking (thinning)

Protracted periods of rainfall during harvest are, unfortunately, an annual reality for many persimmon growing regions. To combat these significant drops in pack-out, most growers now carry out routine "leaf thinning" before harvest. The aim is to remove any leaves that are directly in contact with fruit, and if possible, leaves which are close to the fruit. The theory behind this practice is to change the microclimate around the fruit so that fruit can dry as rapidly as possible. In addition, it results in good skin development (no micro-cracks and good wax layer development).

Reflective mulch

Extenday™ reflective mulch is a New Zealand product that increases light intensity, particularly in the lower canopy (Plate 2). We have shown in several trials that reflective mulch can increase fruit weight and size in persimmon (George *et al*., 2009; Bignell *et al*., 2012). The use of reflective mulch results in increased maximum and mean daily air temperatures within the canopy compared with grass or bare soil under the trees. In addition, it reflects light up into the canopy. Mulches tend to advance maturity by increasing colouration, but also reduce the variability in colouration of fruit, especially in lower canopy locations. We have also observed that reflective mulching reduces the expression of blemishing due to black blotch (Plate 3).

ces

Pre-conditioning

Similar to reflective mulch, pre-conditioning of fruit after harvest can reduce the expression of some blemish symptoms during and particularly after removal from cool storage. (See Chapter 15 for more details).

7.4 Types of blemishing

Over 40 different types of blemishing have been identified and documented (Table 1). There are still many other types of blemishing which are yet to be correctly identified. A description of the different types of blemish is presented in the next section.

TABLE 1.

Various classes and types of blemishing and their suggested market tolerance levels.

Class of blemish	Type of blemish	Severity	Tolerance level (Class 1) Domestic	Tolerance level (Class 1) Export
Pest	Mealybug	Major	Small numbers	Nil
	Qld and Med fly	Major	Nil	Nil
	Yellow Peach Moth	Major	Nil	Nil
	Fruit spotting bug	Major	Nil	Nil
	Thrips	Minor	2 sq. cm	1 sq. cm
	Mites	Minor	2 sq. cm	1 sq. cm
	Fruit piercing moth	Minor	Nil	Nil
	Caterpillar	Minor	Slight	Nil
Disease	Anthracnose	Major	Slight	Nil
	Grey Mould	Major	Slight	Nil
	Sooty Mould	Major	Slight	Nil
	Black spot	Major	None	Nil
	Sooty blotch	Major	None	Nil
	Calyx browning	Minor	Slight	Slight
Mechanical	Wind rub	Major	2 sq. cm	1 sq. cm
	Wire rub	Major	Nil	Nil
	Bruising	Major	Nil	Nil
	Bird scratches	Minor	2 sq. cm	1 sq. cm
	Puncture rots	Minor	Nil	Nil
	Polishing damage	Minor	2 sq. cm	1 sq. cm
Environmental	Sunburn	Major	Slight	Slight
	Water marks	Major	2 sq. cm	1 sq. cm
	Humidity marks	Major	2 sq. cm	1 sq. cm
	Uneven colouring	Major	Slight	Slight
	Fruit creasing	Minor	Slight	Slight
	Internal staining	Minor	Slight	Slight
	Wrinkle skin	Minor	Nil	Nil
	Spray damage	Minor	Nil	Nil
Physiological	Calyx cavity	Major	Slight	Nil
	Apex cracking	Minor	Slight	Nil
	Basal cracking	Minor	Slight	Nil
	Petal adherence	Minor	Slight	Slight
	Calyx adherence	Minor	Slight	Slight
	Flesh browning	Minor	Slight	Slight
	Carpelloidy	Minor	Slight	Slight
	Stamen spikes	Minor	Acceptable	Acceptable
Nutritional	Green blotch	Minor	Slight	Slight

*The current maximum limits for blemish per fruit are set at 1sq. cm for export markets and 2 sq. cm for domestic markets. These are the maximum additive areas for all types of blemish. We have suggested in Chapter 11 that the maximum limit for blemish for both domestic and export markets be reset at 0.5 sq cm per fruit.

7.5 BLEMISHES DUE TO INSECTS – MEALYBUGS

Blemish type: Insect - mealybugs

Blemish importance: major – all states

Blemish description: Mealybugs are found beneath calyx. These secrete honeydew which grows black sooty mould.

Tolerance level – domestic market: Small numbers (1-2) may be acceptable.

Tolerance level – export market: Nil

Prevention: Use a chemical spray program of Applaud® (APVMA Approval No 5157). Biological control with predators (e.g. *Crytolaemus*, *Leptomastix)* is also highly effective. See IPDM manual for more details.
In the packhouse, mealybug beneath the calyx may be removed by air-blasting (Plate 3).

Plate 1. Mealybugs found on the calyx of persimmon

Plate 2. Checking beneath the calyx for mealybugs for export quality fruit

Plate 3. Mealybug beneath calyx being removed by high pressure air-blast.

7.6 BLEMISHES DUE TO INSECTS - FRUIT FLY

Blemish type: Insect – Queensland and Mediterranean fruit fly

Blemish importance: major – Qld, NSW, WA

Blemish description: Stings become blackened and exhibit exudates.

Prevention:
Use a chemical spray program or bait sprays. Biological control is ineffective. See IPDM manual for more details.

Tolerance level – domestic market: Nil. To send fruit to Victoria, fruit from Queensland and NSW must be disinfested.

Tolerance level – export market: None. Fruit may need to be either cold disinfested or irradiated for some export markets.

7.7 BLEMISHES DUE TO INSECTS - YELLOW PEACH MOTH

Blemish type: Insect – Yellow peach moth

Blemish importance: major - Qld, NSW

Blemish description:

Typical appearance of infestation is the webbed insect frass (droppings) around the entry hole into the fruit.

Prevention:

Biological control is also effective. See IPDM manual for more details.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil,

Plate 1.Yellow peach moth damage

7.8 BLEMISHES DUE TO INSECTS - FRUIT SPOTTING BUG

Blemish type: Insect – Fruit spotting bug

Blemish importance: major – Qld, NSW

Blemish description:

Damage is small, round sunken black spots (2 to 10 mm in diameter) on the shoulders of young fruit. Damage penetrates about 1 cm into the fruit.

Prevention:

Use a chemical spray program of. Biological control is not effective. See IPDM manual for more details.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Fruit spotting damage on persimmon

7.9 BLEMISHES DUE TO INSECTS – THRIPS

Blemish type: Insect – Thrips

Blemish importance: major – all states

Blemish description:

Damage consists of uneven, silvery-grey scarring of the fruit surface.

Prevention:

Use a chemical spray program of registered chemicals. Biological control is not effective. See IPDM manual for more details.

Tolerance level – domestic market: Some damage tolerated– up to 2 sq. cm of total blemish area per fruit.

Tolerance level – export market: Some damage tolerated – up to 1 sq. cm of total blemish area per fruit.

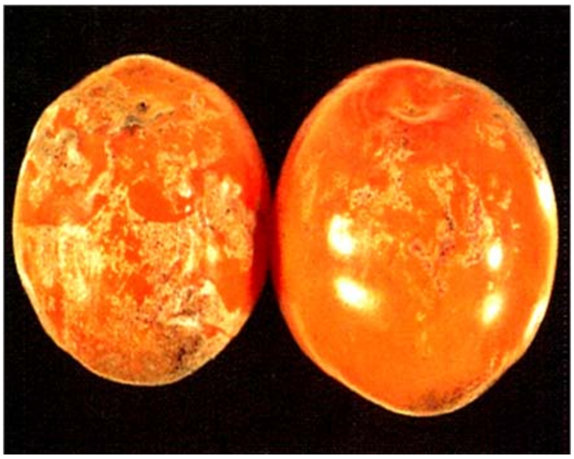

Plate 1. Thrip damage on persimmon

7.10 BLEMISHES DUE TO INSECTS - MITES

Blemish type: Insect – Mites

Blemish importance: minor – all states

Blemish description:

Rust damage caused by Eriophyid mite (*Aceria. diospyri*) initially appears, in mid-summer, as black marks from the calyx. The damaged fruit surface cracks due to fruit enlargement and a dark brown rust symptom (Plate 1) appears during the late enlargement stage to the harvest stage.

Prevention:

Currently there are no miticides registered for use on persimmon. See IPDM manual for more details.

Tolerance level – domestic market: Some damage tolerated – up to 2 sq. cm of total blemish area per fruit.

Tolerance level – export market: Some damage tolerated – up to 1 sq. cm of total blemish area per fruit.

Plate 1. Eriophyid mite damage near calyx of fruit. (Photos: Ashihara, Japan Agricultural Research Centre).

7.11 BLEMISHES DUE TO INSECTS – FRUIT PIERCING MOTH

Blemish type: Insect – Fruit piercing moth

Blemish importance: minor - Qld

Blemish description:

Moths feed at night by penetrating the skin of the ripe or ripening fruit with their strong proboscis and sucking the juice. Internal injury consists of a bruised dry area beneath the skin (Plate 1).

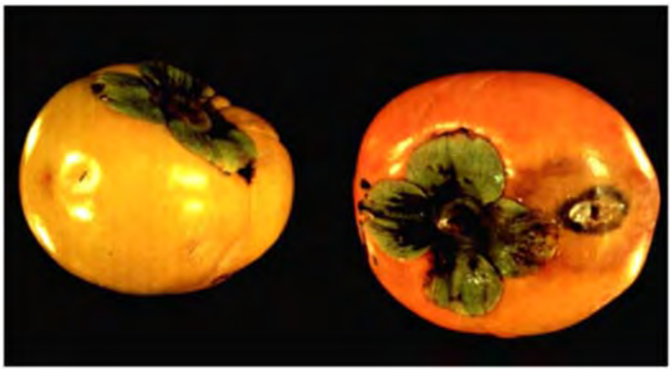

Plate 1. Damage caused by fruit piercing moth.

Prevention:

No satisfactory chemical control measure is known. Hand collection of moths and various traps have had limited success. DAFF has developed a bait to attract and kill fruit piercing moths (*Eudocima* spp.). See IPDM manual for more details.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

7.12 BLEMISHES DUE TO INSECTS – CATERPILLARS (VARIOUS SPP.)

Blemish type: Insect – Caterpillars – various species

Blemish importance: minor – all states

Blemish description: Caterpillars of various species chew on the leaves and fruit (Plate 1), calyx and bark of persimmon.

Prevention: Spray with chlorpyrifos. See IPDM manual for more details.

Tolerance level:
Domestic market: Minor damage may be tolerated provided depth of calyx is very shallow.

Tolerance level:
Export market: Nil.

Plate 1. Caterpillar damage beneath calyx. Unknown species

7.13 BLEMISHES DUE TO DISEASES – ANTHRACNOSE

Blemish type: Disease - anthracnose

Blemish importance: major – all states

Blemish description:

There can be a variety of symptoms. In the early stages, the disease appears as very small spots. These spots later coalesce to form black streaks (Plate 1). The most likely disease organism producing this symptom is *Colletotrichum gloeosporioides.*

Sunken spots may also occur on the leaves and fruit (Plate 1). These symptoms may be caused by a different species, *Colletotrichum kaki*.

Prevention:

In Queensland and NSW, depending on disease pressure, spray every two - four weeks with a fungicide such as mancozeb. Control with these protectants largely depends on the level of coverage achieved. See IPDM manual for more details.

Tolerance level – domestic market: Some minor damage tolerated. Larger anthracnose lesions are not acceptable.

Tolerance level – export market: Nil.

Plate 1. Blemishes caused by anthracnose. Top: Symptoms of anthracnose caused by *Colletotrichum gloeosporioides*. Bottom: sunken spots caused by *Colletotrichum kaki*.

7.14 BLEMISHES DUE TO DISEASES - GREY MOULD

Blemish type: Disease – Grey mould

Blemish importance: major – all states

Blemish description:
The disease appears as discrete grey coloured lesions on younger leaves and calyces (Plate 1). These enlarge and coalesce to infect whole leaflets which later senesce, and fall to the ground. Damage to calyces can reduce fruit size significantly. Fruit can also be damaged due to infected petals.

Prevention:

Fungicides containing mancozeb have activity against Botrytis.

Tolerance level – domestic market: Minor damage tolerated

Tolerance level – export market: Nil.

Plate 1. Top: Botrytis on leaves (Photo: Yuan-Min Shen, Taichung District Agricultural Research and Extension Station, Bugwood.org). Middle: Botrytis on calyx. Bottom: scarring of fruit due to infected petals

7.15 BLEMISHES DUE TO DISEASES - SOOTY MOULD

Blemish type: Disease – Sooty mould

Blemish importance: major – all states

Blemish description:

Sooty mould is superficial and may grow on leaves, twigs and fruit (Plate 1). Sooty mould is the common name applied to several species of fungi that grow on honeydew secretions on plant parts and other surfaces.

Honeydew is a sweet, sticky liquid that is excreted by plant-sucking insects as they ingest large quantities of sap from the plant. Wherever honeydew lands (e.g., leaves, twigs, fruit), sooty moulds can become established.

Although sooty moulds do not infect plants, they can indirectly damage the plant by coating the leaves and calyces to the point that sunlight penetration is reduced or inhibited. Damaged calyces reduce fruit growth and final fruit weight.

Prevention:

Controlling ant populations will reduce the protection they provide to mealybugs and aphids from predators. See IPDM manual for more details.

Tolerance level – domestic market:

Minor coatings of sooty mould near calyx tolerated. Blackening not tolerated. Discard fruit or clean manually.

Tolerance level – export market: Nil

Plate 1. Top: early stages of sooty mould due to honey dew secretions. Bottom: severe infestation of sooty mould

7.16 BLEMISHES DUE TO DISEASES - BLACK SPOT

Blemish type: Disease – Black spot

Blemish importance: minor – all states

Blemish description:

Symptoms developed as small, slightly depressed, dark brown spots (Plate 1). Causal organism is *Alternaria alternate.* Many postharvest rot symptoms have been observed in persimmon fruit during long storage. Infection appeared to begin through small cracks around and beneath the calyx.

Prevention: Maintain clean pack-houses. Make sure fruit are dry when packed.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil

Plate 1. Black spot (*Alternaria alternate*)

7.17 BLEMISHES DUE TO DISEASES – SOOTY BLOTCH

Blemish type: Disease – Sooty blotch

Blemish importance: major – all states, especially Qld

Blemish description:

Symptoms of sooty blotch are smudges and stipples on the surface of the fruit. Sooty blotch can occur where leaves touch the fruit or where fruit touch other fruit (Plate 1). Small cracks and abrasions develop on the surface of the fruit. The disease is very prevalent under wet subtropical conditions. The blotch is due to fungal infections which enter through cracks in the epidermal layers (Plate 2). The fungi colonise the waxy layers of the fruit. The symptoms may not be readily apparent at harvest but develop after removal from storage (Plate 3).

Sooty blotch is prevalent in a wide range of fruits in including apple, pear, orange and banana. A conglomerate of fungi may be involved including the following species which have been identified by Gleason *et al*. (2011). These species include:

- *Dissoconium* spp.
- *Houjia* spp.
- *Ramichloridium* spp.
- *Sporidesmajora* spp.
- *Pseudocercospora* spp.
- *Microcyclospora* spp.

Plate 1. Leaves touching the fruit can cause small abrasions and cracks in the epidermal layers of the fruit (Woolf, 2010; HortResearch, NZ)

Distribution of sooty blotch in Australia is not known but more than likely southern states are less affected due to lower rainfall/temperature. Host species for sooty blotch include other fruits such as blackberries and pome fruits. We suggest that sooty blotch has increased in persimmon orchards in recent years due to increasing production and poor orchard hygiene.

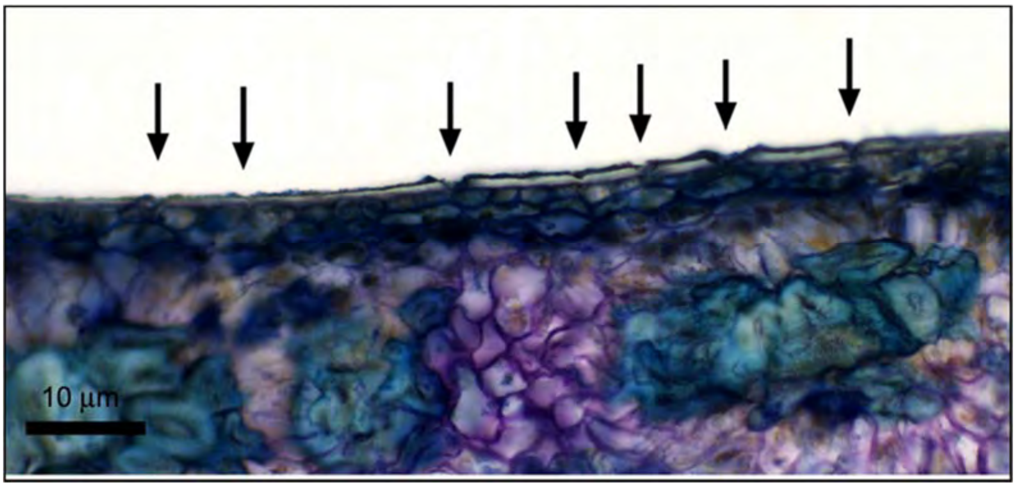

Plate 2. Cracks in the epidermal layer of the fruit where the leaf has had contact with the fruit. (Woolf, 2010; HortResearch, NZ)

Plate 3. Effects of leaf touching on skin blotching. Left: before storage. Right: after 5 days removal from cool storage (Woolf, 2010; HortResearch, NZ).

Prevention:

Pre-harvest

Severity of sooty blotch may be reduced pre-harvest through:

- keeping the tree canopy open to facilitate rapid drying
- leaf plucking (Plate 4)
- use of reflective mulch
- use of a fungicidal spray program

Overseas research has shown that field sprays of fungicides to control this disorder must start from fruit set. Few growers in Australia commence spraying at fruit set. Research in the USA has shown that the fungicide trifloxystrobin is effective against this disease. Natural products such as potassium bicarbonate also appear to be effective. Copper sprays during dormancy give limited protection.

Plate 4. Leaves have been plucked around these fruit to reduce leaf

Postharvest

Israelli studies (Prusky *et al*., 2001) have shown that a single post-harvest chlorine dip increased the percentage of marketable persimmon fruit after four months of storage by up to 40%. No post-harvest fungicide dips are currently approved for control of post-harvest rots in persimmon. However, some growers use chlorine dips of 50mL/100L to reduce blemish and disease after storage.

Pre-conditioning for 2 days at 23ºC may reduce the expression of sooty blotch when fruit are removed from cool storage.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

7.18 BLEMISHES DUE TO DISEASES – FLY SPECK

Blemish type: Disease – Fly speck

Blemish importance: major – all states, especially Qld

Blemish description:

Symptoms are small raised black specks on the surface of the fruit. These types of specks on persimmon first were first called 'Pepper Spot' in Australia. They were originally thought to be caused by high humidity. Later, because they were similar to symptoms of 'Pepper spot' on custard apple and avocado they were attributed to anthracnose infection. More recent research (Gleason *et al*., 2011) has identified this disease as 'flyspeck'. Flyspeck is a disease caused by a complex of saprophytic fungi. These invade and colonise the epicuticular layers of the persimmon skin. Symptoms can cover the entire fruit or sections of fruit. Flyspeck is a grouping of black shiny, slightly raised dots, lacking any visible mycelial connections on the fruit (Plate 1). These dots cannot be easily rubbed off the skin of persimmon.

Distribution of fly speck in Australia is not known but more than likely southern states are less affected due to lower rainfall/temperature. The order *Capnodiales* hold the majority of fungi responsible for fly speck. Some of the responsible fungi for flyspeck are: *Pseudocercospora* sp., *Zygophiala* sp., *Shizothyrium pomi, Zygophiala cryptogama, Zygophiala tardicrescens, Zygophiala wisconsinesis, Dissoconium sp., Ramularia sp., Sybren sp.*

Plate 1. Flyspeck on persimmon

Recent research in the USA suggests that sooty blotch and flyspeck are not two distinctly different diseases but mycelial types which constitute a continuum between flyspeck to sooty blotch. Sooty blotch and flyspeck often referred to as SBFS. In the past they have been classified as two separate diseases, but recent research in the USA and China has found that this may not be the case. A significant number (>64 types) have been identified as causing SBFS. SBFS fungi has eluded many generations of mycologists. In general, these fungi are challenging to isolate and grow in pure culture and isolates on fruit can differ radically from that on agar media.

SBFS thought to be a single species of fungi was reclassified as two species in 1920. *Schizothyrium pomi* anamorph for *Zygophiala jamaicensis* was thought to cause flyspeck. In 1990, observations of flyspeck found that it comprised of a diverse range of mycelial types which has unravelled the two fungi theory. Early research recognised mycelial types of flyspeck in the US as: flyspeck, compact speck, and discrete speck. Current research has expanded this to the following groupings of flyspeck in the USA. These are:

Flyspeck caused by

- *Zygophiala jamaicensis*
- *Pseudoeercospora sp.*

Small flyspeck

- *Zygophiala sp.*

Large flyspeck caused by

- *Zygophiala sp.*

Compact speck caused by

- *Ramularia* sp. or *Peltaster* sp.

Discrete speck caused by

- *Disssoconium* sp.

Prevention:

Pre-harvest

Severity of fly speck may be reduced pre-harvest through:

- keeping the tree canopy open to facilitate rapid drying
- leaf plucking
- use of reflective mulch
- use of a fungicidal spray program

Overseas research has shown that field sprays of fungicides to control this disorder must start from fruit set. Few growers in Australia commence spraying at fruit set. Research in the USA has shown that some fungicides are effective against this disease. Natural products such as potassium bicarbonate also appear to be effective. Copper sprays during dormancy give limited protection.

Post-harvest

Israelli studies (Prusky *et al*., 2001) have shown that a single, post-harvest chlorine dip increased the percentage of marketable persimmon fruit after four months of storage by up to 40%. No post-harvest fungicide dips are currently approved for control of post-harvest rots in persimmon. However, some growers use chlorine dips of 50mL/100L to reduce blemish and disease after storage.

Pre-conditioning for 2 days at 23ºC may reduce the expression of sooty blotch when fruit are removed from cool storage.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

7.19 BLEMISHES DUE TO DISEASES - CALYX BROWNING

Blemish type: Disease – Calyx browning

Blemish importance: minor – Qld, NSW

Blemish description:

Various diseases can damage or blemish the calyces including *Pestalotiopsis* spp. and *Botrytis* spp. (Plates 1 and 2). These diseases reduce the attractive appearance of the fruit and if severe can reduce fruit size (Plate 3).

Plate 1. Left: *Pestalotiopsis* leaf spot on calyces. Right: Botrytis on calyx

Plate 2. Left: healthy calyx. Right: diseased calyx

Prevention:

Maintain fungicide spray program of mancozeb throughout the whole growing season. See IPDM manual for more details.

Tolerance level – domestic market: Minor calyx browning tolerated.
Tolerance level – export market: Very minor calyx browning tolerated.

7.20 BLEMISHES DUE TO MECHANICAL CAUSES – WIND RUB

Blemish type: Mechanical – wind rub

Blemish importance: major – all states

Blemish description:

The common symptoms of rub are elongated rub marks; usually brown (Plate 1). Greater damage occurs in areas exposed to direct wind.

In surveys, we have found no correlation between incidence of wind rub and wind run or speed. This was to be expected since some orchards were well protected by either artificial or natural windbreaks, whilst others were unprotected.

Plate 1: Wind rub can cause various types of damage on the fruit.

Prevention:

In surveys we have found a higher incidence of wind rub damage in Australia compared with New Zealand. This is due to many of our trees being free-standing as opposed to Y-trellis trained trees in New Zealand. Other management factors may also have affected the severity of incidence such as pruning and thinning of laterals to give well-spaced fruit.

In Australia, new orchards are being trained onto palmette trellises; this system of training appears to be highly effective in reducing the incidence of wind rub.

Leaf plucking around the fruit 2-3 months prior to harvest will also reduce leaf rub.

Tolerance level – domestic market: Minor wind rub acceptable – up to 2 sq cm of total blemish area per fruit.

Tolerance level – export market: Very minor wind rub acceptable – up to 1 sq cm of total blemish area per fruit.

7.21 BLEMISHES DUE TO MECHANICAL CAUSES – WIRE RUB

Blemish type: Mechanical – wire rub

Blemish importance: major – all states

Blemish description:

Damage to the fruit can be caused by fruit growing too close to trellis wires (Plate 1). Damage varies widely, but generally consists of thin, depressed corky areas corresponding to the position of the wire.

Prevention: When thinning fruit, do not leave fruit close to trellis wires.

Tolerance level – domestic market: Wire rub renders the fruit unmarketable.

Tolerance level – export market: Wire rub renders the fruit unmarketable

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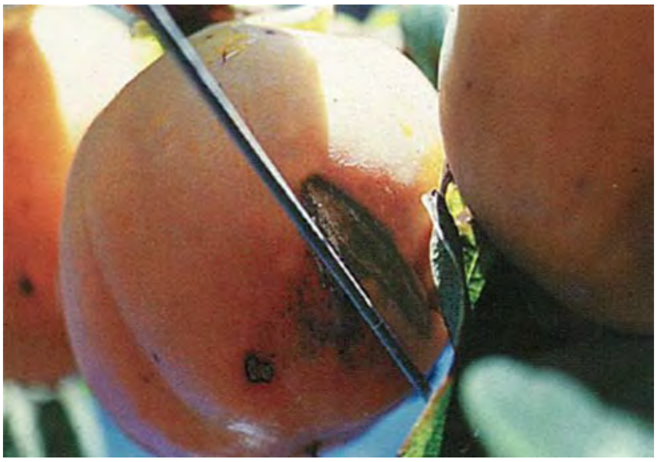


Plate 1. Wire marks on fruit

7.22 BLEMISHES DUE TO MECHANICAL CAUSES – BRUISING

Blemish type: Mechanical – bruising

Blemish importance: major – all states

Blemish description:
Bruising can occur anywhere throughout the harvesting and packing process. Commonly it occurs when:

- when fruit are carelessly dropped onto hard surfaces,
- when fruit or trays are subject to harsh impacts during harvesting and packing
- when too much finger pressure is used to harvest or pack the fruit (Plate 1).

Plate 1. Bruising of persimmon fruit caused by dropping

Immediately after bruising, no visible injury on the fruits will be evident, but the fruits deteriorate rapidly during storage. The skin tissues of the fruits stored at 20 °C become more reddish with the duration of the storage, but no such changes are found with fruits stored at 0 °C (Lee *et al*., 2005). The increase in redness of the skin tissues appears to be associated with storage temperature, but not with the bruising.
The bruising is initiated by the breakage of cell membranes; the resultant browning is caused by the enzyme action on phenolic substrates. Polyphenol oxidase (PPO) is well known enzyme responsible for tissue browning in mechanically injured fruits (Van Lelyveld and Bower, 1984; Sciancalepore, 1985; Nicolas *et al*., 1994). During harvesting, grading, and transport of persimmon fruits, the fruits often deteriorate due to bruising and subsequent storage.

Prevention: Harvest and handle fruit carefully.

Tolerance level – domestic market: Bruising generally renders the fruit unmarketable as the fruit breakdown rapidly in the cool chain and supermarket.

Tolerance level – export market: Bruising generally renders the fruit unmarketable as fruit breakdown rapidly in cool storage.

7.23 BLEMISHES DUE TO MECHANICAL CAUSES – POLISHING DAMAGE

Blemish type: Mechanical – polishing damage (Sooty blotch?)

Blemish importance: major – all states

Blemish description:
Polishing damage occurs when fruit are polished by nylon brushes or by glove/cloth. The damage does not become apparent until after a period in cool storage. In this respect, it is similar to sooty blotch. We suggest that damage to the waxy cuticle layer of the fruit may lead to the entry of disease organisms (see section on Sooty Blotch).

Symptoms of polishing damage are irregular black blotches on the apex end of the fruit. There is no damage around the calyx. The blotches are due to breakage of cell membranes and release of tannins. The resultant browning is caused by the enzyme action on phenolic substrates. Polyphenol oxidase (PPO) is well known enzyme responsible for tissue browning in mechanically injured fruits (Van Lelyveld and Bower, 1984; Sciancalepore, 1985; Nicolas *et al*., 1994). Cultivar 'Jiro' is more affected than 'Fuyu' because of its thinner skin.

Plate 1. Suspected damage due to polishing by glove. Symptoms are very similar to sooty blotch.

Prevention:
Implement similar control measures as for sooty blotch until the causes of this disorder are more fully investigated.
Check whether polishing brushes are too firm. To do this, the fruit must be stored for 2 weeks at 15°C to see if symptoms develop.
Pre-conditioning fruit at 23°C for 2 days prior to packing may eliminate most of the damage. If using gloves for polishing check that they are regularly cleaned.

Tolerance level – domestic market:
Minor polishing damage may be tolerated. However, severity of damage will not become apparent until after 1-2 weeks in cool storage.

Tolerance level – export market:
Polishing damage generally renders the fruit unmarketable because fruit when removed from cool storage they look highly unattractive

7.24 BLEMISHES DUE TO MECHANICAL CAUSES – BIRD SCRATCHES

Blemish type: Mechanical – bird scratches

Blemish importance: minor – all states

Blemish description:

Marks are thin streaks of variable size and shape (Plate 1).

Plate 1. Bird scratches on persimmon fruit

Prevention: Net the orchard to exclude birds from the crop.

Tolerance level – domestic market: Minor scratching acceptable (2 sq. cm)

Tolerance level – export market: Minor scratching acceptable (1 sq. cm)

7.25 BLEMISHES DUE TO MECHANICAL CAUSES – PUNCTURE ROTS

Blemish type: Mechanical – puncture rots

Blemish importance: minor – all states

Blemish description:

Puncture rots are caused by small twigs or fruit stems damaging the fruit during harvesting. The puncture site allows for the entry of a fungus (Plate 1).

Prevention:

Prune trees to create to create well-spaced fruiting laterals. Thin fruit that are close to twigs that are likely to puncture them. When harvesting fruit, clip stems very close to the fruit.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Top: puncture. Bottom: Puncture rot

7.26 BLEMISHES DUE TO ENVIRONMENT – SUNBURN

Blemish type: Weather - sunburn

Blemish importance: minor

Blemish description:

Sunburn is due to exposure of fruit to the sun during hot weather. Sunburn is more of a problem in unhealthy trees that have lost their leaf cover or in trees where pruning and thinning have been poorly managed. Symptoms of sunburn are a yellow to red-brown blotched halo on the exposed cheeks of the fruit (Plate 1). Sometimes the sunburn area may develop a scab due to exudates or allow entry of disease organisms due to cell breakdown (Plate 2).

In surveys, we have found no correlation between sunburn and incident radiation or daily solar hours. Also the incidence of sunburn was higher in New Zealand than in Australia, even though higher radiation and temperatures were recorded in Australia.

Temperatures reach 35ºC in summer, and fruit damage occurs when ambient temperature reaches 32-33°C. The problem is exacerbated by low root activity and low soil moisture.

Plate 1. Top: Mild sunburn. Bottom: Severe sunburn on fruit fully exposed to the sun.

We suggest that other factors besides radiation levels e.g. foliage density, pruning system may predispose the fruit to sunburn. Previous studies have shown that the incidence of this disorder increases under high radiation levels (≥25 MJ/sqm/day). Dry inland areas may therefore experience two to three times the incidence of this blemish compared with coastal areas.

Slight sunburn does not affect marketability or eating quality - as the fruit reaches full colour, the area sunburned disappears. Severe sunburn remains visible when the fruit is full coloured, and the sunburned area softens more quickly when stored. Severely sunburned fruit is therefore non-marketable.

Prevention:

Keep trees in a healthy condition to maintain good leaf cover. This means paying attention to nutrition, irrigation, pruning, pest and disease control, mulching and weed control. Manage crop load through careful pruning and fruit thinning to prevent branches bending and exposing fruit to the sun. Take care with summer pruning to avoid excessive exposure of fruit to the sun. Good leaf cover, individual fruit bagging and overhead netting can reduce sunburn.

Kaolinite and other anti-sunburn products tested have not proven to be effective.

Bird netting, with a shade factor of 5 to 15%, has been shown to significantly reduce sunburn.

Tolerance level – domestic market: Mild sunburn tolerated.

Tolerance level – export market: Mild sunburn tolerated.

Plate 2. Sunburnt fruit showing secondary disease infection possibly anthracnose

7.27 BLEMISHES DUE TO ENVIRONMENT – WATER MARKS

Blemish type: Weather– water marks

Blemish importance: major – Qld, NSW

Blemish description:

Symptoms are water or spray line marks around the circumference of the fruit and, in more severe cases, a cloudy stain may develop. Cause: Exposure of the fruit to prolonged wet weather or high humidity conditions. Symptoms may vary widely from small dark spots to larger smudges (Plates 1 and 2). The smudges may be due to a disease.

We found that the severity of this disorder increased with mean maximum temperatures during the fruit development period with the incidence increasing rapidly approaching harvest. Similar findings have been reported in Japan (Sugimoto and Yasui, 1982).

These marks also appear to be accentuated when pest control sprays are applied under high humidity conditions (>90% RH). The water marks appear to be a reaction of the spray chemicals which are absorbed into the skin surface by osmotic force. Symptoms may be accentuated if trees are under water stress

Plate 1. Different severities of watermarks

Prevention:

Chemical sprays should be applied on clear fine days which permits rapid drying of the residues but not on excessively hot (>30°C) days which may result in scalding of the fruit.

Staining could also be reduced by lowering within canopy humidity through summer pruning, the application of protective calcium and plastic polymer sprays to cuticular cracks, and the exclusion of water from the fruit surface by growing trees under plastic covers (Fukuyo, 1980; Yamane *et al*., 1991).

Plate 2. Water marking down a crease line

Use of reflective mulch and pre-conditioning of fruit after harvest may reduce expression of blemish symptoms.

Tolerance level – domestic market: Mild watermarks tolerated (2 sq. cm)

Tolerance level – export market: Mild watermarks tolerated (1 sq. cm)

7.28 BLEMISHES DUE TO ENVIRONMENT – HUMIDITY MARKS

Blemish type: Weather – humidity marks

Blemish importance: major – Qld, NSW

Blemish description:

Symptoms are loss of bloom and light grey smudges (Plate 1).

Japanese studies showed that the incidence of this disorder was highly correlated with high humidity (Sugimoto and Yasui, 1982).

Plate 1. Humidity marking

Prevention:

There are no controls for this disorder. However, this blemish is not a major cause of non-marketability as the size of the blemish spots is very small and not highly visible. All growers should consider leaf plucking as an important operation to allow better light transmission around the fruit.

Tolerance level – domestic market: Humidity marks tolerated (2 sq. cm)

Tolerance level – export market: Humidity marks tolerated (1 sq. cm)

7.29 BLEMISHES DUE TO ENVIRONMENT – UNEVEN FRUIT COLOURING

Blemish type: Environmental – uneven fruit colouring

Blemish importance: major – all states

Blemish description:

Uneven fruit colouring is often due to shading by leaves directly touching the fruit (Plate 1).

Plate 1. Leaf shading can cause fruit to develop uneven colouring

Prevention:

All growers should consider leaf plucking as an important operation to allow better light transmission around the fruit. Leaf pruning has a number of significant advantages for growers:

- reduces humidity marking of fruit
- reduces Botrytis incidence
- improves uniformity and intensity of fruit colour

Severity and timing of leaf plucking varies with growers – some growers remove all leaves around the fruit and down to the base of the fruiting shoot. It is claimed that this can cause a 0.25% reduction in Brix (sugar concentration) but this is more than compensated for by the improved fruit quality. Other growers only remove leaves that are touching the fruit. Leaf plucking too early may also reduce size. Timing of leaf plucking varies from farm to farm, from late December to late February-March in most regions of Australia.

Tolerance level – domestic market: Mild variations in fruit colour tolerated.

Tolerance level – export market: Mild variations in fruit colour tolerated.

7.30 BLEMISHES DUE TO ENVIRONMENT – FRUIT CREASING

Blemish type: Environmental – fruit creasing

Blemish importance: minor – all states

Blemish description:

Symptoms are longitudinal creases (Plate 1). Fruit creasing may be caused by low temperatures at fruit set. Creases become suberized and corky over time. This blemish is more prevalent in cooler inland regions.

Prevention:

Not known

Tolerance level – domestic market: Slight creasing acceptable.

Tolerance level – export market: Slight creasing acceptable.

Plate 1. Left: mild fruit creasing. Right: severe fruit creasing

7.31 BLEMISHES DUE TO ENVIRONMENT – GROTESQUE FRUIT

Blemish type: Environmental – Grotesque fruit

Blemish importance: major – Qld, NSW

Blemish description:

Symptoms are very misshapen fruit (Plate 1). Fruit distortions and creasing may be caused by low temperatures at fruit set. This disorder is more prevalent with early-season 'Jiro'.

Prevention:

Not known

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Grotesque fruit

7.32 BLEMISHES DUE TO ENVIRONMENT – INTERNAL STAINING

Blemish type: Environmental – internal staining

Blemish importance: minor – all states

Blemish description:

Internal stains (Plate 1) may appear after periods of prolonged wet weather. We suggest that the tannin cells have burst and then oxidised inside the fruit.

Prevention:

Not known.

Tolerance level – domestic market: Some internal staining tolerated.

Tolerance level – export market: Some internal staining tolerated.

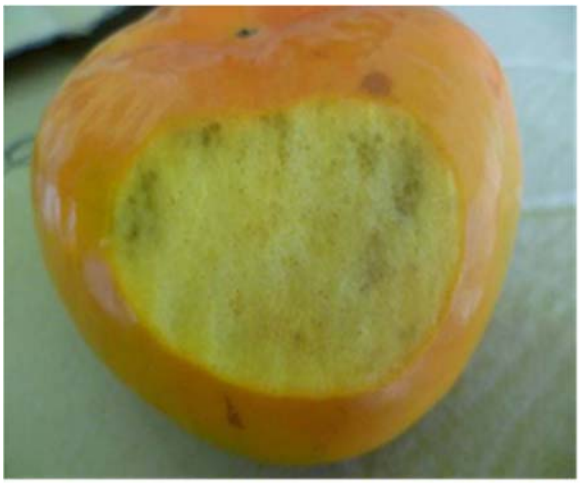


Plate 1. Internal staining due to the tannin cells which have burst and then oxidised inside the fruit

7.33 BLEMISHES DUE TO ENVIRONMENT – WRINKLE SKIN

Blemish type: Environmental – wrinkle skin

Blemish importance: minor – Qld, NSW

Blemish description:

Symptoms are wrinkled dimpled skin (Plate 1).

We suggest that the cause of this disorder is abnormally high rainfall during summer followed by a period of hot, windy weather.

Prevention:

Not known.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Wrinkle skin

7.34 BLEMISHES DUE TO ENVIRONMENT– SPRAY DAMAGE

Blemish type: Weather – spray damage

Blemish importance: major – all states

Blemish description:

Phytotoxicity from pesticide sprays can cause a variety of damage symptoms. The most common symptoms are irregular dark brown or black patches near the apex of the fruit (Plate 1). Sometimes streaking may also occur.

Spray damage can be caused by using too high a concentration of pesticide or more likely to environmental conditions at the time of spraying.

Prevention:

Do not spray when air temperatures are greater than 28°C. High temperatures favour rapid pesticide evaporation and drift and can greatly increase leaf and fruit burn.

Do not spray under excessively high humidity (>80%) conditions as this can reduce the rate of pesticide drying and increase leaf and fruit burn.

Spray either in the morning or afternoon but not too early or too late due to dew or condensation forming on leaves. Most growers suggest before 7.0 am and after 5.0 pm.

Do not apply pesticides to stressed trees. Make sure trees are well irrigated.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Various types of spray damage on fruit and leaves

7.35 BLEMISHES DUE TO ENVIRONMENT– BAIT SPRAY DAMAGE

Blemish type: Weather – Bait spray damage

Blemish importance: minor – Qld, NSW

Blemish description:

The most common symptoms are superficial black splotches on the skin. The damage is caused when bait sprays splash from the leaves to fruit.

Prevention:

Avoid spraying bait spray on fruit. Wash fruit after harvest.

Tolerance level – domestic market: Nil.

Tolerance level – export market: Nil.

Plate 1. Bait spray splotches

7.36 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – CALYX CAVITY

Blemish type: Physiological – Calyx cavity

Blemish importance: major – all states

Blemish description:

A space or cavity develops beneath the calyx (Plate 1). The cavity may become a habitat for mealybugs and fungal rots. The problem is more serious in large fruit on young vigorous trees.

Cause: Rapid growth in fruit following an earlier period of stress during fruit development. More common in some varieties, for example 'Jiro' and 'Suruga'. It can also be related to poor growth of the calyx in its early growth stage. Small calyx size may be due to vigorous shoot growth.

Plate 1. Severe calyx cavity.

Prevention:

Manage crop load by careful pruning and fruit thinning to avoid the development of excessively large fruit. Carefully manage nutrition and irrigation to avoid stress periods during fruit development.

Excessive nitrogen fertilization should be avoided. If trees are thinned early in the season, this will enhance calyx growth and help to prevent the disorder.

Tolerance level – domestic market: Mild calyx cavity tolerated.

Tolerance level – export market: Any form of calyx cavity is not tolerated.

7.37 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – APEX AND CONCENTRIC CRACKING

Blemish type: Physiological – Apex, concentric and line cracking

Blemish importance: minor – all states

Blemish description: Symptoms are fine skin-deep cracks radiating around the circumference of the fruit (Plate 1).

Our surveys have shown that the incidence of these disorders was extremely low with the major non-astringent varieties. The main commercial cultivar 'Fuyu' is not susceptible to cracking disorders. Oku Gosho is commonly affected by apex, distal end cracking.

We suggest that cracking occurs during rapid fruit growth following a physiological stress induced by extreme fluctuations in soil moisture or temperature. Similar finding have been reported in Japan where severity of cracking is dependent on stage of growth, variety and cuticle thickness.

In Japan, the incidence of cuticular cracking increases with irrigation and other factors stimulating excessive fruit growth during the final stage of fruit growth (Tarutani *et al*., 1970; Yamamura *et al*., 1984).

Prevention:

Because the fruit is packed distal end up any cracking is very obvious and renders the fruit unmarketable. We suggest that cracking is controlled indirectly through management of factors such as soil moisture and atmospheric stress.

Tolerance level – domestic market: Mild cracking tolerated

Tolerance level – export market: Any form of cracking is not tolerated

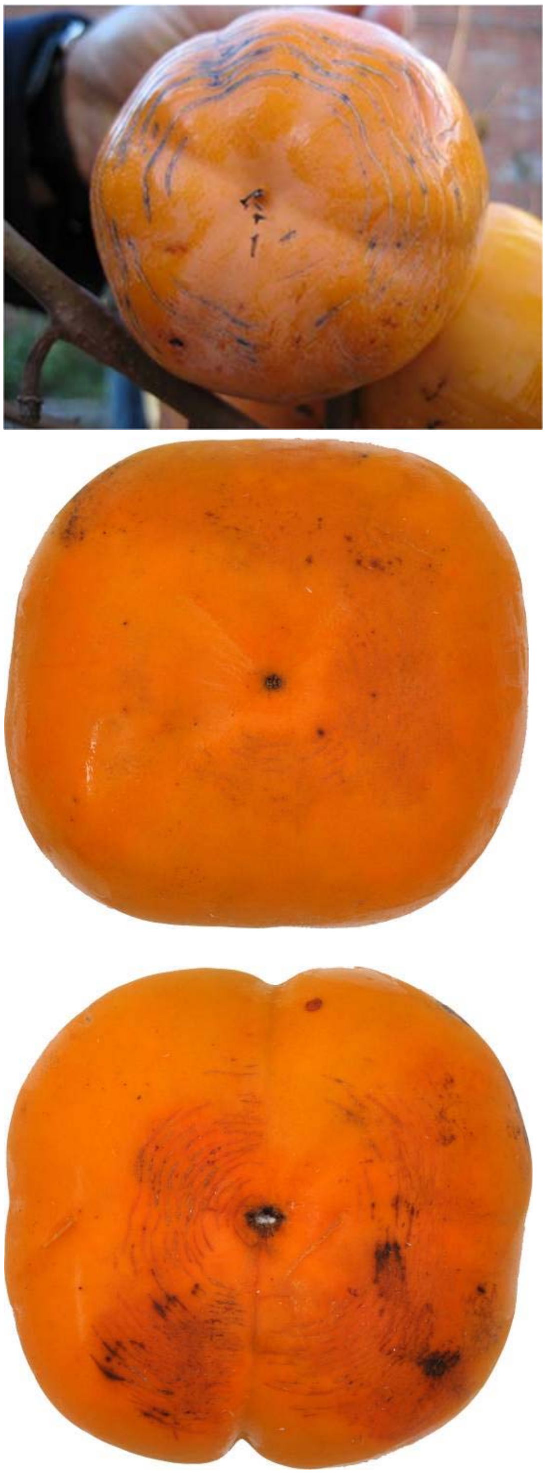


Plate 1. Concentric cracking.

7.38 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – BASAL CRACKING

Blemish type: Physiological –Basal cracking

Blemish importance: minor – all states

Blemish description:

Basal cracking is caused by rapid growth of fruit following earlier water stress at fruit set. Some varieties, such as ‘Oku Gosho’, are more susceptible. The problem is worse on large fruit.

Prevention:

Treatment and prevention: Improve irrigation, particularly during fruit set and early fruit growth. Use soil moisture monitoring devices to improve the accuracy of watering.

Plant only recommended varieties such as ‘Fuyu’ and ‘Jiro’, as these varieties are less susceptible to damage.

Tolerance level – domestic market:

Because the fruit is packed distal end up any cracking is very obvious. Only very mild cracking is acceptable.

Tolerance level – export market: Any form of cracking is not tolerated

Plate 1. Various degrees of basal end cracking. Fruit with very mild basal cracking can be marketed.

7.39 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – PETAL ADHERENCE

Blemish type: Physiological – petal adherence marks

Blemish importance: minor – all states

Blemish description:

Flower petals sticking onto the young fruit as the petals dry and wither. Generally more common in trees suffering from water stress.

Because the flower petals stay attached to the fruit, tannins from the petals may leach onto the skin, causing stains, spots or bands around the circumference of the fruit (Plate 1). A square-shaped mark at the point of petal adherence is the most common symptom.

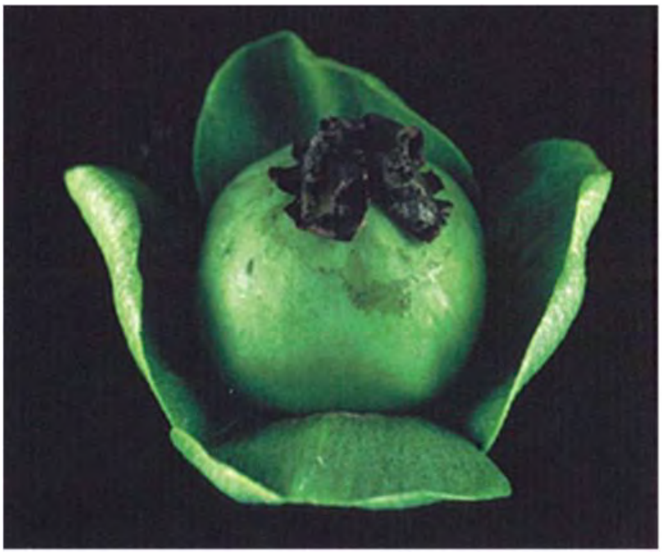


Plate 1. Petal adherence marks

Prevention:

Ensure that there is adequate soil moisture when trees are setting fruit.

Where air blast sprayers are used to apply leaf spot sprays, these are relatively effective in removing spent petals from the young fruit.

Tolerance level – domestic market: Mild marking tolerated.

Tolerance level – export market: Mild marking tolerated.

7.40 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – CALYX ADHERENCE

Blemish type: Physiological – calyx adherence marks

Blemish importance: minor – all states

Blemish description:

Cause: A tight calyx, which restricts growth of the young fruit where it contacts the outer edge of the calyx. More common in varieties with a naturally tight calyx, for example 'Suruga'. Affected fruit show a slightly depressed yellowish line, corresponding to the shape of the calyx, around the top of the fruit (Plate 1).

Plate 1. Calyx adherence mark

Prevention:

The damage is cosmetic and does not affect the eating quality of the fruit. There are no practical preventative measures, apart from avoiding any variety with a naturally tight calyx. Ensure that there is adequate soil moisture when trees are setting fruit.

Tolerance level – domestic market: Mild marking tolerated

Tolerance level – export market: Mild marking tolerated

7.41 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – FLESH BROWNING

Blemish type: Physiological – flesh browning

Blemish importance: minor – all states

Blemish description:

Flesh browning can be due to a number of causes. Partial pollination can lead to uneven seed development (Plate 1).

Even in PCNA varieties such as 'Fuyu', flesh around the seed is darker due to the formation of more tannin cells (Plate 1).

Prevention:

Exclude all pollinator trees to prevent pollination and seed development. Partial pollination is not desirable.

Tolerance level – domestic market: Mild flesh browning acceptable.

Tolerance level – export market: Mild flesh browning acceptable.

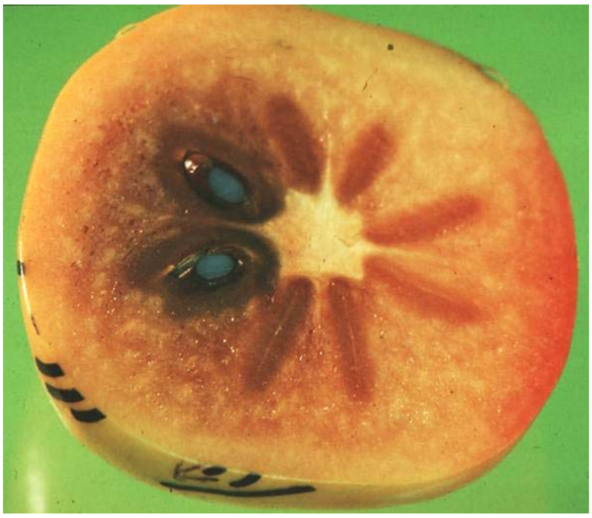


Plate 1. Effects of pollination and seed development on flesh colour. Note: flesh darkening around seed

7.42 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – CARPELLOIDY

Blemish type: Physiological – carpelloidy

Blemish importance: major – all states

Blemish description:

Affected fruit may show a range of symptoms from mild side creasing to an overall misshapen appearance (Plate 1). Individual fruit on occasions show grotesque shapes.

Cause: Not known. May be due to low temperatures at flowering or due to lack of pollination of fruit Varieties 'Suruga' and 'Jiro' are the worst affected.

Prevention:

Either ensure no pollination to produce seedless fruit by eliminating polliniser trees or alternatively ensure maximum pollination of susceptible varieties by carefully managing bee numbers. Partial pollination is to be avoided.

Tolerance level – domestic market: Mild carpelloidy acceptable.

Tolerance level – export market: Mild carpelloidy acceptable.

7.43 BLEMISHES DUE TO PHYSIOLOGICAL CAUSES – STAMEN SPIKES

Blemish type: Physiological – stamen spikes

Blemish importance: minor–Vic, SA

Blemish description:

Stamens (old flower parts) may remain on the fruit and become hard and spiky (Plate 1). The incidence is higher on fully pollinated, seeded fruit. These spikes can then cause damage to other fruit. Therefore, fruit handling is very important. No fruit brushing can be used with these fruit.

This problem is seen more often in southern states, but to a much lesser extent in Queensland and northern NSW.

Prevention:

Physical removal of the spikes at harvest. Plant orchards without pollinators.

Tolerance level – domestic market: Acceptable

Tolerance level – export market: Acceptable

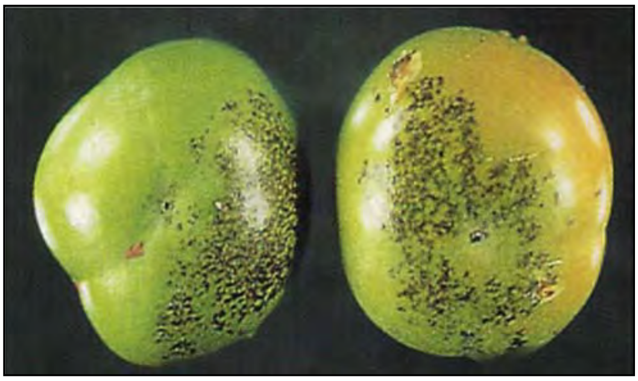
Plate 1. Stamen spikes can damage other fruit when picked.

7.44 BLEMISHES DUE TO NUTRITIONAL CAUSES – GREEN BLOTCH

Blemish type: Nutritional – Green blotch

Blemish importance: major– all states

Blemish description:



Identification notes: Affected fruit have uneven colouring with small black spots in the green blotchy areas (Plate 1).

Cause: High uptake of manganese from the soil. Symptoms occur in soils with high manganese levels when pH falls below 6.5 (1:5 water test).

Prevention:

Growers should get a leaf analysis done to confirm the diagnosis. Apply lime or dolomite to raise soil pH to 6.5 (1:5 water test). In future, do regular leaf and soil analysis to monitor nutrient levels. In high manganese soils, maintain soil pH at 6.5 or above (1:5 water test).

Plate 1. Various degrees of green blotch disorder. Top: severe. Bottom: mild.

In Australia, application of foliar sprays of various formulations of calcium has not reduced severity of the disorder.

Tolerance level – domestic market: Mild symptoms tolerated.

Tolerance level – export market: Mild symptoms tolerated.

7.45 Summary

Considerable progress has been made in identifying the causes of blemishing in persimmon. Almost all types of blemishing started from fruit set onwards indicating that control measures must also be implemented early.

A summary of the more important blemishes and their control is presented in Table 2.

TABLE 2.
A summary of some of the different causes of major blemishes and their prevention.

Type of blemish	Cause	Management/cultural practise to reduce incidence
Wind rub	excessive wind	• site selection • windbreaks • trellising/pruning • fruit and leaf thinning • tree pruning
Humidity marks	low minimum temperatures high humidity	• site selection • summer pruning • leaf plucking
Sunburn	high irradiance low foliage density	• site selection • netting • pruning/trellising system
Apex, concentric and line cracking	rapid changes in soil moisture tension	• control soil moisture • control of fruit size
Petal adherence marks	petal staining the skin	• air blast spraying • control soil moisture stress
Water and spray marks	chemical sprays applied on high humidity days	• apply sprays on clear, fine days of moderate temperatures • summer pruning • fruit bagging
Green blotch	High manganese concentrations	• apply lime or gypsum. • maintain soil pH at 6.5 or above (1:5 water test).
Spray damage (phytotoxicity)	Applying pesticide sprays at too high a concentration or under wrong environmental conditions.	• do not spray when air temperatures are greater than 28°C. • do not spray under excessively high humidity (>80%) • do not apply pesticides to stressed trees. Make sure trees are well irrigated.
Carpelloidy	Uneven pollination	• either ensure no pollination to produce seedless fruit by eliminating polliniser trees • or alternatively ensure maximum pollination of susceptible varieties by carefully managing bee numbers. • Partial pollination is to be avoided.

Type of blemish	Cause	Management/cultural practise to reduce incidence
Uneven fruit colour	Leaf shading	• Leaf plucking • Reflective mulch
Calyx cavity	Soil moisture stress	• Provide good irrigation from fruit set • Restrict nitrogen
Sooty blotch	Diseases and rub	• Leaf plucking • Reflective mulch • Pre-conditioning fruit after harvest • Spray program from fruit set

Plate 1. High quality, blemish free fruit.

Key points

Persimmons are very susceptible to blemishing

Pack-house % may be reduced by 60% unless blemishing is managed

The major blemishes are wind rub, water marks, sunburn, anthracnose and bruising

Orchard management techniques can greatly reduce blemishing – these include:

- trellising
- correct training and pruning
- leaf plucking
- use of reflective mulch
- maintaining adequate soil moisture from fruit set on
- maintaining a good spray program
- spraying at the right temperature/humidity
- preconditioning fruit after harvest

POST-HARVEST DISORDERS

8.1 Overview

Unlike blemishes and defects which are apparent before fruit are harvested, as the name suggest, post-harvest disorders develop after the fruit is picked. Most of these disorders develop after a period of cool storage. The most common disorders are caused by diseases that enter through cuts and abrasions.

8.2 Post-harvest diseases

Symptoms

Initial infections appear as discoloured, water-soaked spots on fruit (Plates 1 and 2). These lesions enlarge rapidly, releasing enzymes that leave the fruit limp, brown, and leaky. Under conditions of high relative humidity, the fruit rapidly becomes covered with a coat of mycelium and sporangiophores of various colours depending on the invading species.

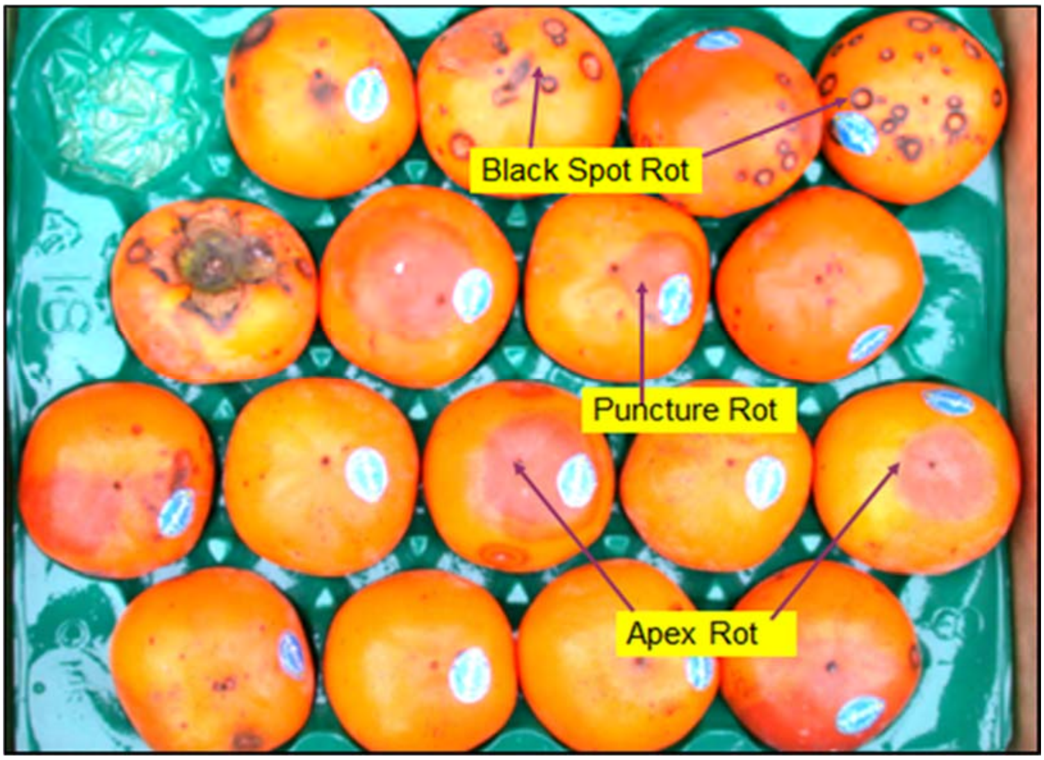
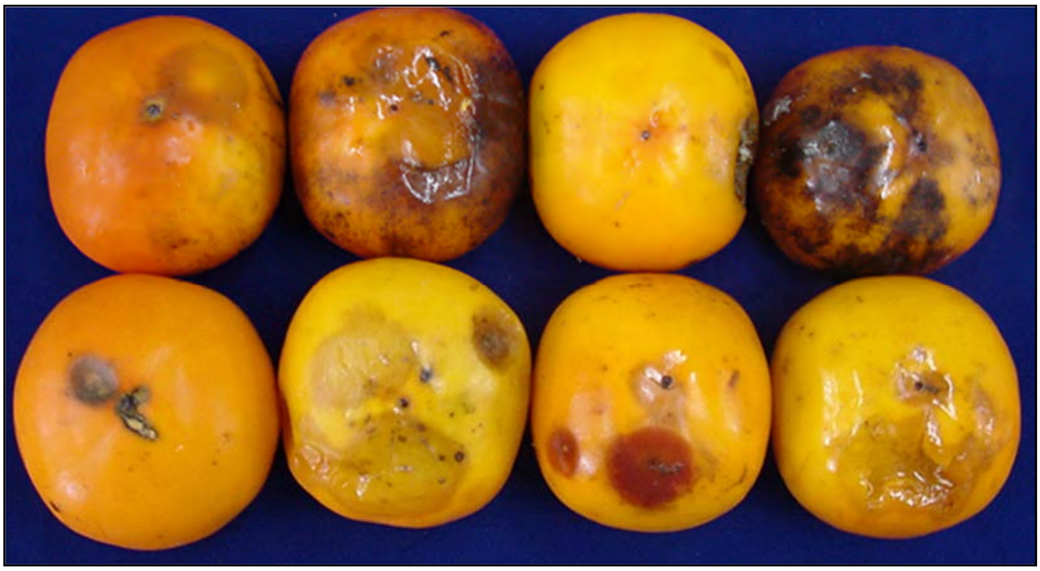


Plate 1. Post-harvest diseases: Black spot (*Alternaria* spp.); puncture and apex rots (*Penicillium* spp., *Rhizopus* spp.) (Photo: Allan Woolf, HortResearch, NZ).

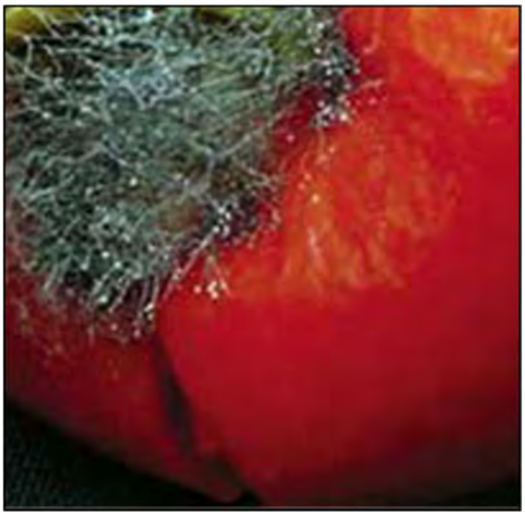


Causal organisms

Various organisms including:

- Alternaria spp. (Black spot) (Plates 1 and 2)
- Rhizopus spp. (Transit rot) (Plates 1 and 3)
- Penicillium spp.(Blue mould) (Plates 1 and 3)
- Cladosporium spp.
- Mucor spp.
- Phoma spp.

These fungi are excellent saprophytes that live on and help break down decaying organic matter. They invades persimmon through wounds and secrete enzymes that degrade and kill the tissue ahead of the actual fungal growth. Spores are airborne. These pathogens have a large host range and are prevalent worldwide.



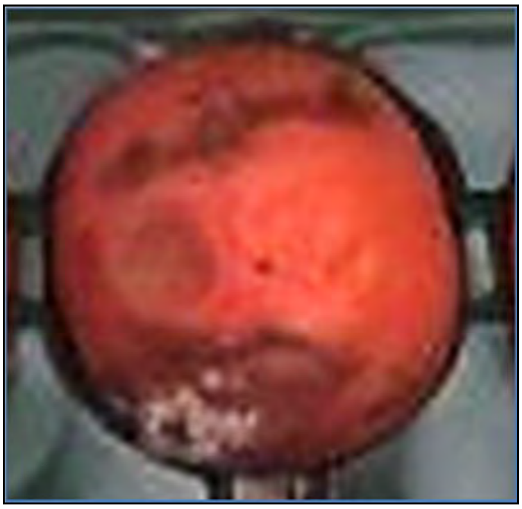


Plate 3. Top: Rhizopus mycelium. Bottom: Penicillium spp

Occurrence and distribution

Rain splashes overwintering spores from soil and crop debris onto developing fruit. Symptom development is favoured by high humidity. Fruit rots occur during warm, wet weather.

Alternaria rot is caused by *Alternaria alternata* which attacks developing fruits. Infections remain quiescent until after harvest, and black spots become apparent as the fruits ripen in store. Wound infection results in earlier appearance of symptoms.

Rhizopus stops growing at temperatures below 8° to 10°C, so rapid postharvest cooling of fruit is essential for disease control. These diseases can spread from fruit to fruit and from contaminated packaging material such as wood wool.

There are a wide range of host species including most fruit and vegetables.

Chemical control

There are some benefits in the use of protective fungicides, but unless the disease is widespread throughout the field, these pathogens should not cause excessive damage. All harvest equipment, the packing line and packing boxes should be sanitized regularly. There are a range of techniques available to sanitise pack-houses including use of:

- ozone generators
- UV-C lights
- vaporous hydrogen peroxide
- Bactigas® (contains Tea Tree oil)
- sodium hypochlorite (bleach)

These methods are described in more detail in an article by Peter Tavener, SARDI, 'Decontamination of cold storage facilities' in Packer Newsletter, Vol. 89, December, 2007. The efficacy of these methods is still under investigation.

Israelli studies (Prusky *et al*., 2001) have shown that a single post-harvest chlorine dip increased the percentage of marketable persimmon fruit after four months of storage by up to 40%. No post-harvest fungicide dips are currently approved for control of post-harvest rots in persimmon. However, some growers use chlorine dips of 50mL/100L to reduce blemish and disease after storage.

8.3 Orchard management strategies

Be sure when fruit are being picked that the entire fruit is removed from the stem, not leaving behind the fleshy receptacle of the fruit as it can serve as a site for invasion by fungus.

Fruit injury during harvest and packing should be avoided – use padding in harvest trays and handle gently. Improved sanitation in the field, and in the packinghouse, is effective at reducing losses due to fruit rots.

Culling infected and injured fruit during packing reduces losses due to post-harvest decays. It may be advantageous to store fruit for 2-3 days before grading and packing to allow symptoms on damaged fruit to appear so that can be more easily identified (see Chapter on Preconditioning).

Wet surfaces should be dried promptly before packing using fans and fruit should be cooled quickly to 15ºC using force draft cooling.

Key points

Pack-house hygiene is important in preventing post-harvest rots

Regularly inspect the pack-house for sources of contamination (water, brushes, rollers, grader cups)

Use a range of techniques to sanitise pack- houses during and after the harvest season is completed

Pre-conditioning may reduce the expression of physical damage and post-harvest disorders

HARVESTING METHODS

9.1 Harvest period

Depending on region, harvesting begins in Australia in early February and finishes in June. For most orchards, varieties need to be picked at least twice weekly between seven to ten times.

9.2 Harvesting methods

Growers should harvest only mature fruit based on maturity standards (see Chapter 6). Fruit are harvested with the calyx attached. Fruit must be clipped from the tree to ensure a good appearance and the quality of the calyx (Plate 1).

Special-purpose precision secateurs are used which have been designed to make a clean cut above the calyx, leaving the calyx attached to the fruit, without bruising the fruit or damaging the branch.

The stem is then trimmed to avoid puncturing other fruit (Plate 2).

Plate 1. Clipping fruit from the trees.

9.3 Harvesting containers

For tall trees, some growers use a picking pouch (Plate 3) to hold the fruit before it is transferred to the harvest trays. Fruit should be placed by hand into harvest crates either 2 or 3 layers deep (Plates 4 and 5). Some growers use bubble wrap between layers of fruit to reduce damage (Plate 4).

Plate 2. Puncture wound caused by a long stem on an adjacent fruit.

Plate 3. Harvesting pouch – useful for holding fruit whilst on ladders. Note use of gloves to avoid bruising.

Plate 4. Top: harvesting crate and trays with bubble wrap between layers of fruit to prevent bruising. Bottom: less desirable – many layers and no padding.

Plate 5. Polystyrene box with handle used for harvesting.

Harvesting into buckets is less desirable due to calyx cuts (Plate 6). All possible care is taken to ensure that only high quality fruit, entirely free of damage, arrives at the pack-house door.

Growers should use soft-tyred transport to get it to the packing shed (Plate 7). Harvest early in the morning after dew has dried. Try to complete harvest before midday. Keep fruit out of the sun to prevent undue heating. Internal fruit temperatures can reach 25°C if left in the sun.

Plate 6. Harvesting into buckets is less desirable than shallow trays.

Plate 7. Harvesting trolley used in NZ.

9.4 Mobile platforms and cherry pickers

Some growers need to harvest very tall trees. These can either be picked using mobile platforms or cherry pickers (Plate 8). These types of harvesting aids must meet State safety regulations.

Plate 8. Mobile platform being used to harvest tall, palmette trellised persimmon trees in Italy.

Key points

Harvest in the morning, keep fruit in the shade

Clip fruit close to the calyx to avoid puncture wounds

Persimmons are easily bruised – avoid rough handling

Use padded, shallow harvesting containers

Pre-conditioning may reduce expression of physical damage

PACKHOUSE PROCEDURES AND SEQUENCES

10.1 Overview

A well designed and an ergonomically efficient pack-house will reduce labour costs associated with packing. Persimmon pack houses use a variety of standard procedures and processes to pack their fruit. However, there is large variation between growers in the processes and equipment that they are using. For example, some growers wash their fruit whilst others don't. Some growers are brush- polishing their fruit whilst others use cloth or glove polishing after weight grading – these growers claim that brush polishing damages the fruit. These different procedures and equipment are discussed below. A standard sequence of pack-house processes and options is presented in Figure 1.

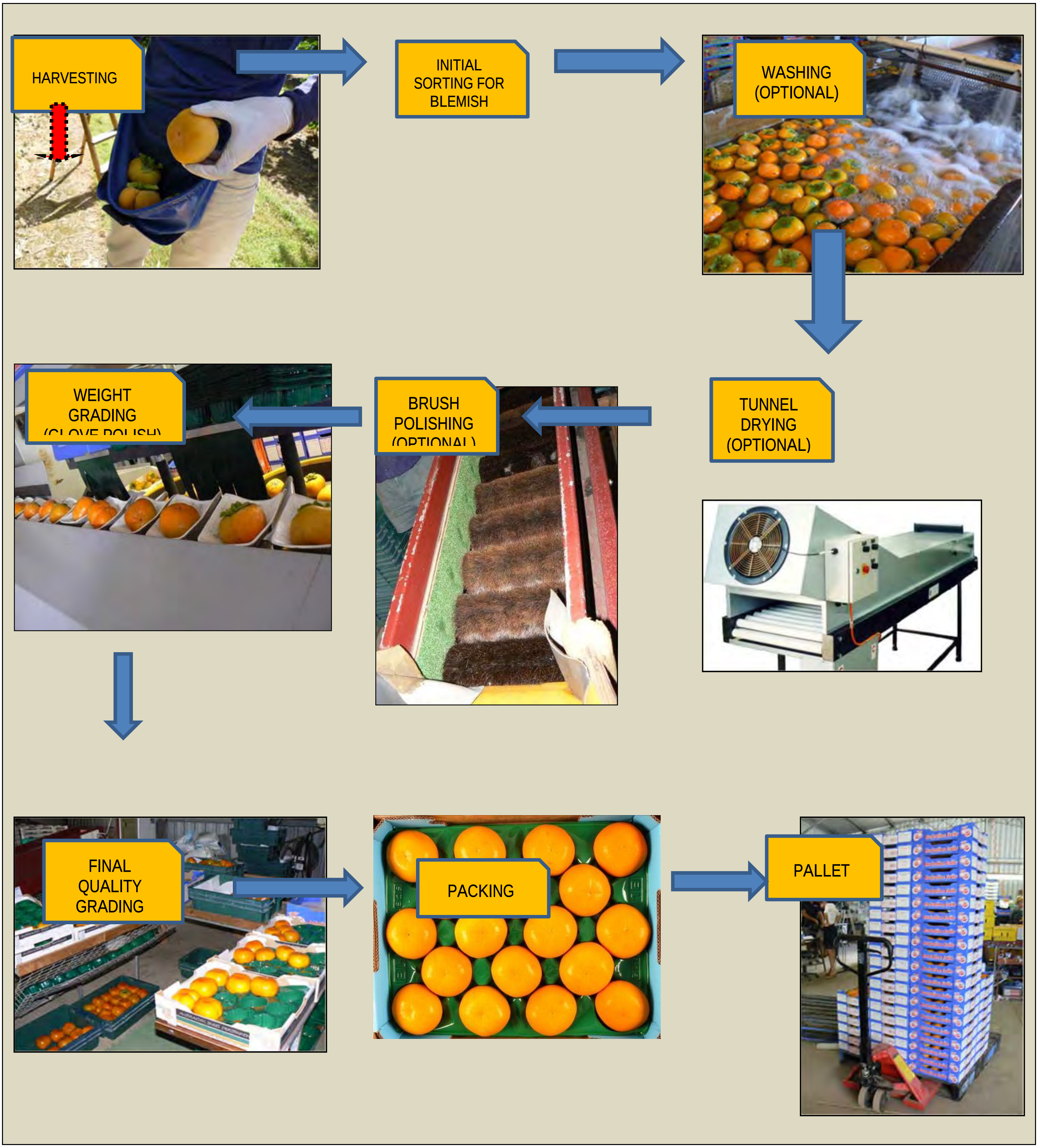


Figure 1. Schematic diagram of the processes and their sequences from harvesting to palletisation. Washing and tunnel drying are optional. Glove or cloth polishing at final quality grading eliminates the need for brush polishing. If storing fruit for short periods of 3-5 days to avoid glutting, store at 15°C. The cool chain from farm to consumer should be maintained at 15°C.

10.2 Initial sorting

Most growers do some initial sorting of fruit discarding blemished or damaged fruit in the field and again before it goes onto the packing line. Other growers do the main sorting after the fruit have been weight graded. We suggest that initial sorting is best done before weight-grading.

10.3 Washing

About 50% of growers surveyed wash their fruit after harvest. Fruit are washed to remove spray residues, dirt and dust (Plates 1 and 2). Alternatively these residues can be removed by polishing alone.

Plate 1. Left: spray residues. Right: dust

Water used through the washing stages must be of a high microbiological quality. Any pathogens introduced at this stage are likely to survive on the fruit and so food safety risks are high. Use HACCP protocols to prevent contamination in water cleaning tanks. Any free moisture left on the fruit can freeze during cool storage leading to skin blackening.

Plate 2. Fruit being washed before polishing and grading.

10.4 Drying

Many grading machines have a heated drying tunnel before the fruit is polished with brushes. Drying removes any condensation from fruit harvested in the morning or fruit which have been washed. It also prevents damage caused by rollers and polishers and may also help prevent post-harvest rots in longer-term storage. Any free moisture left on the fruit can freeze during cool storage leading to skin blackening. Therefore it is very important that fruit are completely dry before they are packed.

Fruit is transported through the drying tunnel on PVC rollers (Plate 3). The rollers automatically turn the fruit while in the drying tunnel allowing the heated air to totally engulf all pieces of fruit. The variable speed roller conveyor allows the flow of fruit to proceed at a compatible pace to other machines on the fruit processing line.

On a single drying tunnel, one fan forces air into the tunnel over a LP gas burner. In a double tunnel, two fans and two burners are used. Burners are fired up with an easy-start switch and maximum oven temperatures may be set from 35 to 45°C. The fruit should dried over a 2-3 minute period and fruit should only be rolled once. Check that burners are not releasing ethylene which initiates ripening.

Plate 3. Drying tunnel designed by KW engineering.

10.5 Polishing

Polishing removes bloom (Plate 4), visible spray residue and dust on the fruit. Polishing enhances the bright orange colour of the skin but can cause skin damage which does not become evident until fruit are removed from cool storage. Korean studies recommend that as much of the bloom as possible be left on the skin (Ahn, pers. Com., 2012).

Types of polishers

Persimmon growers are using three polishing methods:

- Glove or cloth (Plate 5)
- Nylon brushes (Plate 6)
- Horsehair brushes (Plate 7)

Growers using gloves or cloths to polish the fruit suggest that this causes less damage to the fruit than polishing brushes particularly for thin skin varieties such as ‘Jiro’. Glove or cloth polishing is done after weight-grading. Growers say that the process is quick and cost-efficient for high quality fruit.

Plate 4. Left: fruit which has been polished. Right: fruit unpolished with distinct bloom.

The length and coarseness of the hairs will affect the degree of removal of bloom. Excessively rigid hairs will damage the fruit and enhance the expression of existing blemishes. Growers using horsehair brushes suggest that they cause less damage than nylon brushes.

The number of brushes per polisher may also be increased allowing individual growers greater versatility when processing high volumes of fruit. Slower brush speeds may reduce damage.

Brushes can be a source of microbial contamination and therefore need to be cleaned regularly.

Plate 5. Polishing fruit using gloves.

Plate 6. Polisher with several nylon brushes designed by KW engineering.

Plate 7. Rollers made of coarse horse hair about 2.5cm in length.

Damage due to polishing

All types of polishing can cause physical damage to fruit even glove polishing (Plate 8). This damage becomes more evident the longer the duration that fruit are cool stored. The damage is due to the release of the enzyme polyphenol oxidase. Korean studies have shown that both washing and polishing persimmon fruit damages the fruit and should be avoided (Ahn, pers. com., 2012). Pre-conditioning at 23°C for 2 days before storage can greatly reduce expression of damage (see Chapter 15). Growers should regularly check to see if their polishers and polishing methods are causing damage.

Plate 8. Suspected physical damage due to glove polishing. Damage becomes more apparent during cool storage even for fruit held at 15°C. Growers should check to see if their polishers are causing physical damage.

10.6 Grading

Various types of graders can be used to grade persimmon including:

- Grading by sight (Plate 9)
- Electronic in-line weight grading (Plates 10 and 11)
- Circular electronic weight graders (Plate 12)

Sight grading

Smaller growers grade by eye periodically weighing individual pieces of fruit. Operators should be trained in selecting the size desired and to either directly pack the items into containers or place the selected produce gently into a bin for packing further down the line. Some growers use standard size gauges. Examples of the smallest and largest acceptable sizes for each product can be placed within view of the operator for easy reference. Hand held sizers are also used for a variety of products (Kitinoja and Kader, 2002).

Electronic in-line weight graders

In-line graders are used to handle large volumes of fruit. They are installed in pack-houses where there is plenty of room for their set-up. They have the advantage over smaller circular graders in that each size count can have an allocated bin. They may be configured for various numbers of lanes:

- Single lane
- Dual lane

Automated graders allow for extreme accuracy in quality of grading resulting in better appearance and positive enhancement of produce to wholesalers, retailers and consumers. A simple stroke of the keyboard can select pre-programmed weight settings giving great flexibility and speed to gently handle persimmon. Electronic Weight Graders have a capacity to handle up to 14 500 pieces of fruit per hour (1 Lane version).

Plate 9. A simple grading bench where fruit are graded by sight.

Plate 10. Electronic in-line weight grader designed by KW engineering.

Plate 11. Electronic controllers can set weights for each size grade as well as record number of fruit packed in each size range.

Electronic circular weight grader

This type of grader (Plate 12) is used where moderate volumes of fruit are to be graded and where there are limitations on space. They have the disadvantage that there is a limitation on the number of bins allocated for different counts.

Plate 12. A seven bin circular electronic weight grader.

10.7 Conveying

To reduce bruising in Australia packing sheds, conveyer equipment and bins used may feature:

- foam-padded ramps (Plate 12)
- slow produce speed on ramps by installing retarding flaps, curtains, blankets or drapes. Use a flexible drape to slow fruit as it falls from a higher conveyor belt to a lower one (use a lightweight drape for short transition, heavier drape for higher transition)
- belting to prevent produce from falling directly onto roller-sizers

Plate 13. All bins and ramps should be padded to minimise bruising.

10.8 Grading process

When sorting for rejects, and removing any product that is too small, decayed or damaged, the height of the sorting table should be set at a level comfortable for sorters (Plates 14 and 15). Stools, or a firm rubber pad on which to stand, can be provided to reduce fatigue.

Locations of the table and the sorting bins should be chosen to minimize hand movements. It is recommended that the workers' arms create a 45 degree angle when s/he reaches toward the table, and that the width of the table be less than 0.5 meter to reduce stretching.

Good lighting (500 to 1000 lux at work surface) will enhance the ability of the sorter to spot defects, and dark, dull belts or table tops can reduce eye strain. If a conveyor system is in use, the product must not flow too fast for the sorters to do their work.

The rotational speed of push-bar or roller conveyors should be adjusted to rotate the product twice within the immediate field of view of the worker.

Periodical rotation of worker positions on the line will help to reduce monotony and fatigue.

Supervisors should be able to quickly identify under-sorting and over-sorting (Kitinoja and Kader, 2002).

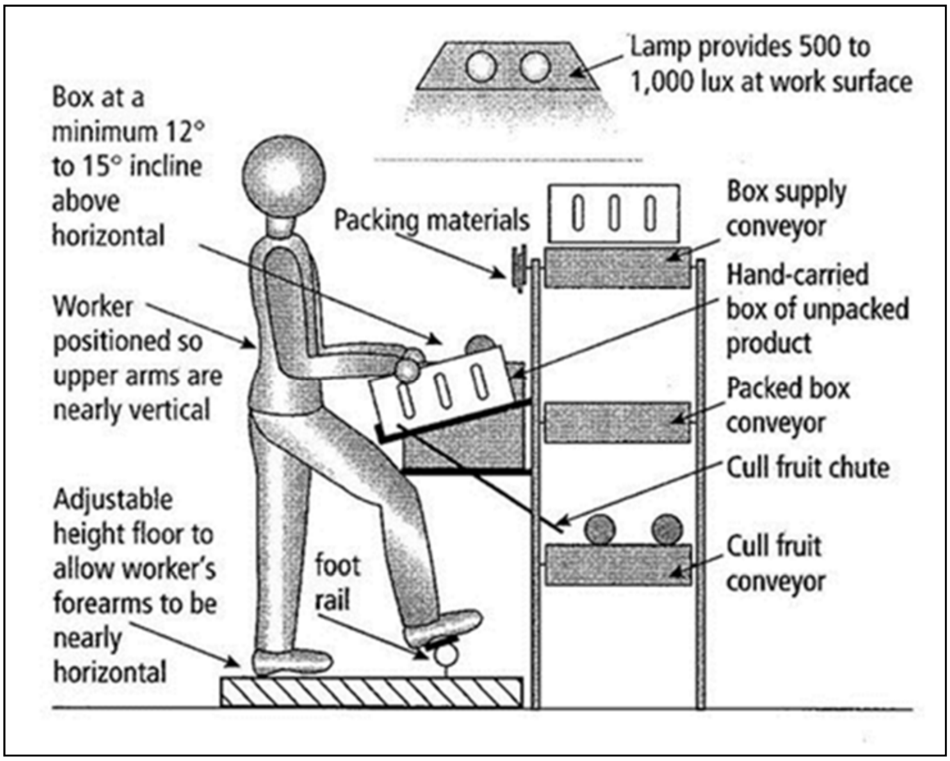


Plate 14. Features of a well-designed sorting/grading station

Plate 15. Well-designed packing station with good lighting.

10.9 Palletising and pre-cooling

Most growers palletise their fruit and pre-cool their fruit to between 12-15°C for several hours or overnight before road transport to domestic markets.

Key points

There are several options in pack-house procedures and processes – the most optimal system to use is still being developed

An ergonomically efficient pack-house will reduce labour costs

Washing and polishing may damage fruit – this type of damage is not evident until fruit are removed from cool storage – further studies are required to verify the severity of damage

GRADE STANDARDS

11.1 Grading for size

Minimum fruit weights

A desirable size for 'Fuyu' is between 230 grams and 250 grams, with 150 grams required as a minimum marketable size (George *et al*., 2005; Sanewski,1988).

Fruit counts

Fruit counts range from 12 to 28 pieces of fruit per tray with most fruit packed to a count of 16 to 20 (Figure 1) with an average weight of 3.5 - 4.6kg per tray. Larger fruit e.g. counts of 12 when packed into smaller inserts will generally produce higher tray weights i.e. 4.6kg.

Count sizes: 4kg tray- 12, 14, 16, 18, 20, 23, 25, 28

- Small fruit are packed 25 or 28 to a tray
- medium 20 or 23 to a tray
- large 12 to 18 to a tray

Smaller fruit are packed loose in 10kg containers. Count sizes 10kg (2 or 3 layer box) - 35, 40, 45, 50, 55, 60, 65, 70, 75.

Monitoring

Most growers now have electronic weight graders which automatically size the fruit. To check the accuracy of the electronic weight grader individual fruit weights are measured periodically on electronic balances or scales.

Plate 1. Measurement of fruit weight with different types of scales.

When using the balance, it should be placed on a stable platform like a table, desk or concrete floor and observe any operational requirements.

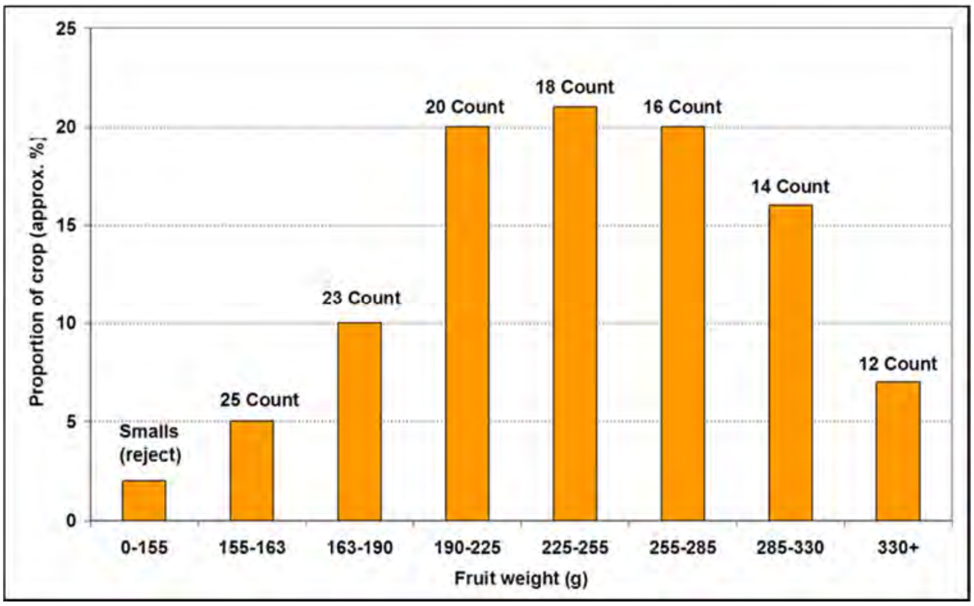


Figure 1. Electronic weight graders allow easy determination of the number of fruit in each size count.

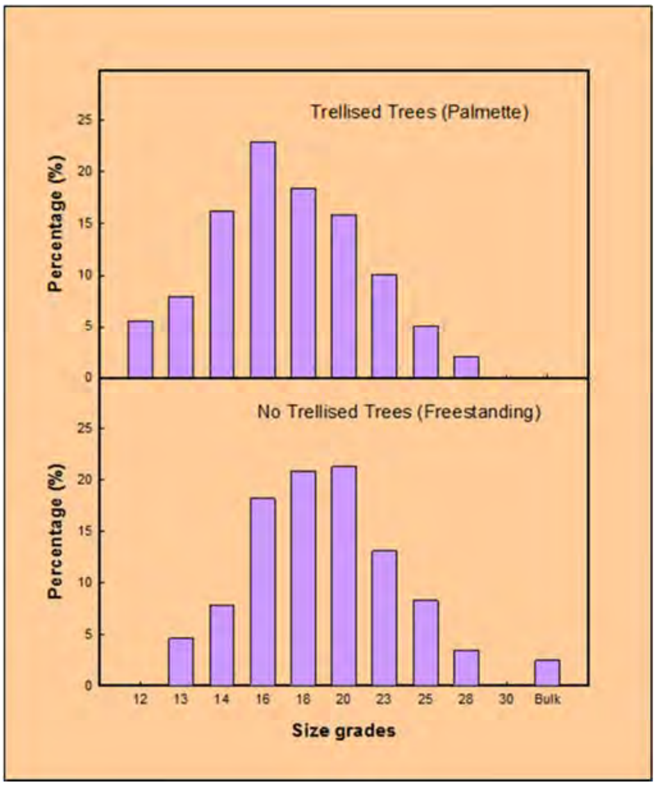


Figure 2. Size grade distributions can be affected by many orchard management factors such as training system, crop load, reflective mulch, and retention of leaf in the autumn.

11.2 Orchard management effects on fruit weight

Orchard management can have a large impact on fruit size distributions (Figure 2). Key factors include:

- Maintaining an open canopy to maximise light transmission (trellising system, summer pruning)
- Restricting vegetative growth using growth retardants (being investigated)
- Adjusting crop load based on tree age and previous performance
- Early thinning to enhance growth rates of remaining fruit
- Use of reflective mulch to improve light transmission through the canopy
- Retaining leaves on the tree in late autumn through regular fungicidal sprays to build up next seasons reserves

Growers should check their fruit size distributions annually and modify their management practices accordingly so as to achieve the desired fruit size range.

11.3 Grading for pests and diseases

Grading starts in the field. Any fruits which have major defects or blemishes are discarded. Once in the pack-house some growers then sort the fruit into either 1st Class fruit or second, others do this process after the fruit are weight-graded. Insect pests can contribute to persimmon "quality loss" either by direct damage to the fruit, or by the damage stimulating wound ethylene production and triggering premature softening. In addition, insect pests can be present on the fruit thereby causing quarantine problems, even though they cause no direct damage to the fruit. In most cases, insect damage can be detected during harvesting and packing. However, some insects go through the harvesting and packing process unnoticed. These pests are usually concealed under the calyx of the fruit and do not appear until the fruit is handled at market or by the consumer.

Queensland fruit fly (*Bactrocera tryoni)* will cause dark sunken spots on persimmons around the egg laying sites. The fruit tissue around these areas tends to darken and soften. The presence of the Queensland fruit fly has limited Australia's export market considerably. Citrus mealybug (*Planococcus citri*) inhabits the area under the calyx, where they are protected from natural predators and insecticides. Citrus mealybug secretions also act as a food source for 'sooty mould' which causes a dark discoloration of the skin. See IPDM manual for control measures.

11.4 Grading for blemishes and defects

Damage from physical causes (abrasions, cuts and bruises) during harvesting and packing has become a problem following recent technological advances to improve efficiency (Marshall and Brook, 1999). Lee *et al*. (2005) found that bruising injury from dropping fruit from a height of 50 cm was not obvious immediately, but flesh discolouration appeared after 2-3 days at 20°C. Therefore, care needs to be taken in the handling persimmons from the tree to consumer sale, to minimise mechanical damage (George *et al*., 2005).

Other physical injuries that affect persimmon fruit quality are associated with orchard management. Spray damage, wire marking, wind rub, sunburn and basal cracking can usually be avoided by good management practices. The size of a blemish or a disease infection can be measured using area circles (Plate 2), ruler or callipers. An example of a template for determining blemish area is shown in Plate 3. A description of the major blemishes and their tolerance levels and orchard management strategies to reduce their incidence is presented in Chapter 12.

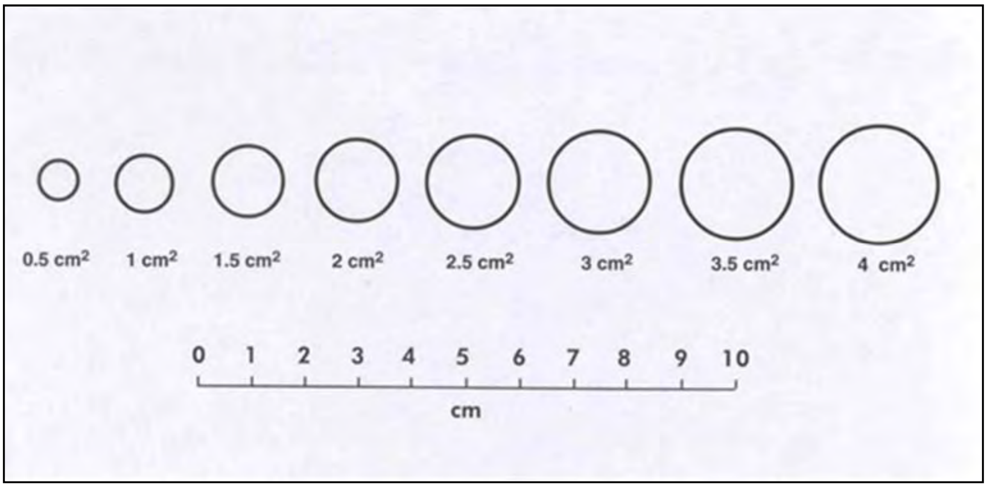


Plate 2. Blemish Size Indicator

The amount and severity of blemish and disease infection can be measured using area/rating scales (Plate 3). Identification of organisms causing disease infections will help in determining appropriate control treatments. (See IPDM manual).

Plate 3. A simple sizing gauge to measure area of blemish.

11.5 Current grade standards for the Australian persimmon industry

Grade standards for Australian persimmons are available on Australian Chamber of Fruit and Vegetable Industries web site and are called FreshSpecs. These standards were developed in consultation with growers as part of the Horticultural Code of Conduct arrangements between merchants/agents and growers. These standards are presented in Appendix Tables 1 and 2 and are relevant to all persimmon growers marketing domestically. Fruit which meets FreshSpec standards is classified as Class 1, other fruit which does not meet these standards but is still sold to local farmer markets etc. is called 'Second class'.

In general, the FreshSpec standards specify that persimmon fruit must be sound, clean, well-formed, not shrivelled, mature but not over ripe, of one cultivar, free from broken skins (for example no calyx separation), and reasonably free from skin blemishes. Grading takes size, shape, firmness, degree of blemish and colour into account.

11.6 Supermarket chain grade standards

Supermarket chains Woolworths and Coles have their own set of grade standards for persimmon which growers must comply with to send to these supermarket chains (Appendix Tables 3 and 4). These standards are very similar to the FreshSpec standards.

11.7 Australian Persimmon Export Company (APEC) grade standards

The Australian Persimmon Export Company (APEC) has established their own grade standards for export markets. Higher export standards are set for their export-only brand 'Sweet Gold'. Details of these standards are only available to APEC members.

11.8 Towards developing a premium grade standard

The FreshSpec standards were set many years ago. Since then, most growers have improved their orchard management. In our surveys, some growers have suggested that the maximum blemish levels of 2 sq. cm per fruit for domestic markets and 1 sq. cm per fruit for exports are currently set too high. They suggest that new blemish standards could be set at a maximum of 0.5 sq. cm per fruit for both domestic and export markets. Therefore, we suggest that the current FreshSpec standards for blemish be revised at a maximum of 0.5 sq. cm of blemish per fruit. The authors also suggest that it may be feasible to develop a premium grade standard due to the high quality of Australian fruit (Table 1).

Many regions due to climatic reasons and orchards can produce excellent quality fruit with higher sugar concentrations and flavour (see Chapter 6 for maturity standards). A premium grade standard could receive up to $5 a tray extra in price. Our suggested premium grade standards are presented in Table 1. Based on our suggestions, Australia growers would then produce three grades of fruit:

- Premium (export and domestic)
- Class 1 (export and domestic)
- Seconds (domestic only)

TABLE 1.
Current industry grade standards and suggested premium grade standard for non-astringent varieties in Australia.

Variable	Industry Class 1 standards		Suggested premium grade standard
	Current domestic grade standards	Suggested revised domestic grade standard	
Astringency at harvest	Nil	Nil	Nil
Seeds	Seeded and seedless	Seeded and seedless	Seedless
Colour rating*	≥3.5	≥3.5	≥5.0
Flavour**	≥6.0	≥6.0	≥6.0
Brix	≥14°	≥14°	≥15°
Calyx cavity	Slight	Slight	Nil
Blemish	<2.0 sq. cm	<0.5 sq. cm	Nil
Maximum count/tray	Count 28	Count 28	Count 28
Fruit fly damage	Nil	Nil	Nil

*Japanese colour chart (1=green, 8=red). **Hedonic scale (1=dislike intensely, 9=likes intensely)

APPENDIX - TABLE 1.

FreshSpec grade standards for astringent persimmon.

FreshSpecs
Produce Specifications

PRODUCE:	PERSIMMON
TYPE:	Astringent
VARIETY:	Various
CLASS:	One

GENERAL APPEARANCE CRITERIA	
COLOUR	Bright orange to orange/red skin; bright orange flesh.
VISUAL APPEARANCE	Smooth, slightly waxy skin; glossy, plump fruit; dry calyx lifted from the skin and surrounding a short stem; free from foreign matter.
SENSORY	Thin, soft skin; unripe fruit has firm, astringent flesh and is not edible; flesh becomes very soft, pulpy and jellyish when ripe; ripe fruit has a sweet, mild flavour.
SHAPE	Round to slightly squat fruit, often slightly pointed at apex.
SIZE	As per pre-ordered size requirements
MATURITY	Firm, full coloured fruit; TSS >14° Brix .
MAJOR DEFECTS	
INSECTS	With evidence of live insects. (eg. fruit fly and mealy bugs)
DISEASES	With evidence of fungal or bacterial rots.
PHYSICAL / PEST DAMAGE	With unhealed cuts, holes or splits from physical or pest damage.
SKIN MARKS / BLEMISHES	With deep seated bruises.
PHYSIOLOGICAL DISORDERS	With evidence of skin russeting and calyx end cracking.
	With evidence of juice leakage or severe softening (over ripe)
	With presence of a cavity beneath the calyx
TEMPERATURE INJURY	With flesh browning, softening and water soaked appearance (chilling injury).
	With evidence of dark water-soaked areas (freeze damage).

Cont.

TABLE 1 (Cont.)

FreshSpec grade standards for astringent persimmon

FreshSpecs
Produce Specifications

MINOR DEFECTS	
PHYSICAL / PEST DAMAGE	With superficial bruising >2 sq cm.
	With superficial cuts, scratches, marks > 2 sq cm.
SKIN MARKS / BLEMISHES	With healed scars >2 sq cm.
CONSIGNMENT CRITERIA	
TOLERANCE PER CONSIGNMENT	Total minor defects (within allowance limit) to be < 2 defects per item Total minor defects (outside allowance limit) must not exceed 10% of consignment. Total major defects must not exceed 2 % of consignment. Combined Total not to exceed 10%
PACKAGING & LABELLING	Packaging manufactured from new food grade materials or sanitised returnable crates. All labelling must meet the current legislative requirements. Labelling to identify grower's name/brand (plus growers name/code if via a pack house), address, contents, class, size and/or minimum net weight. Produce to identify Country of Origin (eg. Produce of Australia) on outer container.
SHELF LIFE	Produce must provide not less than 14 days clear shelf life from date of receival.
RECEIVAL CONDITIONS	Compliance with Quarantine Treatments (if required) for Interstate Consignment. Stacked onto a stabilised pallet. Refrigerated van with air bag suspension, unless otherwise approved. Pulp Temperature 10 - 15 °C for receival.
CHEMICAL & CONTAMINANT RESIDUES	All chemicals used pre/postharvest must be registered and approved for use in accordance with the requirements of the APVMA regulatory system. Residues, Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code ML's and MRL's.
FOOD SAFETY REQUIREMENTS	Produce is to be grown and packed under a HACCP based food safety program that is subject to an annual third-party audit. A copy of current certification to be forwarded to receiver.
Specifications reviewable: eg. to account for specific regional effects or adverse seasonal impacts on quality or early or late seasonal variances as agreed and communicated formally in writing.	

APPENDIX - TABLE 2.

FreshSpec grade standards for non-astringent persimmon.

FreshSpecs

Produce Specifications

PRODUCE:	PERSIMMON
TYPE:	Sweet
VARIETY:	Various
CLASS:	Fuyu Fruit

GENERAL APPEARANCE CRITERIA	
COLOUR	Bright orange to orange/red skin; bright orange flesh.
VISUAL APPEARANCE	Thin skin; glossy, plump fruit; dry calyx lifted from the skin and surrounding a short stem; free from foreign matter.
SENSORY	Smooth, slightly waxy skin; firm flesh softening to slightly crunchy; free from bitterness or astringency; free from foreign and 'off' smells or tastes.
SHAPE	Round to slightly squat fruit, often slightly pointed at apex.
SIZE	As per pre-ordered size requirements
MATURITY	Firm, full coloured fruit; TSS >14° Brix .
MAJOR DEFECTS	
INSECTS	With evidence of live insects. (eg. fruit fly and mealy bugs)
DISEASES	With evidence of fungal or bacterial rots.
PHYSICAL / PEST DAMAGE	With unhealed cuts, holes or splits from physical or pest damage.
SKIN MARKS / BLEMISHES	With deep seated bruises.
PHYSIOLOGICAL DISORDERS	With evidence of skin russeting and calyx end cracking.
	With evidence of juice leakage or severe softening (over ripe)
	With presence of a cavity beneath the calyx
TEMPERATURE INJURY	With flesh browning, softening and water soaked appearance (chilling injury).
	With evidence of dark water-soaked areas (freeze damage).

Cont.

TABLE 2 (Cont.)

FreshSpec grade standards for non-astringent persimmon.

FreshSpecs

Produce Specifications

MINOR DEFECTS	
PHYSICAL / PEST DAMAGE	With superficial bruising >2 sq cm.
	With superficial cuts, scratches, marks > 2 sq cm.
SKIN MARKS / BLEMISHES	With healed scars >2 sq cm.
CONSIGNMENT CRITERIA	
TOLERANCE PER CONSIGNMENT	Total minor defects (within allowance limit) to be < 2 defects per item Total minor defects (outside allowance limit) must not exceed 10% of consignment. Total major defects must not exceed 2 % of consignment. Combined Total not to exceed 10%.
PACKAGING & LABELLING	Packaging manufactured from new food grade materials or sanitised returnable crates. All labelling must meet the current legislative requirements. Labelling to identify grower's name/brand (plus growers name/code if via a pack house), address, contents, class, size and/or minimum net weight. Produce to identify Country of Origin (eg. Produce of Australia) on outer container.
SHELF LIFE	Produce must provide not less than 14 days clear shelf life from date of receival.
RECEIVAL CONDITIONS	Compliance with Quarantine Treatments (if required) for Interstate Consignment. Stacked onto a stabilised pallet. Refrigerated van with air bag suspension, unless otherwise approved. Pulp Temperature 10 - 15 °C for receival.
CHEMICAL & CONTAMINANT RESIDUES	All chemicals used pre/postharvest must be registered and approved for use in accordance with the requirements of the APVMA regulatory system. Residues, Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code ML's and MRL's.
FOOD SAFETY REQUIREMENTS	Produce is to be grown and packed under a HACCP based food safety program that is subject to an annual third-party audit. A copy of current certification to be forwarded to receiver.
Specifications reviewable: e.g. to account for specific regional effects or adverse seasonal impacts on quality or early or late seasonal variances as agreed and communicated formally in writing.	

APPENDIX - TABLE 3.

Woolworths grade standards for astringent persimmon.

PRODUCT :	PERSIMMON
TYPE :	Astringent
VARIETY :	Various
GRADE :	One

GENERAL APPEARANCE CRITERIA	
COLOUR	Bright orange to orange/red skin; bright orange flesh.
VISUAL APPEARANCE	Smooth, slightly waxy skin; glossy, plump fruit; dry calyx lifted from the skin and surrounding a short stem; free from foreign matter.
SENSORY	Thin, soft skin; unripe fruit has firm, astringent flesh and is not edible; flesh becomes very soft, pulpy and jellyish when ripe; ripe fruit has a sweet, mild flavour.
SHAPE	Round to slightly squat fruit, often slightly pointed at apex.
SIZE	As per Woolworths pre-ordered size requirements
MATURITY	Firm, full coloured fruit; TSS >14^{o} Brix .
MAJOR DEFECTS	
INSECTS	With evidence of live insects. (eg. fruit fly and mealy bugs)
DISEASES	With evidence of fungal or bacterial rots.
PHYSICAL / PEST DAMAGE	With unhealed cuts, holes or splits from physical or pest damage.
SKIN MARKS / BLEMISHES	With deep seated bruises.
PHYSIOLOGICAL DISORDERS	With evidence of skin russeting and calyx end cracking.
	With evidence of juice leakage or severe softening (over ripe)
	With presence of a cavity beneath the calyx
TEMPERATURE INJURY	With flesh browning, softening and watersoaked appearance (chilling injury).
	With evidence of dark water-soaked areas (freeze damage).
MINOR DEFECTS	
PHYSICAL / PEST DAMAGE	With superficial bruising >2 sq cm.
	With superficial cuts, scratches, marks > 2 sq cm.
SKIN MARKS / BLEMISHES	With healed scars >2 sq cm.

TABLE 3 (Cont.)

Woolworths grade standards for astringent persimmon.

CONSIGNMENT CRITERIA	
TOLERANCE PER CONSIGNMENT	Total minor defects (within allowance limit) to be < 2 defects per item Total minor defects (outside allowance limit) must not exceed 10% of consignment. Total major defects must not exceed 2 % of consignment. Combined Total not to exceed 10%.
PACKAGING & LABELLING	Packaging as per Woolworths requirements. Labelling to identify grower or agents name/brand (plus growers name/code if via an agent), address, contents, grade/class, size and minimum net weight. Bulk Loose Product to identify 'Packed On' date (e.g. Pkd DD/MM/YY) on outer carton.
RECEIVAL CONDITIONS	Compliance with Quarantine Treatments (if required) for Interstate Consignment. Stacked to Ti Hi specifications onto a stabilised pallet as pre-ordered. Refrigerated van with air bag suspension, unless otherwise approved. Pulp Temperature 10 – 15 °C for receival.
CHEMICAL & CONTAMINANT RESIDUES	All chemicals used pre/postharvest must be registered and approved for use in accordance with the requirements of the NRA regulatory system. Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code A 12 – A 14 MPC's and MRL's.
Specifications reviewable: e.g. to account for specific regional effects or adverse seasonal impacts on quality or early or late seasonal variances as agreed with each state operation and communicated formally in writing by Woolworths.	

APPENDIX - TABLE 4.

Woolworths grade standards for non-astringent persimmon.

PRODUCT :	PERSIMMON
TYPE :	Sweet
VARIETY :	Various
OTHER NAMES :	Fuyu Fruit

GENERAL APPEARANCE CRITERIA	
COLOUR	Bright orange to orange/red skin; bright orange flesh.
VISUAL APPEARANCE	Thin skin; glossy, plump fruit; dry calyx lifted from the skin and surrounding a short stem; free from foreign matter.
SENSORY	Smooth, slightly waxy skin; firm flesh softening to slightly crunchy; free from bitterness or astringency; free from foreign and 'off ' smells or tastes.
SHAPE	Round to slightly squat fruit, often slightly pointed at apex.
SIZE	As per Woolworths pre-ordered size requirements
MATURITY	Firm, full coloured fruit; TSS >14^{o} Brix .
MAJOR DEFECTS	
INSECTS	With evidence of live insects. (eg. fruit fly and mealy bugs)
DISEASES	With evidence of fungal or bacterial rots.
PHYSICAL / PEST DAMAGE	With unhealed cuts, holes or splits from physical or pest damage.
SKIN MARKS / BLEMISHES	With deep seated bruises.
PHYSIOLOGICAL DISORDERS	With evidence of skin russeting and calyx end cracking.
	With evidence of juice leakage or severe softening (over ripe)
	With presence of a cavity beneath the calyx
TEMPERATURE INJURY	With flesh browning, softening and water soaked appearance (chilling injury).
	With evidence of dark water-soaked areas (freeze damage).
MINOR DEFECTS	
PHYSICAL / PEST DAMAGE	With superficial bruising >2 sq cm.
	With superficial cuts, scratches, marks > 2 sq cm.
SKIN MARKS / BLEMISHES	With healed scars >2 sq cm.

Cont.

TABLE 4 (Cont.)

Woolworths grade standards for non-astringent persimmon.

CONSIGNMENT CRITERIA	
TOLERANCE PER CONSIGNMENT	Total minor defects (within allowance limit) to be < 2 defects per item Total minor defects (outside allowance limit) must not exceed 10% of consignment. Total major defects must not exceed 2 % of consignment. Combined Total not to exceed 10%.
PACKAGING & LABELLING	Packaging as per Woolworths requirements. Labelling to identify grower or agents name/brand (plus growers name/code if via an agent), address, contents, grade/class, size and minimum net weight. Bulk Loose Product to identify 'Packed On' date (eg. Pkd DD/MM/YY) on outer carton.
RECEIVAL CONDITIONS	Compliance with Quarantine Treatments (if required) for Interstate Consignment. Stacked to Ti Hi specifications onto a stabilised pallet as pre-ordered. Refrigerated van with air bag suspension, unless otherwise approved. Pulp Temperature 10 – 15 °C for receival.
CHEMICAL & CONTAMINANT RESIDUES	All chemicals used pre/postharvest must be registered and approved for use in accordance with the requirements of the NRA regulatory system. Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code A 12 – A 14 MPC's and MRL's.
Specifications reviewable: eg. to account for specific regional effects or adverse seasonal impacts on quality or early or late seasonal variances as agreed with each state operation and communicated formally in writing by Woolworths.	

Key points

Persimmon fruit are mainly graded for size and blemish

Different markets prefer different size grades

FreshSpec standards are used for domestic markets

Supermarket chains Woolworths and Coles have their own domestic grade specifications

APEC has its own export grade standards

A premium grade standard could be developed to receive better prices for very high grade fruit produced in some regions

Fruit size grades can be improved through early fruit thinning and fungicidal spray programs which improve leaf retention in autumn

Growers should monitor annual fruit quality performance in terms of grade sizes and blemishes and modify management practices accordingly

PACKAGING

12.1 Overview

Packaging is not just to provide product protection and ease of storage and transport. Matters to be considered at all levels from harvest to the end user include ventilation to allow:

- Cooling
- Product respiration

Protect product from:

- Bruising, deforming, crushing – liners, bags, trays, wraps
- Mould, pest, disease – impregnated liners, coatings, waxes, modified atmospheres

Protection during transport to end user:

- Physical - movement and over-stowage
- Ambient temperature and humidity changes
- Storage and transport cooling methods – e.g..: road, air transport

Identification

- Product – description, brand, origin
- Shipment, transaction details

Point of sale marketing

- Package design, marking

Packaging accessories such as trays, cups, wraps, liners, and pads may be used to help immobilize the produce within the packaging container while serving the purpose of facilitating moisture retention, chemical treatment and ethylene absorption.

12.2 Packaging materials

Fibreboard or Cardboard Cartons/Boxes

Solid or corrugated cardboard container types (carton or boxes) can either have a fold over (closes the top of the carton) or slip-on tops (which are made separately). Where a single layer of produce is to be sold shallower cartons/boxes are made and these are normally called trays.

Most of these types of cartons/boxes are manufactured and supplied in collapsed form, (that is pre-cut and flat) and are put together by the grower or packer. In some cases the construction of these boxes requires the fixing of interlocking tabs, sometimes with glue or staples.

These boxes can be manufactured in a wide range of sizes, designs, strengths and are clean and light weight.

Even greater strength can be added to the carton/box by waxing to eliminate moisture from softening the fiberboard. Waxed cartons/boxes are particularly useful in the tropics where moisture absorption is a common occurrence due to large changes in temperature and humidity between storage rooms.
Most modern trays are constructed from Xitex cardboard (Plate 1). Xitex board consists of two flutes joined at their tips with liners on both sides. The perfect alignment of the flute tips means extra strength, at the same price. Boxes made by this technology are lighter, stronger, smoother and squarer. Base sagging of fruit trays is a common problem in conventional material; however.

There are several major manufacturers of cardboard trays and boxes in Australia including the following manufacturers:

- Amcor
- Visy Board
- Carter Holt Harvey

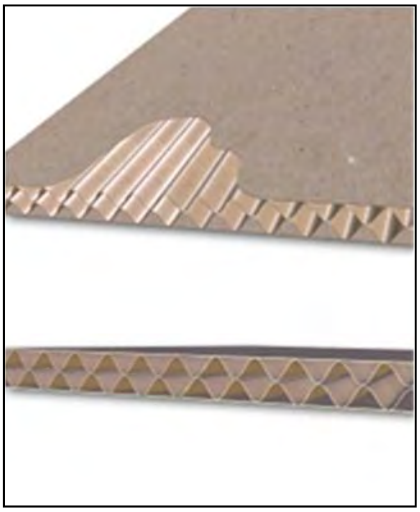


Plate 1. Design of the Xitex cardboard – joined flutes give extra strength.

12.3 Types of packaging for persimmon

Single layer trays

Trays for persimmon hold about 4kg of fruit. They can be lidded or unlidded (Plate 2). Most trays are constructed using the P84 pattern. The advantage of using trays compared with 10kg boxes is that there is less compression damage.

The P84 design was patented in Europe and is produced in Australia under a licence by Amcor Pty Ltd who has an agreement with the holder of this patent. The P84s credentials are impressive. Because of its triangular profile corners, it has high stacking strength.

The P84 has a laminated corrugated cardboard and bonded waterproof membrane, which prevents moisture damage and makes it ideal for cool room storage. Its ventilation pattern allows the even distribution of refrigerated air to ensure maintenance of the highest quality out-turn for produce. In the stackability stakes, the P84 is a real winner. Trays are designed to interlock so that the triangular comers carry the weight.

Trays are an expensive component of marketing – they can cost from $1.50 to $2.50 per tray.

Plate 2. Two types of single layer trays. Top: unlidded. Bottom: lidded. Triangulated corners allow easy stacking

Two and three layer boxes

Smaller fruit are either packed into two- or three-layered boxes or bulk packed into 10kg (18L) cartons (Plate 3).

Many markets prefer 10kg boxes because more fruit are packed into a smaller volume.

However, three layer boxes can suffer compression damage particularly the bottom layer of fruit. Up to 30% of fruit in this layer may be bruised if the boxes are handled roughly.

Another problem with three layer boxes is that fruit may sweat due to lack of air circulation or lack of adequate cooling due to poor ventilation. Boxes with three holes for ventilation at the ends may be better than those with two.

Plate 3. Multi-layer boxes. Top: unlidded. Middle: lidded, two holes for ventilation. Bottom: lidded with three holes which gives better ventilation.

12.4 Tray inserts (liners)

Most growers pack their fruit into plastic inserts or pockets (Plate 4). These come in arrange of sizes, depths and colours. Liners hold the fruit securely and reduce rub.

Types

Inserts are available from several manufacturers including:

- Plix,
- GM
- Q Pak
- SGS

Colours

The most commonly used insert colour is green although other colours such as white and black have been trialled in Australia (Plate 5). In Korea, pink inserts have been used (Plate 5).

Packing into white or black inserts enhances the attractive orange colour of the fruit. These colours need to be retrialled in Australia.

Plate 4. Left: QPAK insert. Right: SGS insert. Some growers prefer the lighter, brighter green colour of SGS liners.

Plate 5. Left: Pink liner used with Korean persimmon. Right: White and black liner colours which have been trialled in Australia.

Pocket size and under-packing

Inserts come in a range of sizes (Plate 6). Inserts designed with shallow pockets to maximise the surface area of fruit presented to the prospective buyer are better than those with deeper pockets which give the appearance that the tray is 'empty'. Given this, fruit should not be squeezed into pockets as this will cause bruising. For larger sized fruit, trays may weight more up to 4.6kg.

Under-packing is highly undesirable (Plate 7). Because depth of fruit varies with climate, and also with variety, the most suitable type of liner to use will also vary between varieties/regions.

Fruit should be completely dry before packing into inserts as condensation can cause post-harvest rots and decay. Pre-conditioning fruit after harvest may be advantageous (See Chapter 15).

Plate 6. Tray liners come in a range of sizes, depths and colours. Left: count of 12. Right: count of 40.

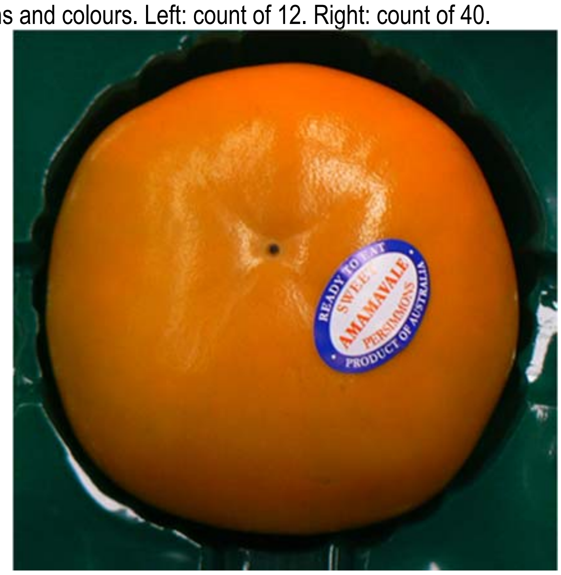


Plate 7. Left: correctly filled insert. Right: under-filled insert.

12.5 Padding sheets

In multilayer packs, some growers use either polycell bubble sheets or polybubble sheets instead of inserts to separate layers of fruit whilst other growers use a combination of both inserts and padding sheets, to protect Class 1 fruit (Plate 8).

These materials are often used to line cartons to reduce handling damage from vibrations etc., (friction damage) or compression. These materials can also protect the fruit from adverse temperatures (e.g. during cool storage).

Disadvantages are:

- can retain gases and vapours (ethylene, causing faster produce deterioration).
- heat builds up, can be slow to disperse thus causing faster produce deterioration.
- prevents proper cooling of produce, limiting shelf life.

- offers no protection from injury caused by careless handling (cuts punctures etc.).
- retains water vapour thus reducing water loss from produce; but where temperature changes occur, they cause a heavy build-up of condensation leading to decay and diseases.

12.6 Layout of fruit

Fruit is normally packed in trays with the calyx end down into the tray. The plastic insert with cups are used to help with the fruit placement and to pack fruit into a tight arrangement.

For 10kg boxes, fruit are normally packed with their calyx end down similar to trays but for second grade fruit they may be packed on their sides (Plate 9). Some growers pack to a pattern with the basal creases of the fruit aligned in the same direction normally at an angle of 45° to the end of the carton (Plate 10).

Stickers should then be applied so that they may be read from the labelled end of the box.

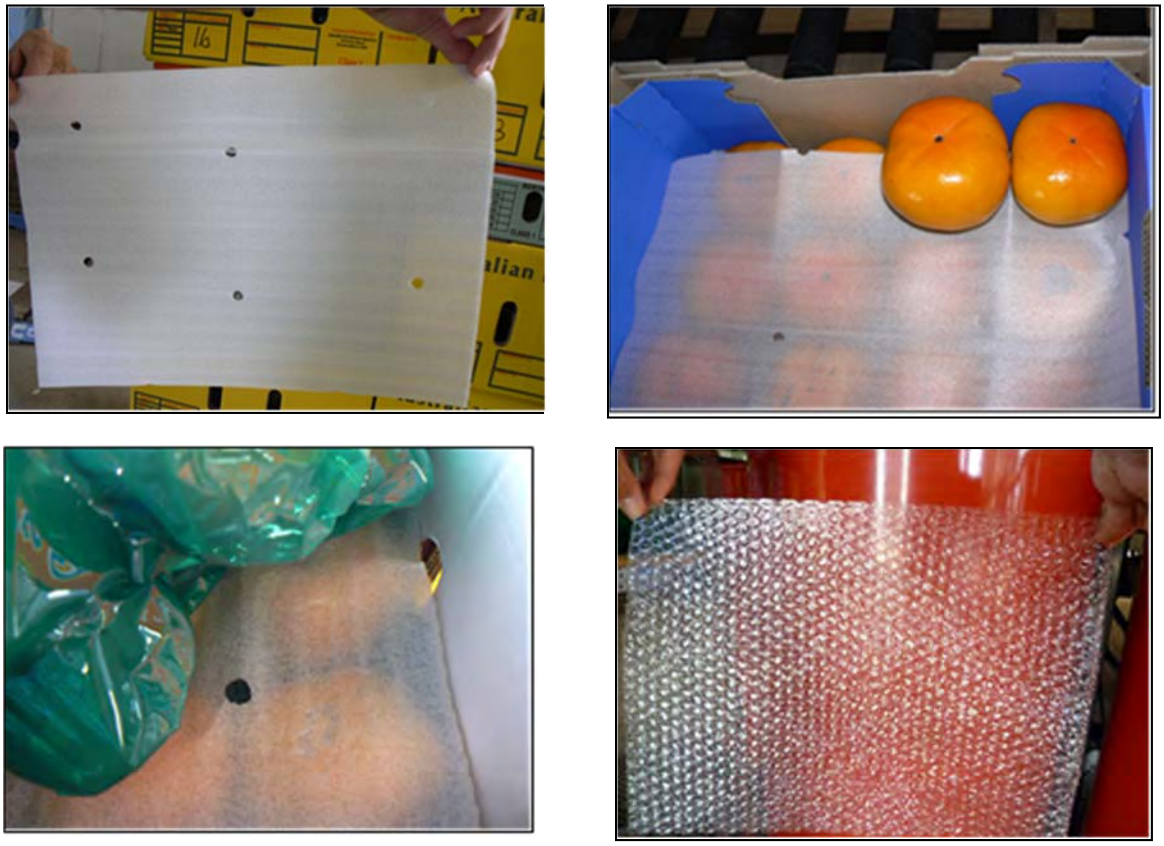


Plate 8. Top left: Perforated polycell bubble sheets. Top right and bottom left: polycell used to separate fruit in multilayer boxes and between inserts. Bottom right: polybubble.

Plate 9. Left: 10kg box with fruit being packed sideways. Right: tray pattern packed with creases of fruit aligned at 45° to the perpendicular.

12.7 Fruit stickers

Most growers use stickers to highlight either their brand name or when to eat the fruit (Plate 10). Stickers should not be placed on the apex of the fruit or used to hide blemishes.

Stickers are available from Label Press Pty Ltd and other manufacturers.

Plate 10. Various types of stickers. These can be used to identify a brand or to highlight how the fruit should be eaten.

12.8 Brand and label names

Australian growers use different brand and label names on trays including:

- Generic labels e.g. Australian fruits (Plate 11)
- Persimmon Australia Inc. e.g Australian sweet persimmon (Plate 12)
- Individual grower
- Australian Persimmon Export Company (APEC) e.g. Sweet Gold and Golden Star (Plate 13)

Growers whose brands are associated with higher fruit quality will generally receive better prices for their fruit, as much as $4-5 per tray higher.

Plate 11. Generic labels used for marketing persimmon in Australia. These trays and boxes are often cheaper than those carrying the "Australian Sweet Persimmon" name.

Plate 12. Labels used by Persimmons Australia Inc. growers to identify sweet persimmon In the domestic market.

Plate 13. Golden Star and Sweet Gold are brand names used by APEC to market their fruit both domestically and for export.

12.9 Tray or box identification

A trade description must appear on one end of the package in letters 5mm high. It includes the following information (Plate 14):

- name and address of the packer
- the word 'persimmon'
- variety
- grade
- count and or weight
- for supermarkets, PLU (Price Look Up) numbers

It may also include the following information:

- a brand name
- grower number
- ICA and QA (Quality Assurance)
- date of packing.

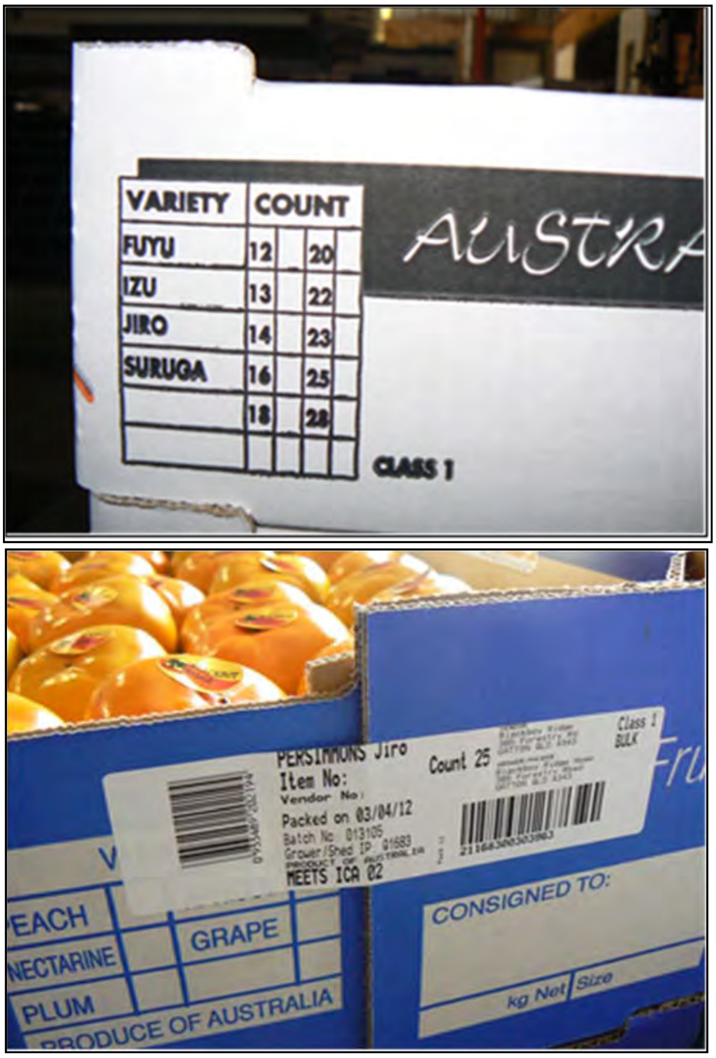


Plate 14. Variety, count and Class displayed on tray.

12.10 Packaging used overseas

A range of smaller fruit packs are used in overseas countries such as Italy, Korea and Japan (Plates 15-20). Currently none of these types of packages are used with persimmon in Australia. These newer types of innovative packaging require further investigation and possible evaluation in Australia. A brief description of these different types of packages is presented below.

Spain

Photo 15. Spanish cultivar Rojo Brillante in plastic packs.

Italy

Plate 16. Packing line in Italy showing fruit after being wrapped in plastic film.

Plate 17. Range of cellular packages used in Italy.

Korea

Plate 18. 10kg boxes and tube MA packs of persimmon in south Korea

Taiwan

Plate 19. Very attractive packaging of persimmon fruit in Taiwan with individual fruit displayed in polysocks.

Plate 20. Very attractive tray packs of persimmon fruit in Taiwan with individual fruit in polysocks.

Key points

Good packaging protects the fruit from bruising and damage in transit

Attractive packaging will increase sales

Under-filled inserts and trays look unattractive to buyers and reduce price

A recognised brand name is associated with fruit quality

A range of newer innovative packaging is being used overseas – these should be trialled in Australia

SENSITIVITY TO ETHYLENE

13.1 Overview

Ethylene is a natural plant hormone that is involved in plant growth, development, ripening and senescence. Persimmon has a very low ethylene (C_2H_4) production rate at 20°C of between 0.1-1.0 uL C_2H_4/kg/hr. (Kader, 2002). Even though persimmons have a very low rate of ethylene production they are very sensitive to exogenous ethylene action.

Most fruit within a consignment can collapse within a few days (see Chapter 4 on Soft fruit Disorder). The exact causes of this rapid softening are unclear. However, ethylene, either produced by the fruit itself or from other sources, appears to be involved (Itamura *et al*., 1991; Mochida and Itamura, 2007; Nakano *et al*., 2002).

Exposure to 1 ppm and 10 ppm ethylene at 20ºC accelerates softening to less than 1.8 kg force (limit of marketability) after 6 and 2 days, respectively (Woolf *et al*., 2007).

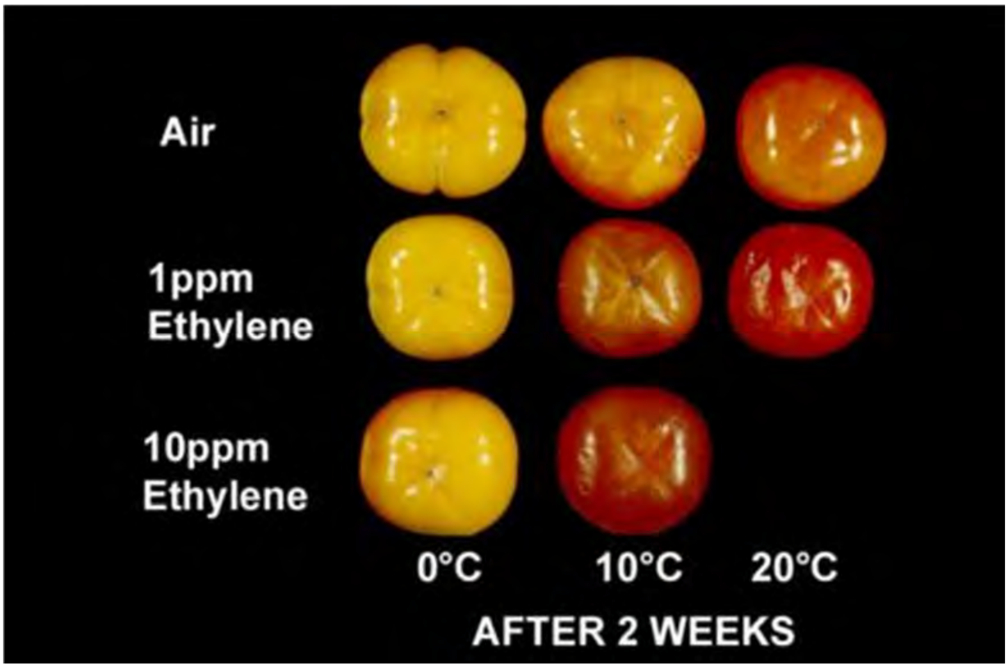


Plate 1. Sensitivity of persimmon fruit to ethylene. Even 1 ppm can induce premature ripening. (Woolf *et al*., 2007, HortResearch, NZ).

13.2 Sources of ethylene

In the field

- Avoid soft fruit disorder (see Chapter 4).
- Avoid damage to the fruit or calyx as this will release ethylene
- Avoid stresses to the fruit and calyces after harvest e.g. high temperature and low humidity

Packhouse

Ethylene can be produced at various stages of harvesting, packing and in cool storage in the pack house (Figure 1). The overall aim is to reduce ethylene concentration at any stage of packing to < 0.1 ppm.

In the pack house:

- Avoid producing ethylene
- Make sure the pack house is well ventilated
- Avoid running LP or diesel forklifts indoor, or letting diesel trucks and tractors idle when under shelter as this produces ethylene.
- Use electric forklifts in pack houses. However, if this is not feasible, it is possible to fit combustion engine exhaust forklifts with catalytic converters, which reduce ethylene emissions by 90%.

Plate 2. LP forklifts are sources of ethylene.

- No fires or smoking in and beside pack house
- Care with heating systems, drying tunnels, or "wet fruit drying systems" which burn gas (i.e. CNG or LPG)
- If in doubt, get gas samples taken!

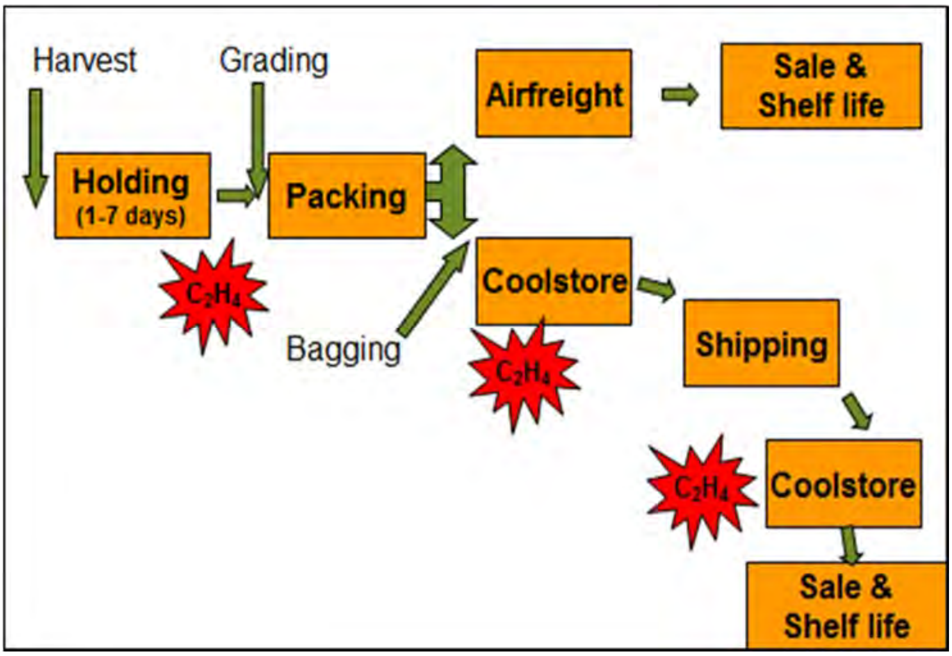


Figure 1. Possible sources of ethylene in the persimmon packing and cool chain. C_2H_4 = ethylene. (Woolf *et al*., 2007, HortResearch, NZ).

Transport and storage

Ethylene removal and/or exclusion from transport and storage facilities is highly recommended.

Fruit are particularly vulnerable to exposure to ethylene at ambient temperature. For example "safe" exposures to ethylene for airfreight are very low:

- 1 day at <0.5 ppm

"Safe" exposures for sea-freight are also very low:

- 1 day at <0.5 ppm
- 2 day at 0.2 ppm

Ethylene producing fruit include: ripening avocados, bananas, papaw, tomatoes, custard apples, passionfruit, rockmelons, honeydew melons, apples, pears, stone fruit, figs or guavas.

Fruit and vegetables that do not produce ethylene can be transported with persimmon provided the transport temperature is within the recommended range.

Once fruit are placed in MA bags and in the cool room at 0°C they are less susceptible to the harmful effects of ethylene. Safe exposure levels at the beginning or end of 8 week cool store period are:

- <10ppm for < 7 days

13.3 Chilling injury

Exposure of ethylene prior to storage increases the severity of chilling injury quite significantly, in some cases up to five-fold (Woolf *et al*., 2007; Besada *et al*., 2010) (Figure 2). (See Chapter 14).

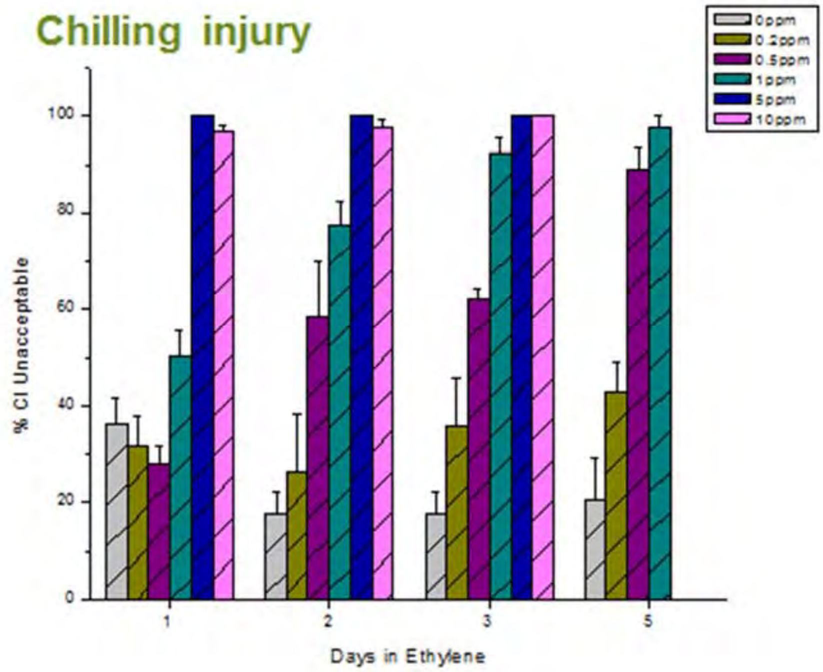


Figure 2. Severity of chilling injury after 7 weeks cool storage at 0 °C after previous exposure to various concentrations of ethylene at 20ºC (Woolf *et al*., 2007, HortResearch, NZ).

13.4 1-MCP and exogenous ethylene

Application of 1-MCP prior to fruit being exposed to exogenous ethylene can negate the effects of exogenous ethylene on fruit softening (Kim and Lee, 2005). The implications of this are that fruit should be treated as soon as possible with 1-MCP (SmartFresh®) after harvest if they are going to be cool stored for long durations.

13.5 Removal of ethylene

Ventilation with Air

Forced ventilation with air is the method which is most commonly used to remove ethylene in conventional and container transport. A disadvantage of ventilation is that ambient air has to be cooled and dehumidified which consumes refrigeration power and hence energy.

Ultra Violet Light

There is some evidence that ethylene can be removed by the use of Germicidal lamps. The lamps emit ultra violet radiation at 184 and 254nm though the active wavelength appears at 184nm. The ultra violet radiation appears to be responsible for the degradation of ethylene and not the ozone which is also produced as a by-product. The ozone can be removed either by a UV lamp emitting at 254nm, rusty steel wool or a propriety filter.

Catalytic Scrubber

In this system, ethylene is oxidised catalytically over a platinum catalyst heated to approximately 250°C. The claimed advantage of the system is that units are easy to install and operate and they maintain a constant low ethylene concentration because the conversion efficiency of the machine stays at 90 - 98%. The disadvantage of the system is that the catalyst bed is very expensive. Further the scrubber even with an efficient heat exchanger puts a significant heat load on the refrigeration system which results in some dehumidification and additional energy use.

Absorbent sachets

Use of absorbent sachets (Plate 3) that remove ethylene from modified atmosphere (MA) bags may be more beneficial than ethylene scrubbers. The sachets contain potassium permanganate which is coated to a material with large surface area such as alumina or expanded mica. The potassium permanganate oxidises the ethylene to water and carbon dioxide.

Most studies have shown that the effects of ethylene absorbents, compared with 1-MCP or MA bags, in extending cool storage life are relatively small (Kurahashi *et al*., 2005; Pekmezci *et al*., 1997; Redpath *et al.,* 2009; Redpath *et al*., 2012). In contrast, Maotani *et al*. (1982) found that inclusion of ethylene absorbents in MA bags could extend storage life of 'Fuyu' for 28 days at 20°C. Inclusion of ethylene absorbents inside the bags can reduce skin browning (Neuwald *et al*., 2008) but the response is relatively minor compared with the application of 1-MCP.

We suggest that response to ethylene absorbent will depend on when ethylene peaks occur during and after storage and this may vary depending on many factors including; variety, production region and stage of maturity.

The size and number of the absorbent sachets to include in MA bags will depend on many variables including:

- length of time required to protect the fruit
- variety
- size of the fruit area to protect
- threshold of sensibility to ethylene
- stage of fruit maturity

Wills and Warton (2004) showed that the efficiency of ethylene absorption decreases substantially at increasing RH. The RH encountered in persimmon trays is normally 90% or higher, and ethylene absorption at 90% RH was 50% less efficient than at 70% RH. The rate of production of ethylene by persimmon is low compared with other fruits (<1 μL·kg–1·h–1 at 20°C). Based on studies by Wills and Warton (2004), for persimmon held at 20 °C in an atmosphere of 90% RH and generating ethylene at <1 μL·kg–1·h–1, 6 g of absorbent is required per 1 kg of produce to reduce the ethylene concentration by 90% (i.e. 24 g per tray).

Korean research indicates that at least 100g of absorbent must be included for every 10 kg of persimmon fruit (Ahn, pers. com., 2012). Currently, we have been including only two 5g sachets per MA bag which encloses 4 kg of fruit. Insufficient volume of absorbents may be one reason why in most studies, absorbents have proven to be ineffective.

If the end of the useful life of a potassium permanganate absorbent is considered to be when 50% has been oxidized, instrumental colour measurement can readily determine this stage. However, visual inspection of crushed beads can be an effective quick test with 60% retention of the original purple colour being the end point.

The number of sachets to include per MA bag requires further investigation. The Koreans also make their own ethylene absorbents. They mix 0.1L of 1M potassium permanganate with 1L of perlite. The colour of the mixture must be purple; if it changes to dark brown the mixture is ineffective.

Ethylene scrubbers and absorbent sachets are available from Bioconservacion Australia Pty Ltd.

Plate 3. Ethylene absorbent sachets which are placed in MA bags.

13.6 Monitoring ethylene

Ethylene can be measured successfully in the field using portable gas chromatographs fitted with a photoionization detector (PID), which are readily available but still somewhat expensive.

Key points

Ethylene concentration as low as 1 ppm can initiate ripening

Ethylene concentration as low as 0.2 ppm can increase chilling injury

Do not pack fruit with Soft Fruit Disorder as this fruit may release higher levels of ethylene

Make sure the pack-house is well ventilated

Avoid running LP or diesel forklifts indoors – use electric forklifts

Persimmons should never be transported with other ethylene producing fruit

Benefits of ethylene absorbents are still being investigated but are probably relatively small at current rates used

Research indicates that 100g of ethylene absorbent should be used for every 10kg of fruit

1-MCP applied before exposure to exogenous ethylene can reduce negative effects on fruit softening and chilling injury

CHILLING INJURY

14.1 Overview

Before growers cool store persimmon fruit they should be aware of the dangers of storing fruit at incorrect temperatures leading to the physiological disorder referred to as ‘chilling injury’ (CI).

14.2 Symptoms

Symptoms of ‘chilling injury’ do not become apparent until the fruit are removed from cool storage and transferred to ambient temperatures for 4-5 days. Symptoms include:

- flesh softening (Plate 1)
- flesh browning (Plate 1)
- water-soaked appearance of the flesh (Plate 2)
- skin browning (Plate 3 and 4)

The drastic softening of fruit after cold storage may be the result of physical damage caused by low temperatures. These chilling symptoms render the fruit unmarketable.

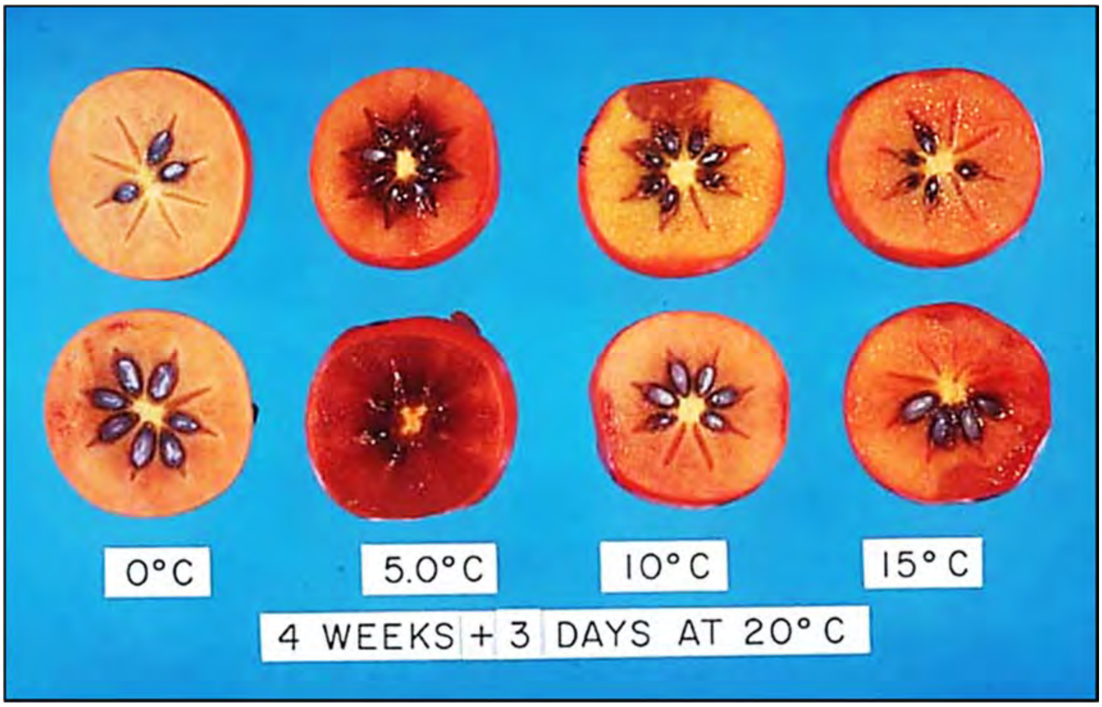


Plate 1. Chilling injury in 'Fuyu' is greatest between 5-10°C.

14.3 Temperature effects on chilling injury

Persimmon fruit are prone to develop chilling injury when stored at temperatures of 15°C or below (MacRae, 1987; Collins and Tisdell, 1995; Woolf *et al*., 1997; Crisosto *et al*., 2001; Orihuel-Iranzo *et al*., 2010; Redpath, *et al*., 2012). Storage at moderate cool temperatures between 5° to 10°C has been shown to be more detrimental than storage at 0°C (Figures 1 and 2). Freezing of fruit occurs at temperatures <-2.1°C depending soluble solids content.

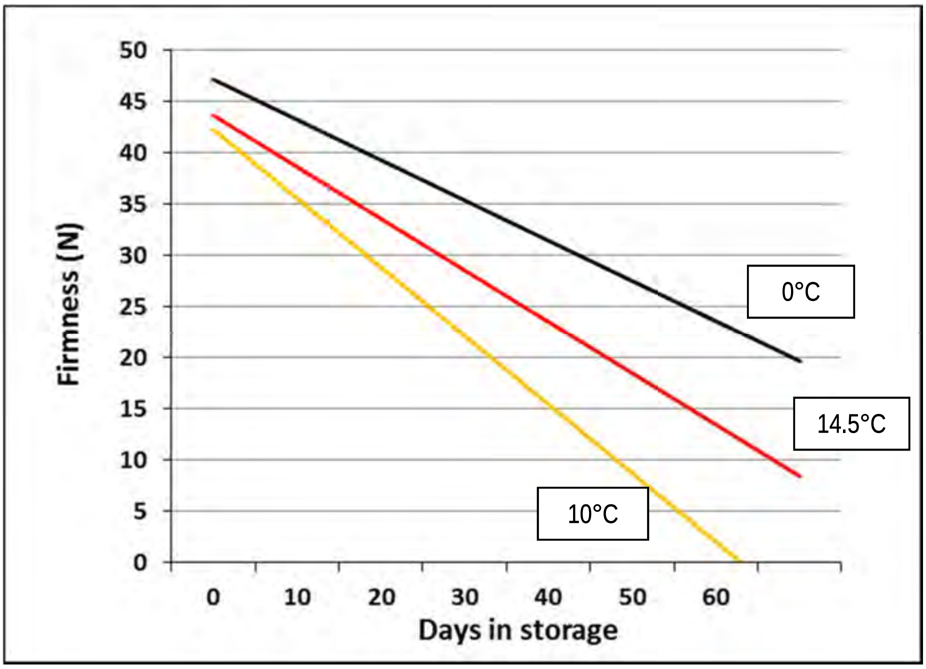


Figure 1. Changes in flesh firmness of persimmon with increasing cool storage life at different temperatures. Note: fruit stored at 10°C softened faster than those stored at either 0° or 14.5°C. (Adapted from Orihuel-Iranzo *et al*., 2012).

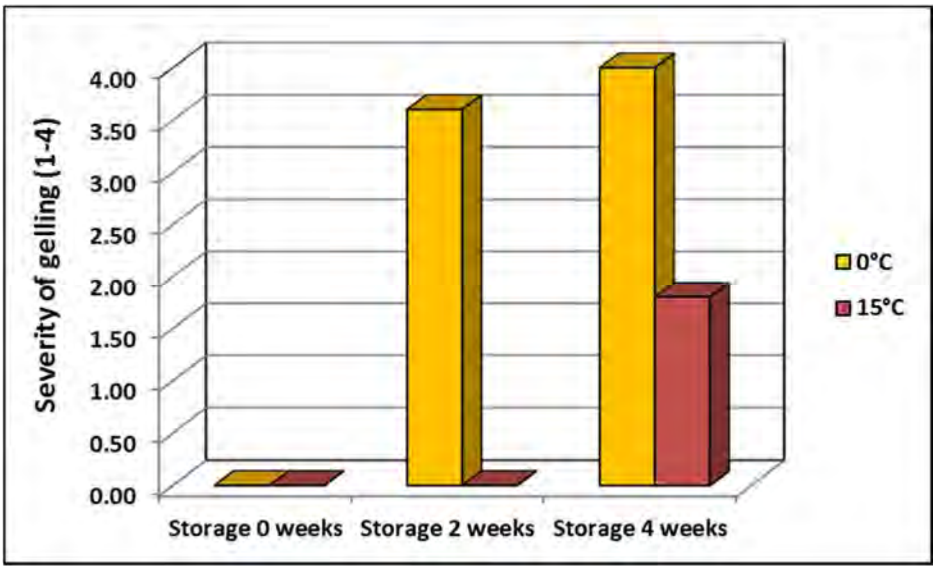


Figure 2. Persimmon fruit 'Fuyu' stored at 0°C show chilling injury symptoms such as internal gelling after storage for 2 weeks. Even when fruit are stored at 15°C, fruit may show chilling injury after 4

weeks of storage. Gelling rated on a scale of 1-4, 1=no gelling, 4=severe gelling. (Adapted from Golding, 2005).

Some varieties such as 'Jiro' are more sensitive to chilling than 'Fuyu' even when stored at 15°C (Figure 3). Injury to 'Jiro' became apparent even after 1 week of cool storage at 15°C (Redpath *et al*., 20120 (Plates 2 and 3).

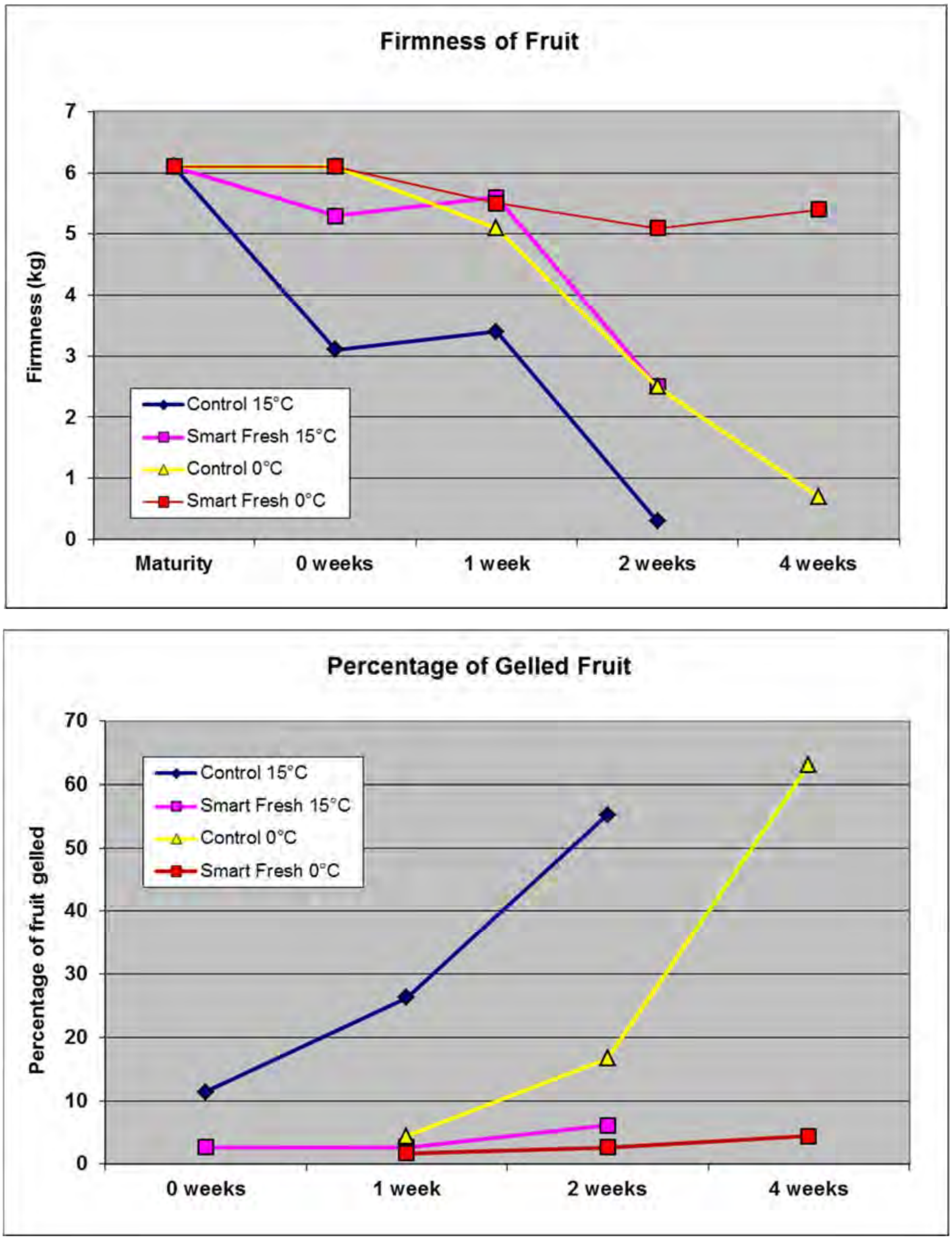


Figure 3. Top: changes in fruit firmness of 'Jiro' persimmon treated with 1-MCP (SmartFresh®) and stored at either 0° or 15°C. Data are the averages of six growers. A fruit firmness level of <1kg is regarded as very soft and non-marketable. (Redpath *et al*., 2012).

Plate 2. Left: SmartFresh™ treated 'Jiro' fruit. Right: Control fruit. Fruit cool stored at 15°C for 2 weeks. Note symptoms of chilling injury in control fruit as compared with fruit treated with 1-MCP.

Plate 3. Left: 'Jiro' fruit treated with 1-MCP. Right: Control fruit showing severe gelling after 4 weeks storage at 0°C.

14.4 Sensitivity to chilling injury

Variation in sensitivity to chilling injury comes from various sources:

- variety
- country to country variation
- seasonal variation
- within growing region variation
- differences in stage of fruit maturity

14.5 Varietal differences

'Fuyu' is chilling sensitive at temperatures between 0°C and 15ºC with greatest sensitivity at 5°C (Plate 1) (Beede, 1976; Collins and Tisdell, 1995). Even 'Fuyu' stored at 15°C can suffer chilling injury (Figure 2). Other non-astringent varieties such as 'Suruga' have been shown to be far less sensitive to chilling (Collins and Tisdell, 1995). Incomplete data exists for 'Jiro' but early evidence indicates that it is more sensitive to CI than 'Fuyu' (Redpath *et al*., 2012) (Figure 3).

Many growers are storing 'Fuyu' and 'Jiro' at temperatures between 10-12°C; this may be acceptable for short periods of <5 days but it may result in chilling injury if fruit are stored longer. Further research is needed to elucidate on the effects of these intermediate temperatures on chilling injury. Estimated relative sensitivities of different varieties to chilling injury are shown in Table 1.

TABLE 1.
Estimated chilling sensitivity based on current and past studies.
(George et al., 2009, Collins and Tisdell, 1995; Redpath et al., 2012).

Variety	Sensitivity to chilling injury
Rojo brillante	Extremely high
Jiro	Very high
Fuyu	High
Suruga	Low

Our results indicate that 'Jiro' is very sensitive to chilling injury being much more sensitive than 'Fuyu' (Table 1). Many growers are currently storing 'Jiro' at temperatures from 10 to 15°C for short durations of between 2-5 days before sending to domestic markets. This practice could be potentially devastating as expression of chilling injury will not become apparent until the fruit reaches the consumer.

Over all growers, application of 1-MCP has reduced the severity of chilling injury to less than 10% (George *et al*., 2009). This is in agreement with many overseas studies (Girardi *et al*., 2003; Kim and Lee, 2005; Tibola *et al*., 2005; Salvador *et al*., 2006).

14.6 Country differences in responses to CI

In Japan, persimmon fruit store for up to 6 months in MA bags at 0°C (Tarutani 1965; Kawada 1981). In contrast, storage trials in Israel, Italy, California and Australia (Guelfat-Reich and Ben-Arie 1975; Monzini and Gorini 1982; Beede 1983; Collins and Tisdell, 1995; Redpath *et al*., 2010, 2011) have shown that locally grown 'Fuyu' fruit have not been able to match the storage life of Japanese fruit without suffering severe chilling injury, having a maximum storage of about 3 months at 0°C.

14.7 Regional differences

Preliminary data indicates that fruit from coastal Queensland and northern NSW regions are more susceptible to chilling injury. Early-season harvested fruit from coastal Queensland and northern NSW regions also appears to be more susceptible to chilling injury. New Zealand studies have shown that persimmon fruit exposed to sun are more susceptible to chilling injury (Woolf and Ferguson, 2000).

14.8 Ethylene

Exposure to ethylene at concentrations as low as 0.2 ppm or higher prior to storage severely aggravates chilling symptoms of 'Fuyu' persimmons (see Chapter 13). Respiration and ethylene production rates of chilled 'Fuyu' persimmons are higher than those of non-chilled fruits. Ethylene production of chilled persimmon is higher on the first day after removal from storage and subsequently declines (Woolf *et al*. 1997; Orihuel-Iranzo *et al*., 2012).

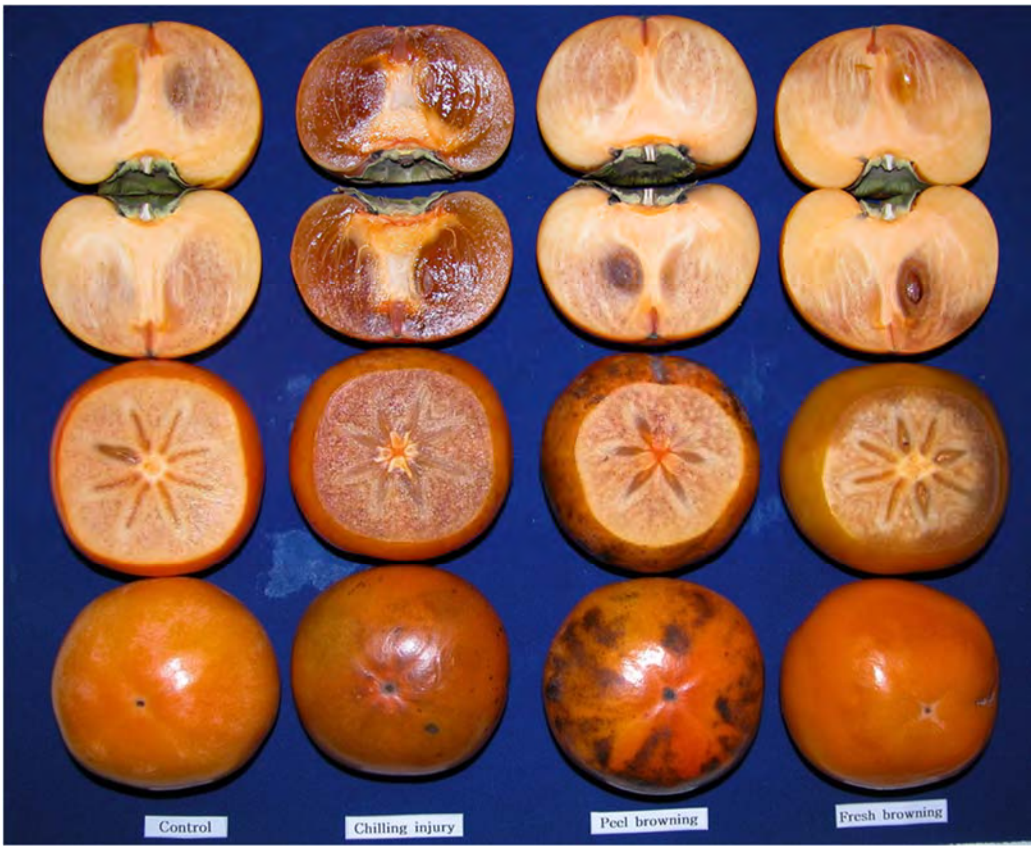


Plate 4. Various types of chilling injury.

14.9 Prevention of chilling injury

Correct storage temperature

Avoid exposure of 'Fuyu' persimmons to temperatures between 0ºC and 15ºC. Fruit should not be held for more than a few days at temperatures between 2°C and 15°C, otherwise chilling injury will occur. Optimum long-term storage and transport temperature is 0ºC.

Avoid exposure to ethylene

Avoid exposure to ethylene during postharvest handling of 'Fuyu' persimmons. See Chapter 13.

Treatment of fruit with 1-MCP

We have found that application of the ethylene inhibitor 1-MCP nearly eliminates all chilling injury (Chapter 20).

Pre-conditioning and heat treatments

Pre-conditioning and use of hot air (HAT) and hot water (HWT) treatments may also reduce chilling injury but to what extent has not been determined for Australian-grown fruit (See Chapter 15). HATs and HWTs are used commercially in New Zealand to reduce chilling injury and to disinfest fruit.

Selection of fruit

Severity of chilling injury may also be influenced by:

- variety
- season
- stage of fruit maturity

Very early-season and very late-season fruit appears to be more susceptible to chilling injury. The effects of the above factors on chilling injury require further investigation.

Plate 5. Top: Internal gelling and browning due to chilling injury. Bottom: fruit stored at the correct temperature.

Key points

Persimmons are very sensitive to chilling injury if stored for long periods between 0°C and 15°C

Storage at moderate cool temperatures between 5-10°C has been shown to cause more chilling injury than storage at 0°C

Varieties differ in their sensitivity to chilling injury - ‘Fuyu’ and especially ‘Jiro’ are very sensitive to chilling injury

To eliminate chilling injury fruit must be treated with 1-MCP

For short-term storage, store fruit at 15°C

Storage at 12°C requires investigation

Pre-conditioning and heat treatments before cool storage at 0°C may reduce some chilling injury – these techniques require further evaluation

For long-term storage, store fruit at 0°C but fruit must be treated with 1-MCP to prevent chilling injury

PRE-CONDITIONING AND HEAT TREATMENTS

15.1 Overview

Pre-conditioning is related to holding fruit at near or above ambient temperatures prior to cool storage. Pre-conditioning appears to stimulate genes and activates heat shock proteins (HSPs) that increase the fruit's cold tolerances at low temperatures by maintaining the integrity of the cellular organs and skeleton (Souza *et al*., 2011). It appears that the higher the temperature and longer duration of treatment leads to greater stimulation of these heat shock proteins. Treatment at higher temperatures may also be beneficial in disinfesting fruit of insect pests. Macrae (1987) also found that the ethylene peak after removal from storage was also markedly reduced. Pre-conditioning may also dry the fruit and reduce respiration (Choi pers. comm. 2007).

The potential benefits of pre-conditioning are summarised below:

- allows the fruit to acclimatise to future cold storage temperatures
- reduces chilling injury and expression of physical damage after removal from storage
- allows damaged fruit to be removed before storage
- allows the fruit to dry properly before storage
- using higher temperatures, pre-conditioning can be used to disinfest fruit of insect pests
- may eliminate the need to use 1-MCP to prevent chilling injury
- may eliminate the need to use MA bags

15.2 Acclimatization

The drastic softening of fruit after cold storage is the result of chilling injury caused by low temperatures. This problem can be partially attenuated through pre-conditioning fruit prior to longer term storage. Pre-conditioning reduces the loss of firmness during and after the removal from storage.

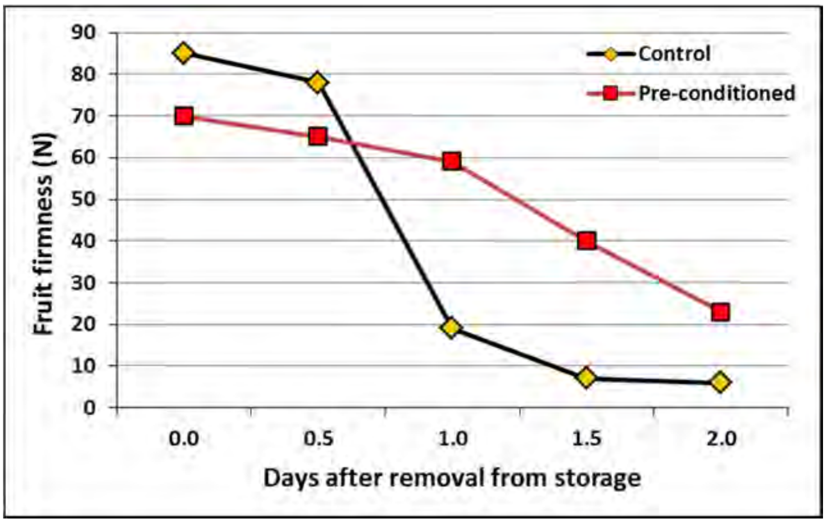
15.3 Pre-conditioning at near ambient temperature

Studies on 'Fuyu' in Brazil (Souza *et al*., 2011) showed that the optimum pre-conditioning temperature was 23±3 °C for 2 days prior to cold storage (Figure 1). Pre-conditioning for longer periods at this temperature may result in loss of firmness and initiation of ripening particularly if fruit are picked at a more advanced stage of maturity.

In contrast, in New Zealand, Macrae (1987) found that the best preconditioning temperature was between 15°±5 °C for 5 days. However, this may be a reflection of the lower ambient temperatures during harvesting in New Zealand. Obviously, the preconditioning period needs to be increased at lower temperatures. Studies are in progress to determine the best pre-conditioning temperatures for Australian fruit.

All damaged fruit are removed before storage. Forced draft cooling/drying at 15°C would be desirable. The higher the moisture content of the fruit after harvest, the more problems are found in the storage of fruit. We found that higher RH may increase fruit respiration and water loss through greater stomatal activity of the calyces which may subsequently lead to increases in ethylene release. The effects of RH on storage life need further elucidation.

Preliminary studies conducted in Australia on cv. Jiro (Bignell *et al*., unpublished data, 2010) have shown that preconditioning at 23±3 °C for 2 days did not reduce chilling injury when fruit were stored at 0°C but it did significantly reduce the expression of physical damage.



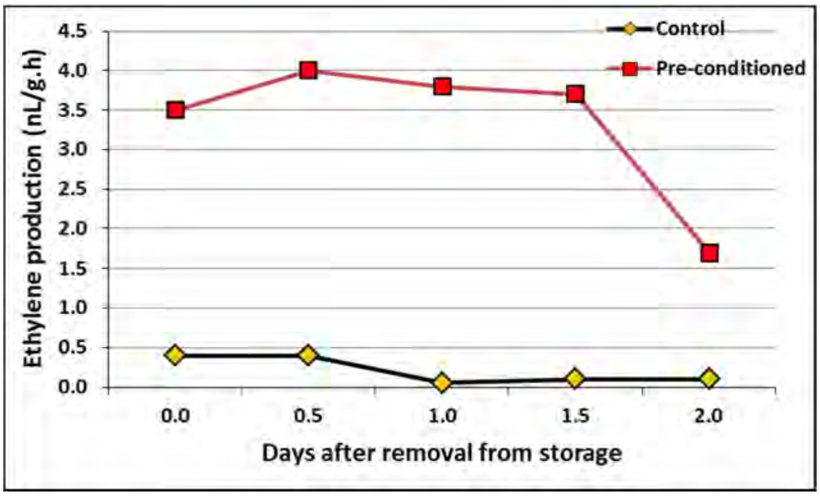


Figure 1. Changes in firmness and ethylene production of 'Fuyu' after 30 days of storage at 0°C. Fruit were pre-conditioned for 2 days at 23°C before storage. Note: pre-conditioned fruit were firmer after storage and exhibited a normal climacteric ethylene pattern compared with control fruit which suffered severe chilling injury. (Adapted from Souza *et al*., 2011).

15.4 Hot water treatments for disinfestation (HWT)

Persimmon fruit, unlike other fruit crops, appear to be relatively heat tolerant using both hot water and hot air treatments (Burmeister *et al*., 1997; Lay-Yee *et al*., 1997). Besides reducing persimmon chilling injury, heat treatments are an environmentally friendly disinfestation treatment, and can kill leaf-roller and mealy bug insects, as well as other insects. The use of such treatments would remove the need for methyl bromide fumigation on arrival in export markets, and the use of polybags for fruit exported via sea freight. Consequently heat treatments show great potential for increasing market access.
In one experiment at HortResearch in New Zealand, 'Fuyu' persimmons were treated in hot water at temperatures between 47° to 54°C and stored at 0°C for 6.5 weeks in air (no polybag) to simulate sea freight. Fruit were then left for 5 days at 20°C to simulate consumer handling of the fruit, before being assessed for fruit quality.

The results showed that heat treatments for 2 hours at 47°C reduced the incidence of chilling injury. In comparison, non-treated fruit stored at 0°C in air were severely damaged by chilling injury. While treatments at 47°C show promise in reducing chilling injury, the temperature during treatment needs to be accurately controlled since exposure to higher temperatures may cause:

- browning of the skin
- browning of the fruit flesh (Besada *et al*., 2008)
- skin cracking (Pérez-Munuera *et al*., 2009)

In South Korea, Lee et al. (2008, 2010) found that the best treatment to control insects and at the same time suppress fruit quality deterioration was hot-water dipping at 48 for 10 min. Lee YongJae et al. (2008) found however that when the level of oxygen concentration in MAP storage is low, the fruit samples treated by hot-water dipping showed higher incidences of pitted blotch browning. Therefore it is necessary to select MA bags which maintain higher oxygen concentration.

In Spain, Besada *et al.* (2008) found that the response of the astringent cv. Rojo Brillante to HWTs (45°, 50°, or 55°C for 2.5,5, 10, 20, 30 or 40 min) depended to a great extent on maturity stage of the fruit. HWTs applied to fruit harvested at an early maturity stage alleviated chilling injury (CI), preserving fruit firmness, whereas HWTs applied to fruit in more advanced stages of maturity caused heat damage to fruit and did not reduce CI.

Besada *et al*. (2008) also showed that mechanical damage during packing is a decisive factor in the incidence of flesh browning, and this alteration is found to increase the damage intensity. HWTs significantly alleviated flesh browning disorder by affecting the anti-oxidative system enzymes; the activity of catalase and ascorbate peroxidase was increased by HWTs while the activity of peroxidases was reduced.

Note: HWT has not been trialled in Australia and studies would need to be conducted to determine its effectiveness.

15.5 Hot air treatments for disinfestation (HAT)

Similar results in reducing chilling injury were obtained when persimmons were treated with hot air at temperatures between 45°C and 49°C, and then stored and assessed in the same manner as the hot water treated fruit (Cowley *et al*., 1992; Woolf *et al.,* 1997a, 1997b). Exposure of fruit to 47°C for 2.5 to 5 hours reduced chilling injury and loss of juiciness while increasing fruit firmness. However, low levels of external browning were observed.

HortResearch entomologists in New Zealand have tested the thermo-tolerance of insect pests of quarantine concern associated with persimmons. Insect thermo-tolerance is tested by treating insects on fruit with hot water or hot air for a range of times and calculating an estimate of the time when 99% of the insects have died.

They have tested the response to heat treatments of light-brown apple moth, which has been shown to be the most thermo-tolerant lepidopteran leaf roller present in New Zealand, and long-tailed mealybug. At 47°C, which is the temperature most beneficial to fruit, both quarantine pests were killed with 34 minutes immersion. This time is well within the limits of the fruit quality.

Plate 1. Immersion of treatment containers in hot water bath at HortResearch New Zealand.

Note: HAT has not been trialled in Australia and studies would need to be conducted to determine its effectiveness.

15.6 Culling of damaged fruit

Culling infected and injured fruit during pre-conditioning reduces losses due to post-harvest decays. Therefore, it may also be advantageous to store fruit for 2-3 days before grading and packing to allow symptoms on damaged fruit to appear so that can be more easily identified and removed before final

grading and packing. We therefore suggest that persimmon fruit be pre-conditioned (acclimatised) for between 2-3 days at 23°C before grading, packing and storage at 0ºC.

15.7 Peel blackening and condensation

Another benefit of pre-conditioning is that it allows all fruit surfaces to completely dry before fruit are placed in long term storage at either 15° or 0°C. The symptoms of peel blackening occur due the condensation and freezing of dewdrops on the surface of the fruit at low temperature (Plates 2 and 3). Free moisture on the skin can also increase incidence of post-harvest diseases.

Plate 2. Left: fruit covered with ice crystals. Right: Peel blackening due to freezing of dewdrops. (Photo: Ahn, South Korea).

Plate 3. Symptoms of peel blackening. (Photo: Ahn, South Korea).

15.8 Expression of physical damage

Besides reducing chilling injury, we have also found that pre-conditioning greatly reduces the expression of physical damage during cool storage caused by polishing and packing (Plate 4). In New Zealand, curing has been shown to improve external quality of fruit following long-term storage (more highly coloured and reduced levels of disorders and rots). We suggest that it may be advantageous to store fruit at 23° for 2 days before they are packed.

15.9 Timing of application of 1-MCP

If 1-MCP is being used to extend storage life (see Chapter 20) timing of application may be critical. Wright and Kader (1997) and Watkins (2008) indicated that a longer delay before 1-MCP treatment is associated with increasing ethylene concentration in the fruit which in turn limits fruit storability.

Studies are needed to determine if fruit should be treated immediately after harvest or after a period of 2 days pre-conditioning at 23°C. Use of HWT and HAT may eliminate the need to use 1-MCP as a means of preventing chilling injury when fruit are stored at 0°C but these techniques require further investigation in Australia.

Plate 4. Top: 'Jiro' fruit pre-conditioned at 23°C for 2 days before cool storage for 2 weeks at 15°C. Bottom: Control fruit (no pre-conditioning) stored at 15°C for the duration of experiment. Photo taken 9 days after removal from storage. Note the enhanced expression of physical damaged of fruit in bottom photo.

Key points

Pre-conditioning may eliminate some chilling injury when fruit are stored at either 0ºC or 15°C.

Pre-conditioning significantly eliminates expression of physical damage after removal from cool storage

Suggested temperature and duration for pre-conditioning is 2 days at 23°C - however further research is needed to validate this

Hot water (HWT) and hot air (HAT) treatments are used to disinfest fruit and reduce chilling injury in some countries. HWT and Hat may eliminate the need to use 1-MCP. These treatments need to be trialled in Australia

During pre-conditioning, damaged or diseased fruit should be eliminated and fruit allowed to dry properly before long-term storage

SHORT TERM COOL STORAGE (15ºC)

16.1 Benefits of storing at 15°C

For local domestic markets, it is feasible to cool store persimmon fruit for short durations of between 7-21 days at 15°C. We found that compared with 20°C, overall storage life was greatly extended by storing fruit at 15°C (Figures 1 and 2).

The advantage of storing fruit at 15°C instead of 0°C is that there is no chilling injury for cv. Fuyu but 'Jiro' is susceptible to chilling injury even at 15°C (see Chapter 14). It may be feasible to store some varieties at temperatures slightly lower than 15°C e.g. 12°C without chilling injury but this requires further investigation.

The other main advantage of storing at 15°C is that it allows the grower to control the release of fruit onto the market during periods of glutting which tends to happen mid-season. This is particularly the case for 'Jiro' grown in Queensland which tends to mature over a relatively short time period.

16.2 Regional differences

The length of cool storage at 15°C is regionally dependent. For example, fruit from a Nambour orchard stored for an extra seven days before reaching 50% eating soft. In contrast, fruit from a South Australian orchard stored for an extra 15 days at 15°C and afterwards took 14 days to reach eating soft. Even more remarkable, fruit from Victoria stored for 28 days at 15°C (George *et al*., 2009) (see Figure 1).

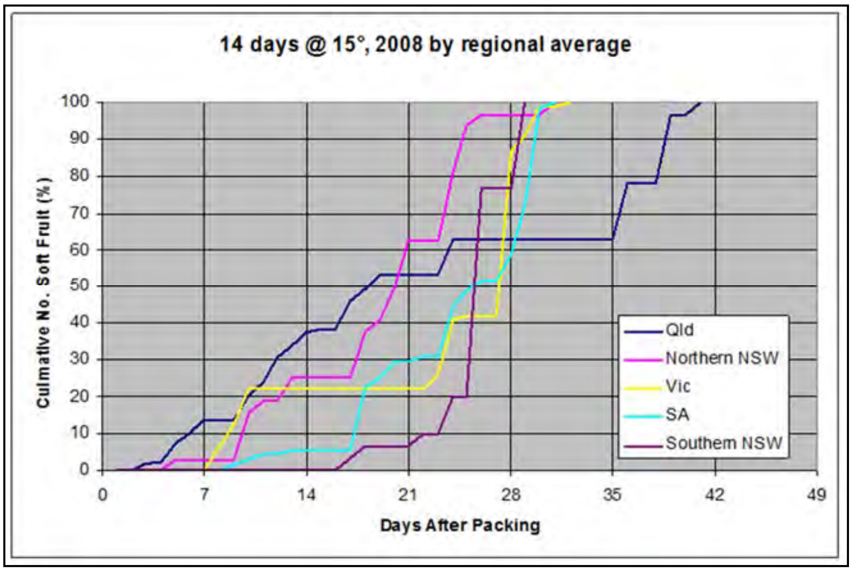
An estimated range of storage duration for different regions is presented in Table 1.

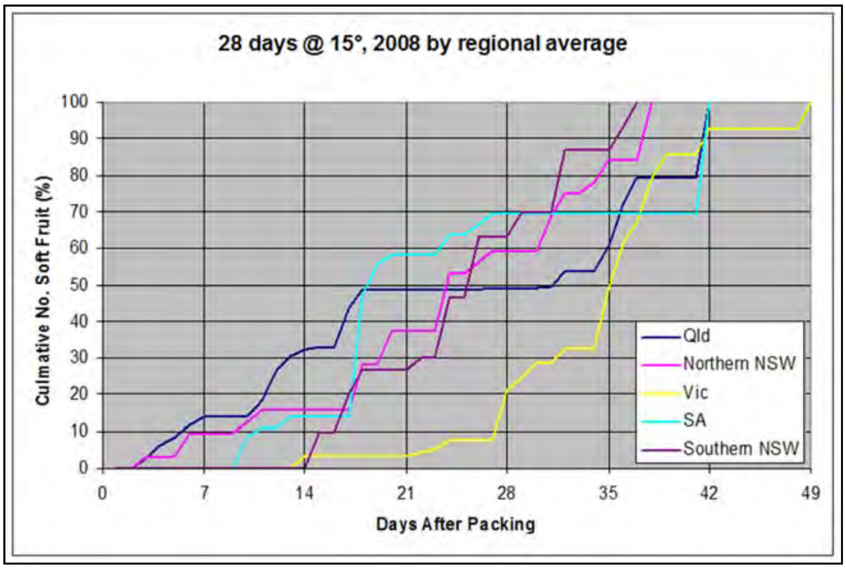
TABLE 1.
Estimated range in storage times for 'Fuyu' persimmon fruit held at 15°C. Note these are estimates.

Region	Storage duration (days)
Coastal Queensland	7
Inland Queensland	7-10
Western Australia	7-10
Victoria	14-21
South Australia	14-21

16.3 Stage of fruit maturity

Amongst the many factors that determine the storability of persimmons, fruit maturity at the time of harvest may be one of the most important (Öz and Ergun, 2010). High flesh firmness at harvest plays a decisive role in the preservation of fruit quality during storage and shelf-life (Salvador *et al*., 2007).





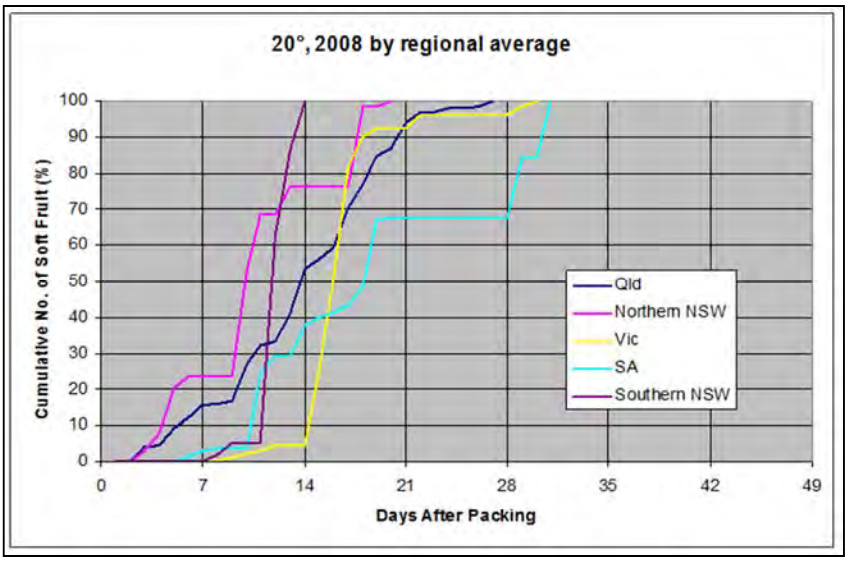


Figure 1. Changes in rates of fruit softening for cv. Fuyu harvested for different states for fruit stored at either 20°C or at 15°C for 14 or 28 days before removal and being held for 4 days at 20°C.

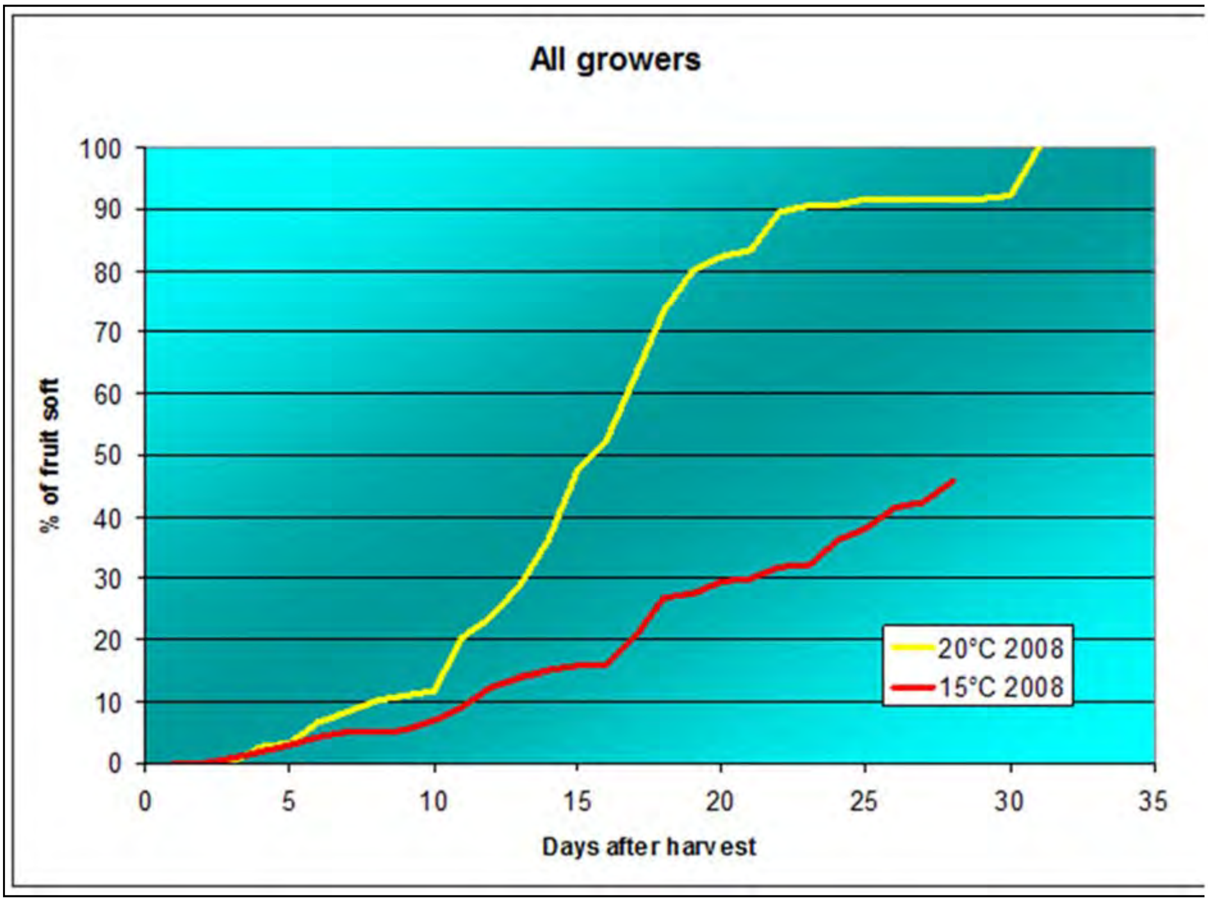


Figure 1. Effects of storage of 'Fuyu' at 15°C compared with 20°C averaged for all growers (George *et al*., 2009).

Fruit with greater colour development store for shorter periods than those which are harvested 'greener'. This is in agreement with the findings by Besada *et al*. (2009) and Bill (2012) who found that loss of firmness during storage is lower in fruit picked less ripe compared to fruit picked more ripe. Skin colour generally seems to be a good external parameter for use in predicting the storability and shelf life potential but there is a compromise between storing ‘greener fruit’ which stores longer and better eating and external quality of more highly coloured fruit.

Our grower surveys indicate that early-season fruit from coastal Queensland has a shorter storage life than fruit harvested from later maturing regions. There appears to be an optimal fruit development period for each region where storage life is maximised.

16.4 1-MCP

When fruit are treated with the ethylene inhibitor 1-MCP, storage life at 15°C may be extended for up to 3 weeks (see Chapter 20). Treatment with 1-MCP may be particularly useful for coastal Queensland and northern NSW fruit which is more highly susceptible to chilling injury than southern fruit and therefore is more difficult to store at 0°C.

Key points

Periods of glutting on domestic markets can be reduced by short-term storage at 15°C

‘Fuyu’ can be stored for short periods at 15°C with minimal or no chilling injury

‘Jiro’ may be susceptible to chilling injury even when stored for short periods at 15°C

Length of storage at 15°C is regionally dependant and can vary between 1-3 weeks

Treatment with 1-MCP can extend storage life at 15°C by 30-50%

LONG-TERM COOL STORAGE (0°C)

17.1 Cool storage at O°C

Reducing the storage temperature will slow down the respiration rate and ethylene production of the fruit, and delay deterioration. For most fruit, the lower the storage temperature the longer the storage life (Wills *et al*., 1989).

However, optimum long term storage temperatures are different for most fruit and therefore there are standard storage temperatures for nearly every fruit (Wills *et al*., 1989). Storing fruit outside the ideal cold temperatures for too long will usually result in chilling injury (CI) (See Chapter 14).

The best cold storage conditions for storing persimmon fruit (particularly 'Fuyu') for longer than two weeks is 0±1˚C with 95±5% relative humidity (Crisosto, 1999; George *et al*., 2005; Kitagawa and Glucina, 1984; Collins and Tisdell,1995).

Freezing point may occur at -2°C depending on soluble solids content.

Rates of respiration

- 2-4 ml CO2 / kg•hr 0ºC
- 10-12 ml CO2 / kg•hr 20ºC
- To calculate heat production multiply ml CO2/kg•hr by 440 to get Btu/ton/day or by 122 to get kcal/metric ton/day.

17.2 Chilling injury (CI)

For persimmon, the most common chilling injury symptoms are rapid softening of the flesh after removal from cold storage (0°C), with varying degrees of flesh browning and translucency (Plate 1) (See Chapter 14 for more details).

Chilling injury can occur in susceptible fruit. For example, chilling injury can be quite prevalent for ‘Fuyu’ and ‘Jiro’, stored at 0˚C for four weeks, but is not present in all consignments. (Redpath *et al*., 2007 unpublished data).

‘Fuyu’ and ‘Jiro’ are particularly sensitive to chilling injury (CI) if stored between 0-15°C for longer than seven days (Collins and Tisdell, 1995; Crisosto, 1999; George *et al*., 2005).

17.3 1-MCP and MA bags

With the exception of South Australian and Victorian fruit, most Australian fruit needs to be treated with 1-MCP to prevent chilling injury when stored at 0°C (See Chapter 20 on using 1-MCP).

To further improve storage life at 0°C, additional technologies to cold storage must be used (see Chapter 21), such as:

- pre-conditioning fruit after harvest
- use of modified atmosphere (MA) bags
- application of 1-methylcyclopropene (1-MCP)
- modified atmosphere (MA) bags + 1-methylcyclopropene (1-MCP)

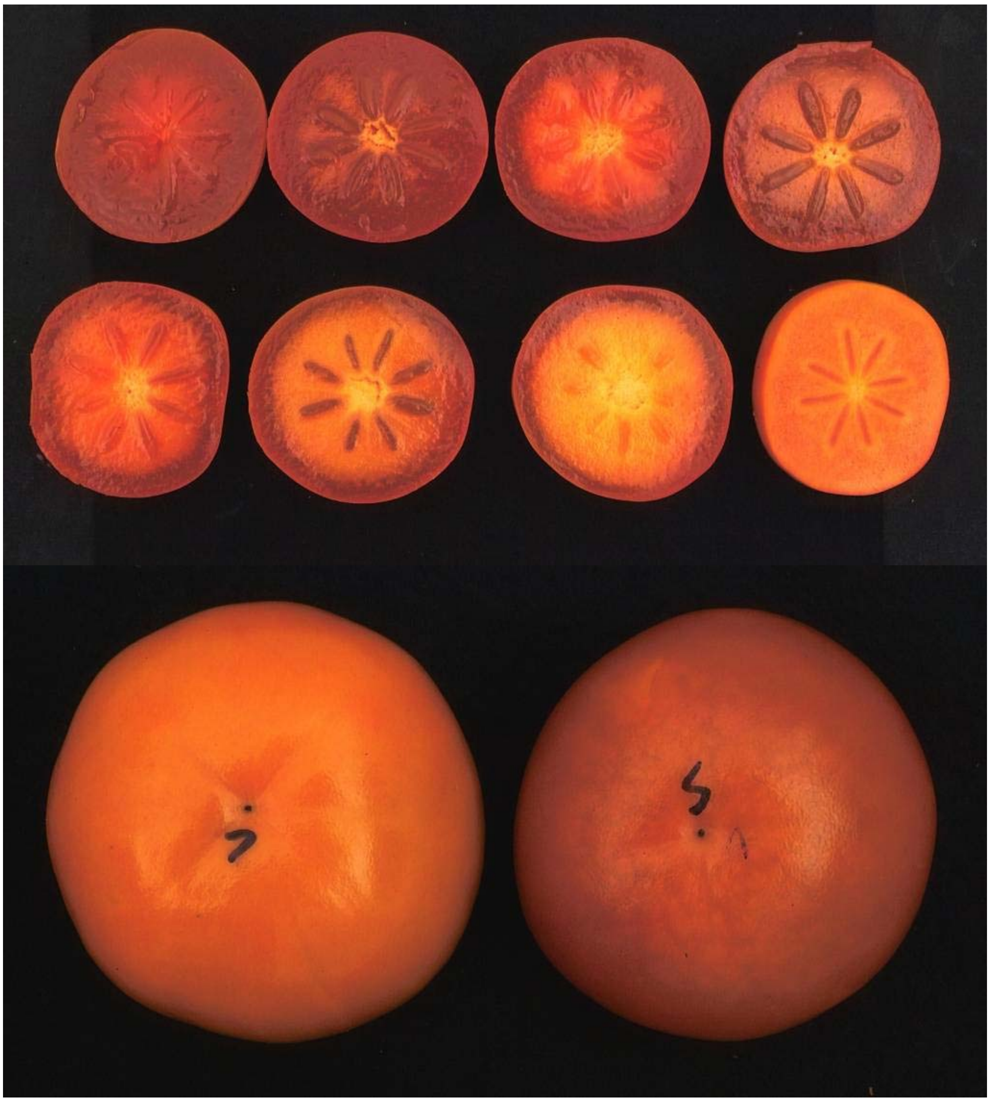


Plate 1. Differing severities of chilling injury for 'Fuyu' held at 0°C for 4 weeks and then 20°C for 1 week. Note the translucency and the slight skin "browning" appearance (Redpath *et al*. unpublished data).

Key points

Australian persimmon fruit can be stored for up 3 months at 0°C

Storage life is regionally dependant

Fruit stored at 0°C are highly susceptible to chilling injury

Fruit stored at 0°C must be treated with 1-MCP to prevent chilling injury

Modified atmosphere bags can extend storage life when used in combination with 1MCP

MODIFIED ATMOSPHERE BAG STORAGE

18.1 Mode of action

Modifying atmospheres

The main aim of modified atmosphere packaging (MAP) is to change the composition of the atmosphere around the product so that the storage life of the product can be extended (Jobling, 2001). Most fruit age less quickly when the level of oxygen (O_2) the atmosphere surrounding them is reduced. This is because the reduced oxygen slows down the respiration and metabolic rate of the products and therefore slows down the natural aging process. Raising the level of carbon dioxide (CO_2) to levels of 2 % or more can also be beneficial. Elevated CO_2 levels can reduce the products sensitivity to ethylene. High CO_2 can also slow the growth of many of the postharvest fungi that cause rots. All these effects can help to extend the storage and shelf life of persimmon.

However, while basically a simple system for commercial usage it is critical that considerable care is paid to several factors the most important of which is temperature control. When a given weight of produce is sealed within a plastic bag, it uses oxygen and produces carbon dioxide. As the oxygen concentration inside the package falls, below about 10% the rate of respiration (oxygen use) starts to decrease. At the same time, oxygen moves into the bag through the walls of the plastic bag and carbon dioxide moves out. Oxygen and carbon dioxide move across the film in proportion to the drop in concentration of oxygen and rise of carbon dioxide concentration inside the plastic bag. The rate of oxygen movement through the plastic bag depends on the surface area, thickness and chemical properties of the plastic film. The permeability of the film can be increased by adding holes. The commercially used film LifeSpan™ packaging is a microporous film that has a number of tiny holes and this ensures enough oxygen is supplied to the product when this film is use as recommended by the manufacturer. The difficulty with using modified atmosphere packaging is the establishment of a stable atmosphere inside the plastic bag. MAP is a dynamic system that is not controlled. As currently used there is no feedback system that can cut in if one of the factors listed above changes. Therefore it is important to use MA packaging only as recommended by the manufacturer.

Temperature and cool chain

The factor that causes most problems in a commercial situation is temperature (Jobling, 2001). Unfortunately the cool chain for fresh produce is not always continuous throughout the marketing system. Breaks in the cool chain such as during loading or unloading of trucks or packing of warehouses mean that the cool product can warms up. Warming of only a few degrees can be enough to cause the respiration rate of the product to rise and the oxygen within the package to fall below the recommended level. If the oxygen level falls too low then anaerobic respiration can be initiated. If this happens alcoholic off flavours develop within the product, making it unmarketable. There is always a risk/benefit when using modified atmosphere packaging, particularly when a low oxygen atmosphere is providing the benefit (Figure 1). The greatest extension of shelf life occurs at the lowest possible oxygen concentration before anaerobic respiration is initiated. This point also carries the greatest risk. For example, if the respiration rate increases as a result of a small change in temperature then the oxygen level will fall below the critical level and off flavours will be produced. The same is true for atmospheres where the main benefit is high carbon dioxide. If respiration increases due to an increase in temperature then the level of CO_2 may rise above the critical level and the product will also be damaged and made unsaleable. There are two ways to minimise the risk of spoilage. Firstly you could use a package that provides slightly more oxygen, and so provides less benefit in terms of shelf life but the package would also have a reduced risk of spoilage. Secondly ensure that the cool chain is maintained. If you can't guarantee the temperature then you will be taking a very big risk with this type of packaging system. If the temperature rises by more than a few degrees then damage could be avoided by opening the bags to ensure adequate oxygen for the product. This is not often feasible but some packers recommend that the MA bags are opened once the product arrives at the wholesale market to ensure there is no risk of spoilage. The main factors determining gas composition under MA are:

- variety
- stage of fruit maturity (see Chapter 5)
- product temperature (both of which determine respiration rate)
- mass of product per unit surface area of barrier film
- permeability of the film

18.2 Optimum atmospheres in MA storage for persimmon

A best modified atmosphere for persimmon appears to be about 1-3% O_2 and 5-8% CO_2 in the MA bag (Tanaka *et al*., 1971; Kim *et al*., 2010; Ahn, 2012) (Figure 1). Various types of skin and internal browning of 'Fuyu' persimmon fruit may be induced by an extreme MA environment of ultra-low O_2 below 1% (0.50kPa) irrespective of CO_2 concentrations (Lee *et al*., 1999; Ahn *et al*., 2001; Lee, 2001; Park and Lee, 2008).

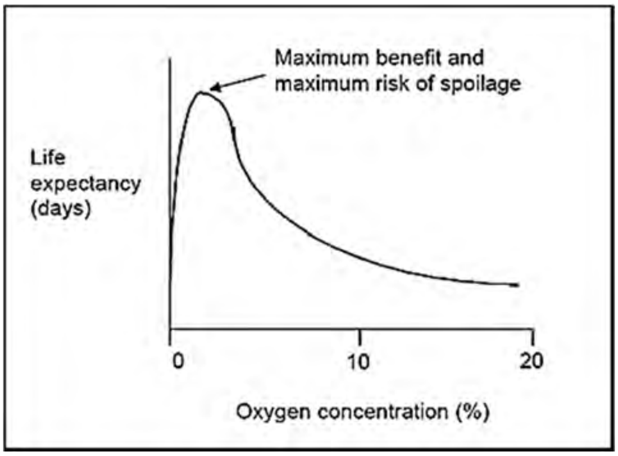


Figure 1. Low oxygen concentration increases cool storage life of persimmon but if oxygen concentration falls below 1% fruit enter anaerobic respiration and develop physiological disorders and off flavours (Jobling, 2001).

18.3 Thickness of plastic films

Plastic film is the main type of barrier used, and the usual factors determining permeability of the film are:

- composition of the film
- thickness of the film
- presence or absence of micro-perforations

In relation to persimmon, the effect of thickness of the low density polyethylene bags has been studied extensively. Thicknesses between 0.045 mm and 0.08 mm generate the optimum atmospheric conditions to prolong storage life and alleviate chilling injury (CI) symptoms and subsequent soft fruit in 'Fuyu' (Ahn *et al*., 2001; Lee and Yang, 1997; Park *et al.*, 1997; Cia *et al*., 2006; Neuwald *et al*., 2008).
In New Zealand, MacRae (1987) found the optimum thickness for "Fuyu" to be 0.06 mm whereas in Israel, Ben-aire and Zutkhi (1992) found that it was 0.08mm. However, most studies indicate that 0.06 mm appears about optimum (MacRae, 1987, Cia *et al*., 2006). Kim *et al*. (2010) showed that stage of fruit maturity can have a large influence on respiration rates in cool storage (see Chapter 5). Therefore, bag thickness may need to be modified accordingly.

Changes in gas composition within MA bags of different thicknesses are presented in Figure 2.

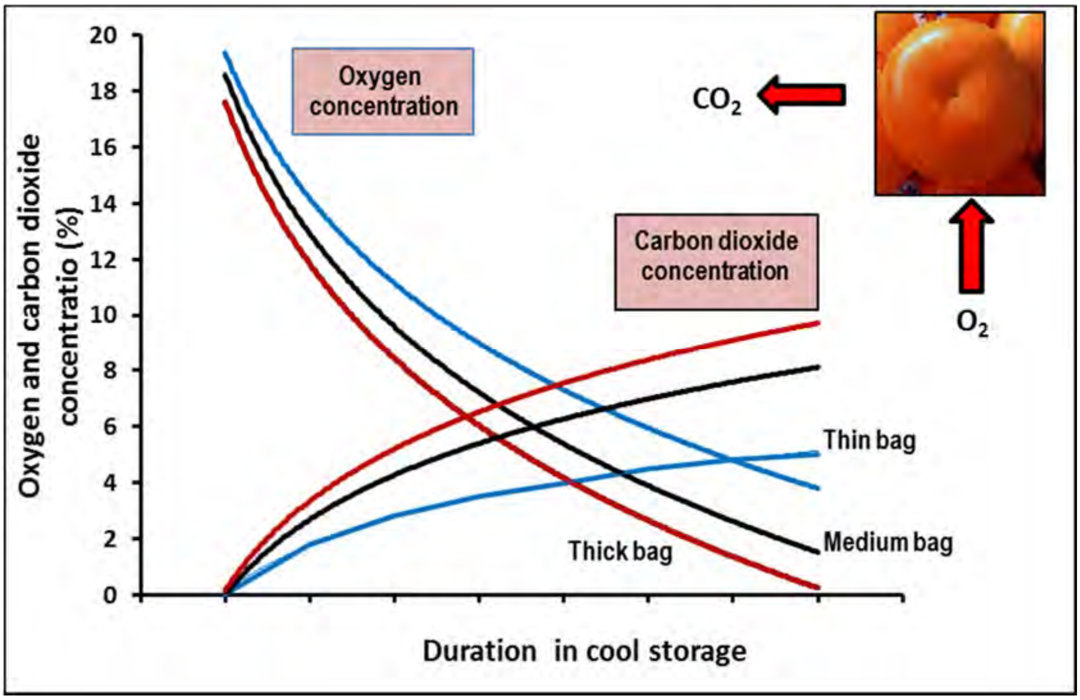


Figure 2. Schematic diagram showing the effects of bag thickness on the changes in composition of oxygen and carbon dioxide gases within the MA bag during cool storage. The optimum bag thickness will give an atmosphere of 2-3% oxygen and about 5-8% carbon dioxide. Oxygen concentrations <1% and carbon dioxide concentrations >10% cause physiological disorders.

18.4 Effects of MA bags on cool storage life

Although storage times can vary from two weeks to six months (Park *et al*., 1997), it appears that 1 to 3 months is the most common storage life (Ahn *et al*., 2001; Lee and Yang, 1997; Neuwald *et al*., 2008).

Furthermore, storage life can be greatly influenced by growing region and cultivar (MacRae, 1986; Cia *et al*., 2006; Redpath *et al*., 2010).

MA storage can be lengthened considerably by combination with 1-MCP, application of which also alleviates most chilling injury (Golding *et al*., 2005; Kim and Lee, 2005; Redpath *et al*., 2010). Inclusion of ethylene absorbents inside the bags can reduce skin browning and maintain flesh firmness but effects are relatively minor compared with applying 1-MCP (Neuwald *et al*., 2008; George *et al*., 2012).

18.5 Preconditioning and heat treatments

There may be some advantages in pre-conditioning the fruit before placing in MA bags (see Chapter 15). Keeping fruit at 23°C for 2-3 days before applying MA bags may allow fruit to dry out properly and for cuts and abrasions to seal. However, this practice needs to be verified. Korean researchers recommend that after pre-conditioning fruit be placed immediately into the MA bags and fruit quickly cooled within a day to the correct cool storage temperature of °C (Ahn, pers. Com., 2012). Hot water treatments (HWT) and hot air treatments (HAT) have not been trialled in Australia but are used commercially in New Zealand.

18.6 Types of MA bags trialled in Australia

Three types of MA Bags designed to enclose trays have been trialled in Australia:
- Amcor Lifespan Chilean L297 persimmon bag. It is clip sealed (Plates 1 and 2)
- Amcor Lifespan L298 bag, manufactured in NZ. It is heat sealed (Plate 3)
- Amcor LifeSpan® L342 bag specifically designed for persimmon (Plate 4)

Larger MA bags are available to enclose three layer boxes (Plate 5). In limited trials, we found that the Amcor Chilean L297 persimmon bag performed better than the L298 bag. Further studies are needed to determine if the L342 bag is better than the L297 bag.

Unreliable heat sealing of the MA bag and therefore atmosphere establishment failure can be a problem with the L298 type bag.

18.7 Optimum storage temperature

We found that using MA bags did not alleviate chilling injury when fruit are stored at 0°C with over 90% of them showing signs of chilling injury. If storing MA bags at 0°C, fruit must be prior-treated with 1-MCP.

There have been some overseas studies which have shown that persimmon fruit can be stored for up to 30 days in MA bags held at 15°C (Arnal *et al*., 2008). Our Australian studies have shown large regional differences in storing fruit in MA bags at 15°C.

18.8 MA bags in combination with 1-MCP and/or ethylene absorbents

1-MCP and MA bags

There are additive effects when 1-MCP and MA are used together. Chilling injury can be greatly reduced to less than 5% or eliminated entirely through the use of 1-MCP and MA bags (Redpath *et al*., 2010). The combination of 1-MCP and MA bags also delays the climacteric peak (Figure 2) and greatly reduces the rate of fruit softening in long term storage (Tibola *et al*., 2005; Kim and Lee, 2005; Luo, 2007; Oz 2011) (Figure 3).

A combination of MA bags and 1-MCP will produce the maximum storage life of up to 12 weeks for fruit from Victoria and South Australia. Protocols for applying 1-MCP are presented in Chapter 22. Estimated cool storage lives using MA bags and 1-MCP for different production regions of Australia are presented in Table 1. (Also see Chapters 20 and 21 for more details).

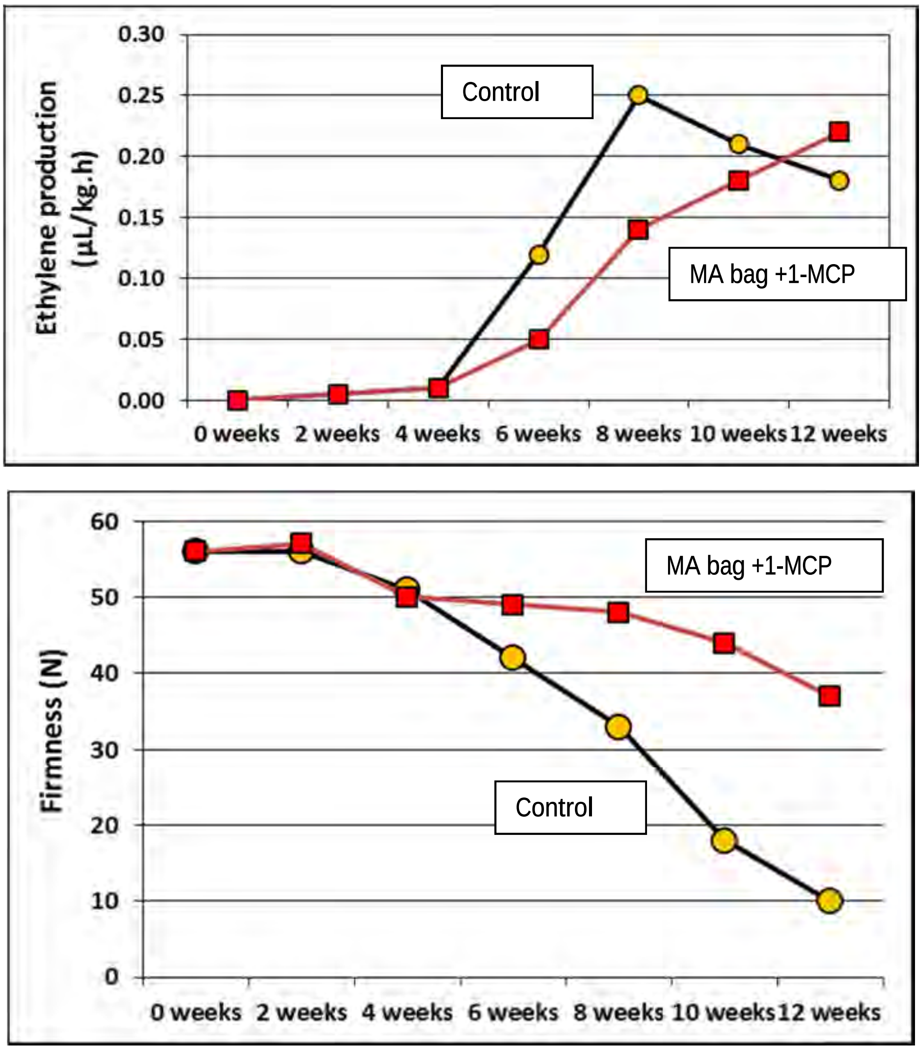


Figure 3. Changes in ethylene concentration and firmness during storage at 1°C. Control fruit reached climacteric after 2 months of storage whereas MA bagged fruit treated with 1-MCP do not reach climacteric until released from storage. Bagged fruit retained firmness for the duration of storage – about 3 months. A fruit firmness level of <10N is regarded as very soft and non-marketable. Adapted from Oz (2011).

TABLE 1.

Estimated range in storage times for fruit in MA bags prior-treated with 1-MCP and stored at 0°C. Note: these are estimates.

Region	Storage duration (weeks)
Coastal Queensland	3
Inland Queensland	4-6
Western Australia	6-8
Victoria	6-12*
South Australia	6-12*

*12 weeks may be feasible. Also see Chapter 21.

Ethylene absorbents and MA bags

Maotani *et al*. (1982) showed that ethylene absorbents can reduce ethylene production in MA bags during storage and maintain fruit firmness (Figure 4). In their Japanese study, they showed that 'Fuyu' persimmon could be stored for 28 days at 20°C in MA bags with ethylene absorbent. Other studies have shown that the effects of ethylene absorbents, compared with 1-MCP or MA bags, in extending cool storage life are relatively small (Kurahashi *et al*., 2005; Pekmezci *et al*., 1997). Similarly, Redpath *et al*. (2010) found little beneficial effects on chilling injury or rate of fruit softening by adding ethylene absorbents to 'Fuyu' in MA bags stored at 0°C for 4 weeks. Pekmezci *et al*. (1997) showed that compared with using MA bags alone, inclusion of ethylene absorbents reduced rate of loss of fruit firmness in 'Fuyu' by about 10%. However, inclusion of ethylene absorbents inside the bags can reduce skin browning (Neuwald *et al*., 2008) but the response is relatively minor compared with the application of 1-MCP.

The number of sachets to include per MA bag requires further investigation. Korean research indicates that at least 100 g of absorbent must be included for every 10 kg of persimmon fruit (Ahn, pers. com., 2012). Currently, we have been including only two 5 g sachets per MA bag which encloses 4 kg of fruit. Insufficient rates of absorbents may be the reason why the absorbents have been ineffective.

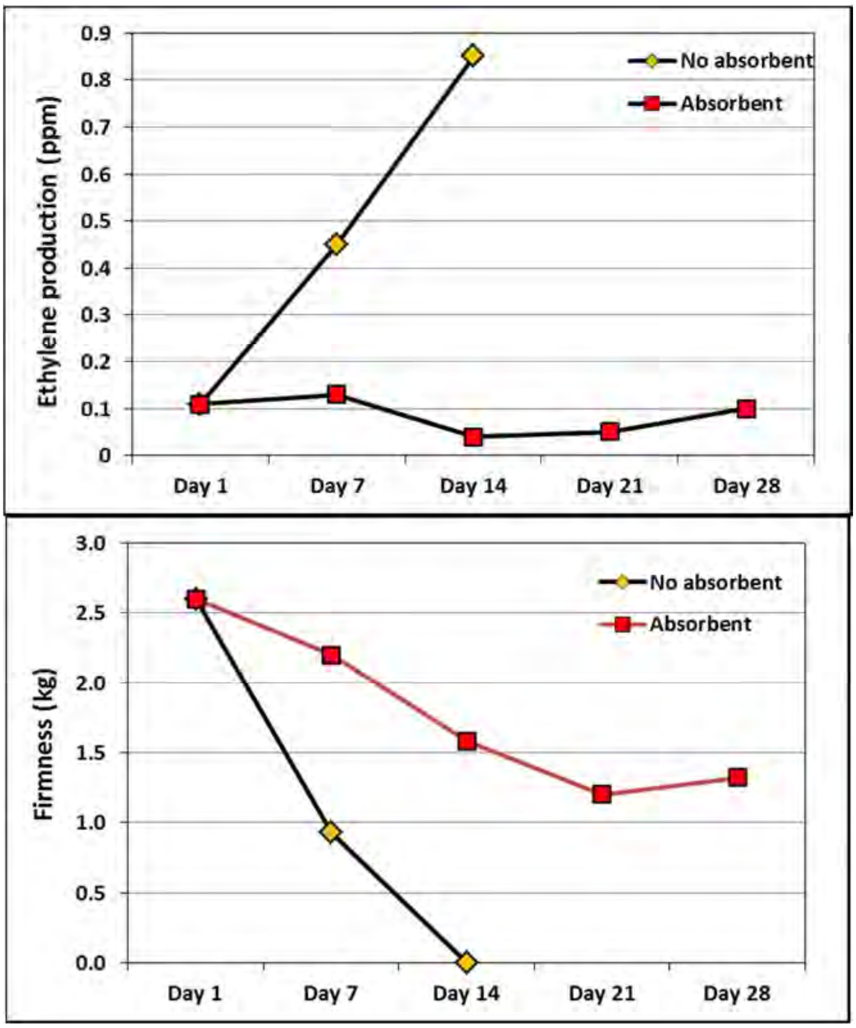


Figure 4. Effects of ethylene absorbents on ethylene production and firmness of 'Fuyu' persimmon in MA bags stored for 28 days 20°C. (Adapted from Maotani *et al*., 1982).

Plate 1. Left: Chilean persimmon bag which is twist tied. Right: bag clips.

Plate 2. Details on twist sealing using clips.

Plate 3. Fruit placed in Amcor L298 bag and heat sealed.

LifeSpan®
Modified Atmosphere Packaging

PACKING INFORMATION

FUYU PERSIMMONS

DESIGNED FOR STORAGE AT 32°F-36°F

CARTON LINER PRODUCT NO: L342

This liner is only to be used for 25lb of FUYU persimmons stored at 32°F to 36°F. Liner is not proven on other varieties of persimmons. Persimmons should be harvested at full maturity for best results. The liner is designed to be sealed with an easy release clip. Tape sealing may be used as an alternate sealing method.

- **Check that printed details on carton liner agree with your intended use, if not contact Amcor Flexibles Australasia or your local LifeSpan dealer.**
- **The persimmons should be pre-cooled to below 41°F and held in cool storage overnight. Packing persimmons without adequate pre-cooling may cause heat build up and condensation in the carton liners.**
- **Keep the persimmons cool whilst packing. Bring out one bin at a time. Return packed persimmons to coolstore immediately.**
- **Ensure cartons being used do not have sharp corners or staples that will puncture the carton liner.**
- **Seal the box liner by bunching the neck of the liner. Put several tight twists into the bunch. Place a yellow release clip around the twisted area and squeeze to close. The lobes on the clip will retain the necessary twist in the liner neck.**
- **Store packed cartons in cool storage between 32°F and 36°F, low temperatures are best. If cartons are removed from cool storage, the carton liners must be opened.**

Use of this product or information is not guaranteed, and is for general guidance only. Users should conduct their own tests to determine suitability. Freedom from patent restrictions cannot be assumed.

For further information, please contact LifeSpan on (+61-3) 9555 9666; Fax (+61-3) 9532 5385

REVISION No. 1 30/10/2003

Plate 4. Details on how to use the Lifespan L342 bag.

Plate 5. Three layer box of Korean 'Fuyu' persimmon fruit enclosed in MA bag.

18.9 Disorders in MA storage

Exposure to oxygen levels below 1% or carbon dioxide levels above 10% during storage or duration can result in failure of persimmons to ripen and off flavours. Exposure to carbon dioxide levels above 10% during storage for longer than one month can cause brown discoloration of the flesh and off-flavours (Plate 6). Flesh browning can be caused by too much carbon dioxide. Peel browning can be caused by high oxygen and high moisture.

Plate 6. Skin and flesh browning induced by low oxygen and very high carbon dioxide concentration (Ahn, 2012).

18.10 Removal of MA bags after storage

Studies have shown that MA bags should be removed as late as possible in retail shops as ripening will be more rapid than for non-MA stored fruit. In Korea, fruit are held in their MA bags after cool storage at 0°C and normally displayed in the refrigerated display cabinets in the supermarket store to prevent expression of chilling injury and other physiological disorders (Plate 7, Figure 5) (see Chapter 23). For this reason, the Korean industry markets their fruit as individual fruit in MA bags or as five pieces of fruit per MA bags. They do not use 1-MCP to prevent chilling injury. Consequently, supermarket staff needs to be educated on how to manage fruit sealed in MA bags.

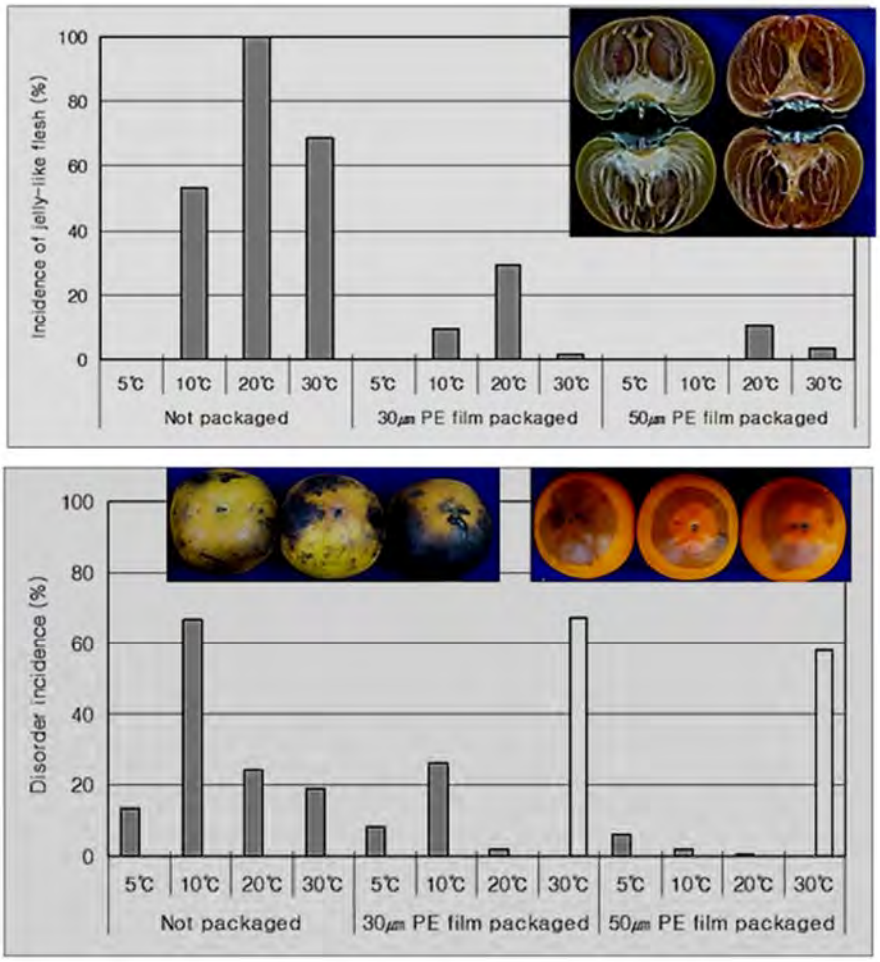


Figure 5. Keeping Korean 'Fuyu' fruit in MA bags in the refrigerated cabinets at 10ºC in retail stores after cool storage at 0°C prevents expression of chilling injury and other physiological disorders. Jelly flesh is a symptom of chilling injury (Ahn, 2012).

18.11 MA bags for small fruit numbers

No research has been conducted in Australia on using MA bags for single or small numbers of fruit per bag (Plates 8, 9). However, considerable research has been conducted in Korea and Japan to adapt MA technology to market small numbers of fruit in bags. Bag thickness varies with fruit size and number of fruit per bag - usually 5 fruit per bag. Ahn *et al* (2001) found that five fruit per 0.05 or 0.06 mm thickness bag, tie-sealed (compared to heat-sealed), produced O_2 and CO_2 levels of 1.1~3.0% and 4.0~5.5% respectively, which preserved fruit firmness while reducing flesh and skin browning. Lee (2004) developed models to determine bag area and gas compositions for Korean persimmon fruit cv. Fuyu based on fruit weight, and bag thickness (Tables 2 and 3).

Plate 7. Korean persimmon in MA bags held in the refrigerated display cabinets in store.

TABLE 2.

Model equations used to predict polyethylene MA bag area, O_2 concentration and CO_2 concentration using fruit weight and bag thickness (Lee, 2004).

Y	**Model Equation**	**X_1**	**X_2**
MA Bag Area	$Y=-4055.707+627.993X_1-0.701X_1^2$	Fruit Weight (g)	
O_2 Concentration	$Y=5.798-0.0109X_1-0.0491X_2$	Fruit Weight (g)	MA Bag Thickness (µm)
CO_2 Concentration	$Y=-2.427+0.01927X_1+0.09646X_2$	Fruit Weight (g)	MA Bag Thickness (µm)

TABLE 3.
Relationship between fruit weight and bag thickness for individual pieces of Korean 'Fuyu' fruit stored in MA bags *(Lee, 2004).*

Fruit weight (g)	Depth (cm)	Width (cm)	LDPE thickness (µm)
150	12.5	14.0	65.0
200	13.0	14.5	57.5~60.0
250	13.5	15.0	52.5~55.0
300	14.0	15.5	47.5~50.0
350	14.5	16.0	45.0~47.5

Plate 8. Korean 'Fuyu' being stored in modified atmosphere bags containing 5 fruit.

Plate 9. Modified atmosphere bags used for Korean ‘Fuyu’ persimmon – single fruit. Bag thickness varies with size of fruit – larger fruit need thinner bags to develop optimal gas ratios.

Other types of MA bags used in different countries are shown in Plates 10 and 11.

Plate 10. Individual persimmon fruit presented in MA bags.

Plate 11. Polystyrene trays holding four fruit covered with a low density polyethylene film in Italy.

Key points

Use of MA bags allows fruit to be stored 30-50% longer, irrespective of storage temperature

Maximum storage life of up to 3 months at 0°C is achieved when MA bags are used in conjunction with 1-MCP

MA bags used alone do not prevent chilling injury

Optimum bag film thickness appears to be about 0.06mm

Optimum gas concentrations in bags are about 1-3% O_2 and 5-8% CO_2

Stage of fruit maturity can affect gas concentrations

MA bags can be used either with trays of fruit or for smaller numbers of fruit including individual fruit

Holding fruit in MA bags in the refrigerated display cabinets within store after removal from cool storage can delay expression of chilling injury

CONTROLLED ATMOSPHERE STORAGE

19.1 Controlled atmosphere conditions

Low oxygen

In CA storage, oxygen (O_2) is reduced and carbon-dioxide (CO_2) increased to prolong the storage life of fruit. Low O_2 and high CO_2 atmosphere slows activity of cell wall degrading enzymes (Kader and Saltviet, 2003) and reduces fruit respiration. When coupled with low storage temperatures, it can further extend storage life (Wills *et al*., 1989).

Low oxygen (1-3%) delays ripening and 5-8% CO_2 helps maintain firmness and reduce chilling injury symptoms in 'Fuyu' (Crisosto, 1999; Kitagawa and Glucina, 1984; Wills *et al*., 1989). Carbon dioxide at 5-8% helps retain firmness and can reduce chilling injury symptoms on 'Fuyu' and similar cultivars.

CA storage is best used in large cool rooms or containers where there are considerable volumes of fruit to be treated. Currently the technique is used to store 'Triumph' persimmon in Israel. Storage conditions are: 1.5% O_2 and storage temperature of 1 °C. It is claimed that 'Triumph' persimmon fruit can be stored for 3 to 4 months under these conditions (Testoni, 2002).

CA storage has not been tested on persimmon in Australia.

Nitrogen

Applying nitrogen gas may be alternative method of developing suitable CA conditions. Using 97% Nitrogen + air, persimmon variety "Rojo Brillante" could be stored for up 30 days at 15°C maintaining commercial firmness.

19.2 Disadvantages

While CA give very good control of gas composition, it is expensive and may provide better results if coupled with ethylene absorbers (Ahn *et al*., 2000). Chilling injury may be severe when fruit are stored at 0°C unless treated with 1-MCP. It may be feasible to stored persimmon fruit under CA conditions at 15°C.

19.3 Disorders induced by low O_2 and/or high CO_2:

CA has been shown to retard softening and to reduce astringency (Arnal *et al*., 2008) of persimmons during storage, but the level of CO_2 required to achieve this, results in internal browning due to the accumulation of acetaldehyde (Ben-Arie *et al.*, 1991). Off-flavours also develop under high CO_2 levels due to the accumulation of ethanol (Neuwald *et al*., 2009). Exposure to carbon dioxide levels above 10% during storage for longer than one month can cause brown discoloration of the flesh and off-flavours.

19.4 Cool room design and equipment

An airtight room is essential for proper controlled atmosphere storage of persimmon.

CO_2 adsorber / scrubber

A CO_2-adsorber/scrubber (Plate 1) removes carbon dioxide from cold stores and some ethylene. It contains active carbon, which enables it to adsorb (bind) the CO_2 molecules. The CO_2 is effectively removed from the cold store by transporting the air from the cold store through the active carbon and then back to the cold store

PSA nitrogen generator

A PSA (Pressure Swing Adsorption) nitrogen generator (Plate 1) produces pure nitrogen from normal environmental air. A nitrogen generator may also be needed to quickly remove oxygen from the room quickly and slow down respiration of stored fruit. Oxygen concentrations in the room need to be lowered within 48 hours of sealing the rooms.

Ethylene scrubbers

For persimmons, controlled atmosphere rooms may also need to be equipped with ethylene scrubbers to maintain very low ethylene levels in the room. It is necessary to use an ethylene analyser that can monitor the level of ethylene in the rooms and allow preventive action if necessary.

Plate 1. Left: CO_2 absorber. Right: scrubber PSA nitrogen generator (Photos: Bioconservacion Australia Ltd)

19.5 Monitoring

A O_2/CO_2 analyser (Plate 2) is used to daily monitoring of oxygen and carbon dioxide in the rooms. CO_2 absorbers are needed to adjust CO_2 concentrations. Some companies have developed their own analysis system which enables the cold store to operate fully automatically. You only need to input the desired parameters and the system will measure, regulate and maintain the selected atmosphere. Furthermore, for example, it involves the control and, when required, the operation of:

- O_2 (oxygen)
- N_2 (nitrogen)
- CO_2 (carbon dioxide)
- C_2H_4 (ethylene)
- T (temperature)
- RH (relative humidity)

Plate 2. Oxygen and carbon dioxide monitor.

Key points

CA storage is an option for bigger growers

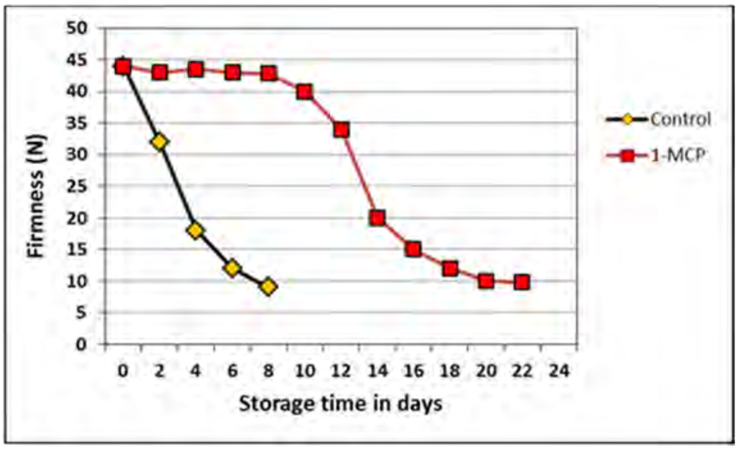
CA storage requires use of specialised equipment to maintain correct gas compositions

CA has not been trialled in Australia

1-MCP

20.1 Mode of action

1-MCP reduces ethylene effects in a range of fruits including persimmon (Blankenship and Dole, 2003; Luo, 2007; Oz, 2011) (Figure 1). The molecular structure of the gases 1-MCP (C_4H_6) and ethylene (C_2H_4) are very similar (Kim and Lee, 2005). 1-MCP binds to the receptor site for ethylene, thereby blocking its action (Blankenship and Dole, 2003; Sisler *et al*., 1996). The application of 1-MCP delays the ethylene climacteric and reduces the rate of fruit softening even for fruit stored at 20°C (Figure 1). The response may be as dramatic as a doubling of storage life.



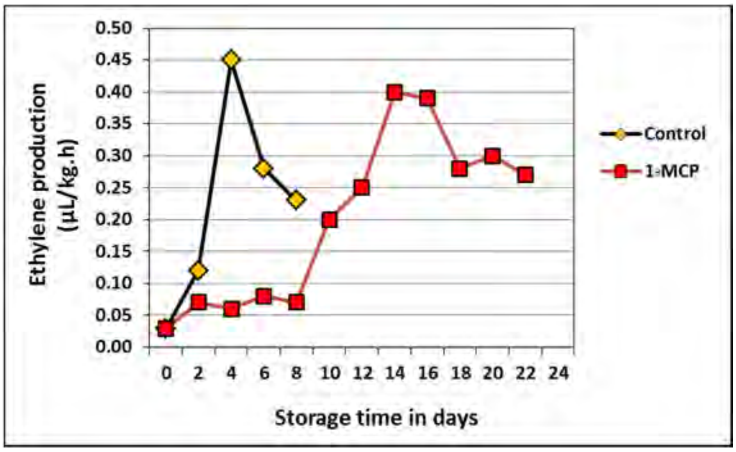


Figure 1. Effects of 1-MCP on fruit firmness and ethylene production of persimmon for fruit stored at 20°C. A fruit firmness level of <10N is regarded as very soft and non-marketable. (Adapted from Luo, 2007).

1-MCP has also been shown to lower the activity of polygalactonuronase (PG), an enzyme responsible for cell wall softening (Ramin, 2008). Consequently, 1-MCP treated persimmon fruit can maintain their firmness and cell wall integrity for significantly longer periods than non-treated fruit and can also reduce chilling injury, respiration and ethylene production at ambient temperatures (Luo, 2007; Isabel Perez-Munuera (2009) (Plates 1). Improvement of chilling tolerance by 1-MCP may also involve reduced levels of pro-oxidative enzymes and enhanced levels of antioxidant enzymes (Zhang and Zhang, 2010).

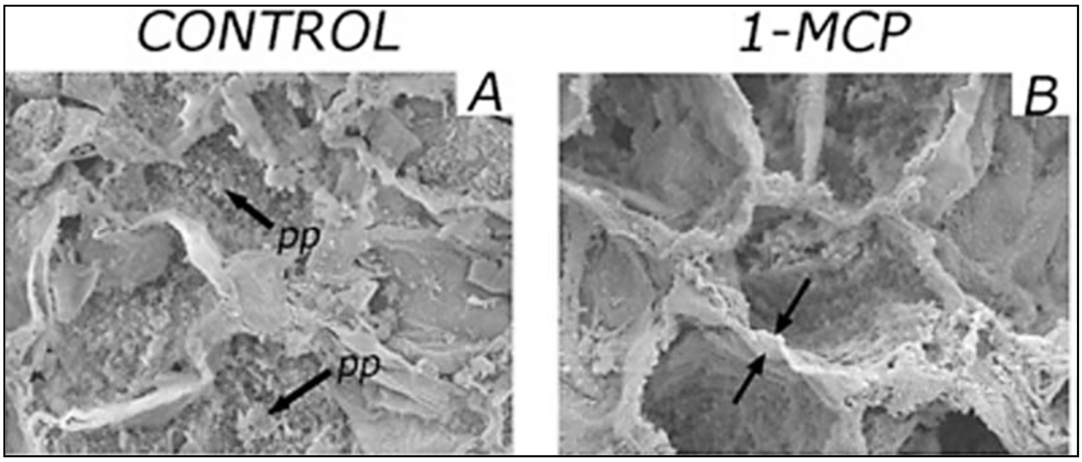


Plate 1. Effect of 1-methylcyclopropene (1-MCP) on the structure by scanning electron microscopy from flesh samples of persimmon cv. Rojo Brillante stored at 1°C for 30 days. Arrows indicate contact between the cell wall of adjacent cells. pp = precipitate inside of the cells. Note: breakdown in cell walls of control compared with 1-MCP treated fruit. Photos: Isabel Perez-Munuera (2009).

1-MCP research has been conducted in all the major persimmon growing regions around the world. The bulk of the work has been aimed at reducing rapid fruit softening of the major astringent varieties after removal of astringency (Nakano *et al*., 2003; Salvador *et al*., 2004; Ortiz *et al*., 2005), although there has been considerable research with 'Fuyu' fruit (Kim and Lee, 2005; Niikawa *et al*., 2005; Tibola *et al*., 2005).
.

A summary of dose rates and efficacy of 1-MCP for different countries and persimmon varieties is presented in Table 1.

20.2 Pre-conditioning

There may be some advantages in pre-conditioning (see Chapter 15) persimmon fruit prior to treatment with 1-MCP, particularly to remove damaged or diseased fruit. 1-MCP effectiveness in improving fruit storability is dependent on the time of application. Wright and Kader (1997) and Watkins (2008) indicated that a longer delay before 1-MCP treatment is associated with increasing ethylene concentration in the fruit which in turn limits fruit storability. Studies are needed to determine if fruit should be treated immediately after harvest or after a period of 2 days pre-conditioning at 23°C. 1-MCP will not prevent damaged fruit from ripening pre-maturely. These fruit should be removed after pre-conditioning and before cool storage.

TABLE 1.

Variety	Removal of astringency	Conc. of 1-MCP	Treat. temp. (°)	Efficacy	Max. storage life (days)	Reference
Fuyu	No	0.50 µl/L	0°	effective	35 days	Redpath *et al*. (2007)
Fuyu	No	0.50-1.5 µl/L 16 hrs	20°	effective	28 days	Kim and Lee (2005).
Fuyu	No	0.50 µl/L 24hrs	0°	effective	63 days	Golding (2007).
Fuyu	No	0.50 µl/L 24hrs	0°	effective	63 days	Considine (2006).
Matsumoto Wase Fuyu	No	0.50 µl/L	ambient	effective	13 days	Niikawa *et al.* (2005).
Rojo Brillante	Yes	0.50 µl/L	15°	effective	25-30 days	Salvador *et al*., (2006)
Rojo Brillante	Yes	0.50 µl/L (24 hrs)	1° or 15°	effective	40 days	Besada *et al* (2008).
Saijo	Yes	0.50-1.0 µl/L	ambient	effective	Not presented	Kurahashi *et al*., (2005).
Saijo	Yes	0.3 0 µl/L (3 hrs)	20°	effective	Not	Not presented
Lentaisu	Yes	Not presented	Not presented	effective	Not presented	Shinbong and Ru Yin., (2007).
Youhou	No	0.50 µl/L	0, ambient	effective	90 days	Hu Fang (2007)
Nathanzy	No	0.5-1.5 µl/L; 1.0 µl/L best	20°	effective	30 days	Ramin (2008)
Tonewase	No	0.3 0 µl/L (3 hrs)	20°	effective	Not presented -	Nakano *et al*. (1997)
Qiandaowuhe	yes	3.0 µl/L (6 hrs)	20°	effective	Not presented	Zisheng Luo., (2007).
Triumph	yes	0.60 µl/L (24 hrs)	20°	effective	Shelf life trebled	Ben-aire *et al*. (2001).
Rendaiji	yes	20.0 µl/L (24 hrs)	20°	effective	28 days	Ortiz *et al.* (2005).

Dose rates and effects of 1-MCP on storage life of a range of persimmon cultivars.

20.3 Dose rate of 1-MCP

The concentration of 1-MCP to use may vary with stage of maturity and the level of ethylene produced by the persimmon fruit (Ortiz *et al*., 2005; Ramin, 2008). 1-MCP application rates vary from 0.1 µL/L to 2 µL/L for 'Fuyu' (Hu *et al*., 2007; Kim and Lee, 2005; Krammes *et al*., 2005) and up to 20 µL/L for astringent varieties (Ortiz et al., 2005). However, Tsviling *et al*. (2003) found that ethylene production and fruit softening declined with increasing 1-MCP from 0 to 0.6 µL/L, but had no further effect with higher dosages.

Harima *et al*. (2003) showed little difference between 0.1 µL/L and 1 µL/L in regards to ethylene production and percentage soft fruit. Furthermore, low concentrations (2.5 nL/L to 1 µL/L) of 1-MCP applied over longer periods (12 -24 hrs.) appear to be most effective (Blankenship and Dole, 2003).

The most commonly used dose rate over a wide range of varieties is 0.50 µl/L (500 ppb) applied at 20°C for a minimum of 6 hours. For cv. Fuyu, the most effective dose rate appears to be between 0.5-1.0 µl/L applied at 20°C for 16 hours (Kim and Lee, 2005; Golding, 2007, Considine, 2006) (Figure 2, Plates 2 and 3).

For Australian, non-astringent varieties we recommend use according to the product label. 1-MCP is trademarked as SmartFresh[SM] and is registered for sweet persimmon (Fuyu) in Australia. The chemical and its application are controlled by Agrofresh Pty. Ltd.

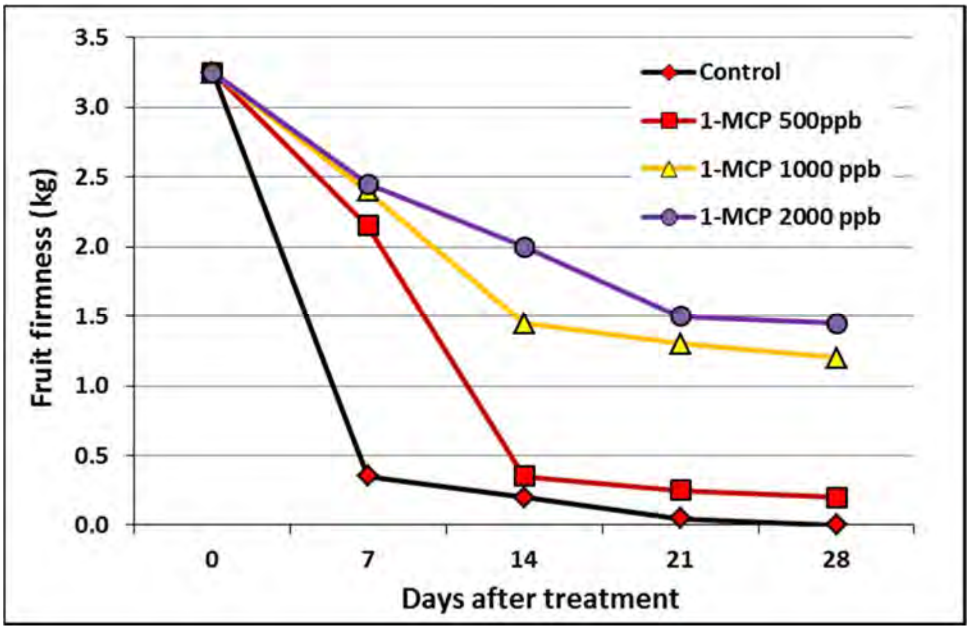


Figure 2. Effects of 1-MCP concentrations on fruit firmness of 'Fuyu" persimmon stored at 20±2°C. Note: most effective concentration is 1000 ppb. A fruit firmness level of <1kg is regarded as very soft and non-marketable. Based on Korean study by Kim and Lee (2005).

Plate 2. Left: Untreated control. Right: 1-MCP-treated fruit (SmartFresh™). Fuyu' persimmons after nine weeks storage at 0°C and one week at 20°C. All fruit were stored at 0°C in Modified Atmosphere (MA) bags which generated an atmosphere of around 1.4% O_2 and 5.5% CO_2 within the bag after nine weeks storage (Photo: Golding, 2007).

Plate 3. Firm SmartFresh™ treated 'Fuyu' persimmon after nine weeks storage in a MA bag at 0°C then one week at 20°C. Photo: Golding, 2007).

20.4 Treatment temperature

1-MCP should be applied at ambient temperature of between 18-20˚C. However, some researchers have recommended that 0°C be used to reduce fruit disorders as this exposes fruit to cold storage temperatures (Choi pers comm. 2007). We found that when 1-MCP was applied at 0°C up to 9% of fruit suffered from internal flesh blackening just beneath the skin and around the seeds (Plate 4).

We found no blackening when 1-MCP was applied at either 15° or 20°C. Therefore, we recommend application of 1-MCP at these temperatures before fruit are placed into lower storage temperatures.

Plate 4. Skin and internal blackening due to treatment with 1-MCP at 0°C. This disorder was prevented by treatment at either 15º or 20°C.

20.5 Effects of 1-MCP on storage life

0°C storage

Australian research has shown that persimmon MA bagged fruit can be stored for up to 8 weeks at 0°C with a 7 day shelf life after application of 1-MCP (Figure 3, Plate 4) (Golding *et al*., 2005; Considine, 2006; Redpath *et al*., 2009). Longer cool storage lives of up to 12 weeks may be feasible for some orchards/regions. Korean studies have also shown that 'Fuyu' persimmon can be stored for 3 weeks at 20°C or for 3 months at 0°C after treating fruit with 1-MCP at 1000 ppb and sealing in MA bags (Figure 4) (Kim and Lee, 2005).

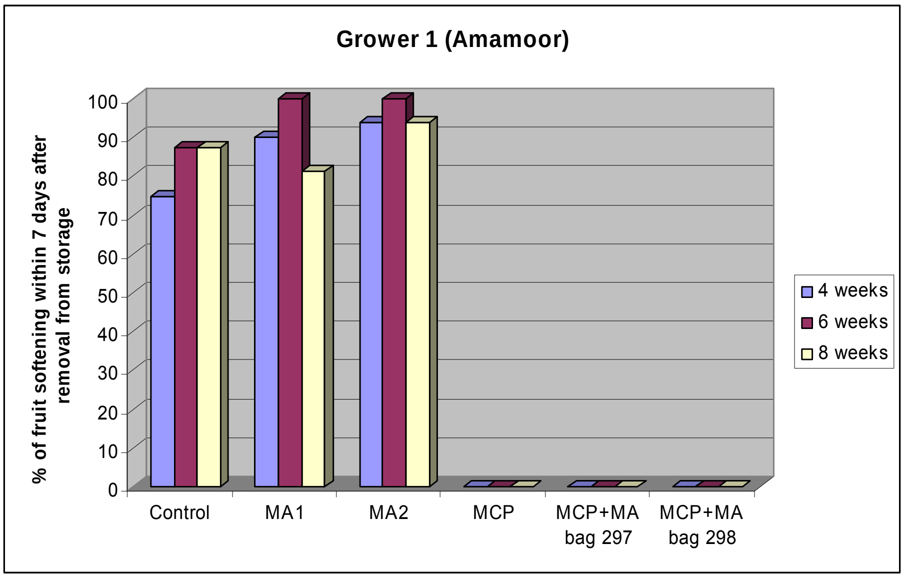


Figure 3. Effects of 1-MCP and MA bags on % of fruit softening within 7 days after removal from storage for 4, 6 and 8 weeks at 0°C.

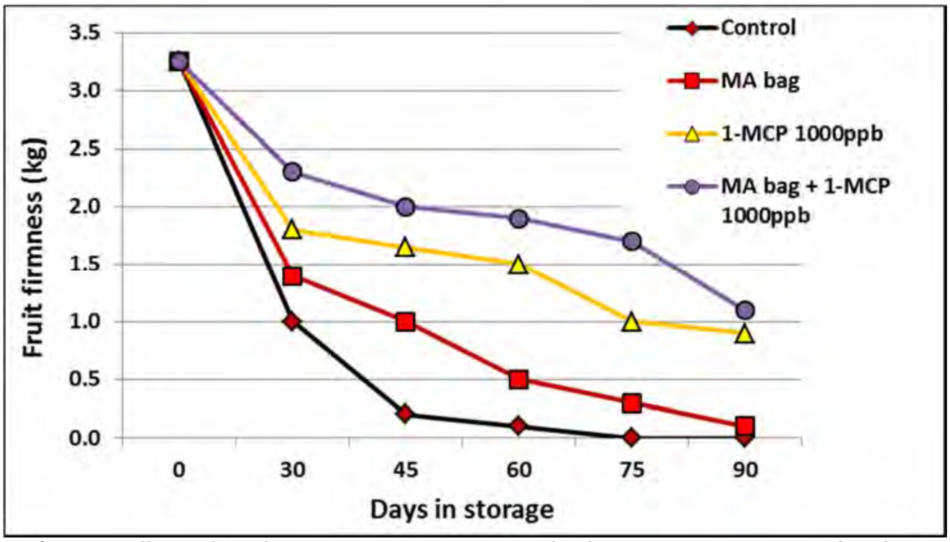


Figure 4. Effects of 1-MCP and MA bags on storage life of Korean 'Fuyu' held at 0°C. A fruit firmness level of <1kg is regarded as very soft and non-marketable. Note: combination of 1-MCP and MA bags gives maximum storage life. (Adapted from Kim and Lee, 2005).

15°C storage

Overseas studies in Spain, China and Korea have shown that persimmon fruit treated with 1-MCP could be stored for between 22-40 days at 15-20°C (Besada *et al*., 2008; Luo, 2007; Kim and Lee, 2005; Salvador *et al*., 2006). In Australian studies, we found storing fruit at 15°C, as compared with 20°C, increased days to softening of 1-MCP treated fruit by about 30% with a maximum storage life of 2-3 weeks (Figure 5).

Preliminary data indicates that fruit from coastal Queensland and northern NSW regions is more susceptible to chilling injury. Fruit from southern producing regions of Victoria and SA is less susceptible to chilling so it may be more desirable to treat these with 1-MCP for loner-term storage at either 15º or 0ºC.

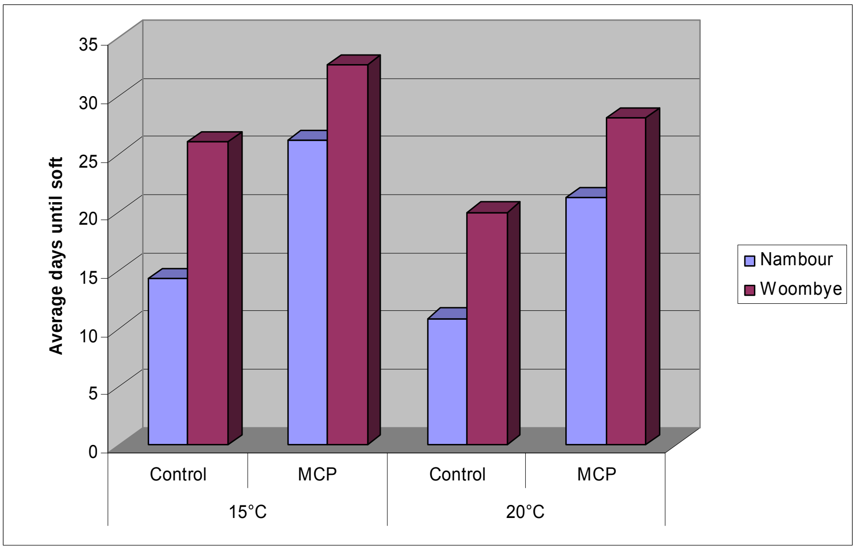


Figure 5. Effects of 1-MCP and storage temperature (15° vs. 20°C) on average days to softening for cv. Jiro (Nambour) and cv. Fuyu (Woombye).

20.6 Effects of 1-MCP on chilling injury

1-MCP has been shown to reduce chilling injury symptoms of cold-stored persimmon (Girardi *et al*., 2003; Kim and Lee, 2005; Tibola *et al*., 2005; Salvador *et al*., 2006; Golding, 2007) (Plate 5).

Preliminary data indicates that fruit from coastal Queensland and northern NSW regions is more susceptible to chilling injury. Early-season harvested fruit from coastal Queensland and northern NSW regions also appears to be more susceptible to chilling injury.

Summarizing, in Australia we have found that application of 1-MCP greatly reduced chilling injury to near zero for fruit from southern states and to less than 10% for Queensland-grown fruit (Figure 6).

Plate 5. Left: Untreated control. Right: 1-MCP treated fruit (SmartFresh™). 'Fuyu' persimmons treated with SmartFresh™ (right) after nine weeks storage at 0°C and one week at 20°C. All fruit were stored at 0°C in Modified Atmosphere (MA) bags which generated an atmosphere of around 1.4% O_2 and 5.5% CO_2 within the bag after nine weeks storage (Golding 2007).

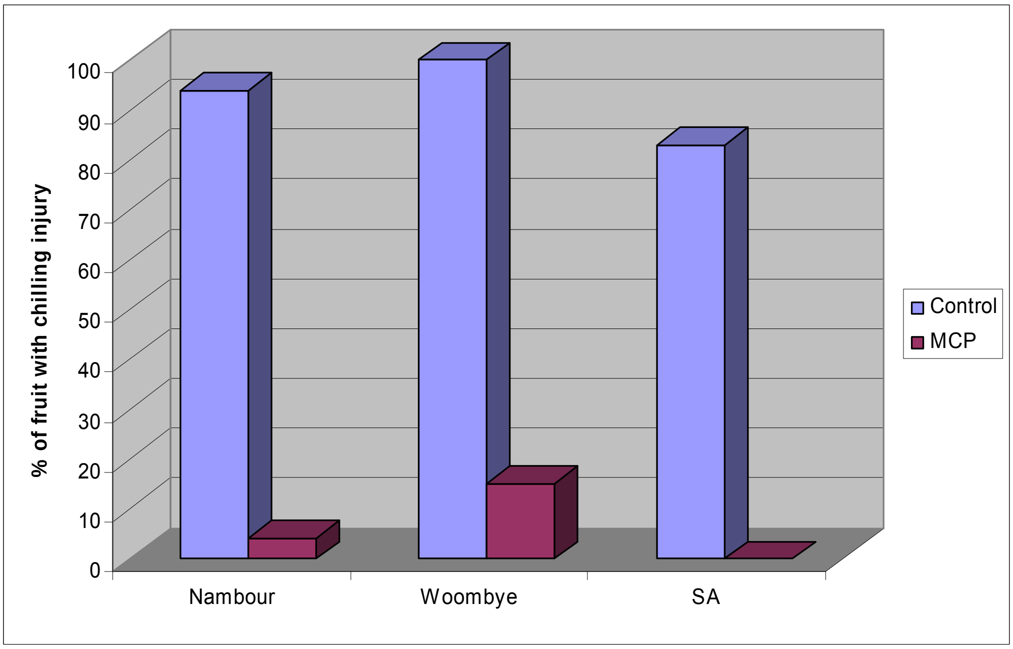


Figure 6. Effects of 1-MCP on chilling injury. Chilling injury is characterised by internal gelling. Fruit were treated with 1-MCP at 15°C. Fruit were stored for either 4, 6 or 8 weeks at 0°C and assessed after 7 days at 20°C. Nambour site cv. Jiro, other sites cv. Fuyu. Note marked reduction in chilling injury due to 1-MCP.

20.7 Effects of 1-MCP on flavour

We have found little or no effect of 1-MCP, whether applied alone or with MA bags, on fruit flavour or the development of any “off” flavour. This is in agreement with findings of Kim and Lee (2005) for cv. Fuyu treated with 1-MCP in Korea and cv. Fuyu treated with 1-MCP in Western Australia (Considine, 2006). Considine (2006) also showed little effect or no effect of 1-MCP on fruit colour and Brix.

20.8 Costs of application

Application of Smartfresh® costs about 70-76 cents per tray for treatment. However, cost will be lower where substantial volumes of fruit are treated.

20.9 Protocols for application of 1-MCP

Before application of 1-MCP

Ensure fruit to be treated is of high quality and at the correct maturity; 4.0 on the Japanese colour chart and minimum Brix 14°.

Take all necessary care during picking and packing (into bulk bins/trays) to ensure fruit is not damaged before treatment. Place fruit to be treated into a cool room at 15°C and hold until 1-MCP is applied.

Cool room requirements

Cool room must be air tight to stop 1-MCP gas leakage. Alternatively, a tent must be able to be sealed effectively (Plate 6).

Cool room should be capable of holding fruit at 15°C for 24hrs. Air must be circulated during the 24hr treatment via cool room forced air or a simple pedestal fan.

Hydrated lime should be available to reduce excess CO_2 build up in the cool room or tent (Plate 7). Lime can be placed in a flat tray approximately 2.5 cm (1 inch) thick.

Plate 6. Tent used to apply SmartFresh™; bagging and heat-sealing MA bags after treatment with 1-MCP

Application of 1-MCP

Fruit bulk bins or trays to place appropriately inside cool room or tent to maximise the volume to be treated but also allowing for reasonable air flow around and between bins/pallets.

1-MCP gas will be released from either a powder or tablet. The operation will be performed by a qualified contractor (Plate 7). The process should take around 5-15 minutes.

Fans will be turned on as contractor exits cool room/tent and then the room sealed for 24hrs at 15°C. After 24hrs the cool room/tent will be aired for 30mins.

Storage of treated fruit

Once fruit has been treated it can be packed and sent to market straight away or cool stored for later packing and marketing (Plate 9).

Depending on regions treated fruit is to be stored at 0-1°C for between 4 – 12 weeks (Plate 9). Treated fruit can be stored for 2-3 weeks at 15°C if desired.

When storage has finished, treated fruit should be sent through the packing line or if already packed use appropriate cool supply chains to access markets

Fruit should easily hold firmness during supply chain and shelf life for at least 7 days. Colour and Brix should increase during this period.

Plate 7. 1-MCP gas is generated by combining yellow SmartFresh™ tablets with a blue activator tablet and an activator solution.

Plate 8. Hydrated lime should be available to reduce excess CO_2 build up in the cool room or tent.

Plate 9. Storage of 1-MCP treated fruit in 0°C cool room up to 3 months.

20.10 SUMMARY

Irrespective of region, persimmons stored for greater than four weeks at 0°C had less than seven days of shelf-life and showed severe internal gelling, a sign of chilling injury (CI). In contrast, persimmons treated with 1-MCP ripened slowly after storage and exhibited little or no signs of CI or internal gelling. 1-MCP increased shelf life after storage by 2-3 weeks.

After eight weeks of storage at 0°C, 1-MCP-treated persimmons, stored in MA bags, were significantly firmer and exhibited little or no signs of internal gelling compared to the untreated fruit and un-bagged fruit.

1-MCP must be applied at either 15º or 20°C and not 0°C to avoid internal blackening.

1-MCP has no adverse effects on fruit flavour, fruit colour or Brix.

In conclusion, the storability and saleability of 1-MCP treated persimmons is greatly enhanced compared to untreated fruit kept under the same conditions.

We suggest that storage recommendations for Australian persimmon will vary with region of production due to variability in fruit quality between regions. Our tentative recommendations on storage treatments and conditions are presented in Chapter 23.

Key points

1-MCP can alleviate chilling injury when persimmon fruit are stored below 15°C especially when fruit are stored at 0°C

1-MCP can greatly increase storage life by at least 50% at both 15°C and 0°C

Maximum storage life of up to 3 months is achieved when 1-MCP is used in combination with MA bags

1-MCP will not prevent pre-mature ripening of damaged fruit; these fruit need to be removed before cool storage

1-MCP should be applied at rates from 500-1000 ppb and treatment applied at either 15ºC or 20ºC

1-MCP is trademarked as SmartFresh™

1-MCP (SmartFresh™) and its application in Australia are controlled by Agrofresh Pty. Ltd.

COOL STORAGE OPTIONS

21.1 Choosing between short and long-term cool storage

Cool storage can be short-term or long-term:

1. Short-term storage usually lasts from three to seven days, just long enough to get the fruit to the domestic consumer.
2. Intermediate storage of 1-3 weeks is used to control release of fruit onto the domestic market during periods of glutting. It may also be used when fruit are air-freighted to Asian markets.
3. Long-term storage is used for exports particularly via sea-freight where storage periods of between 1-3 months are required.

21.2 Cool storage temperatures

- Fruit in **short-term storage** must be maintained at about 15°C.
- Fruit in **long-term storage** must be forced-air cooled to a temperature of 0 ±1°C, then held at that temperature. This should allow fruit to be stored for between two weeks to several months. Fruit held longer will be at risk of chilling injury.

21.3 Tools for increasing cool storage life

The grower has four main tools than he can use to increase the cool storage period whilst avoiding chilling injury. These tools are:

- 1-MCP
- MA bags
- Pre-conditioning
- Ethylene absorbents

Of these tools, 1-MCP is the most powerful for extending storage life. Whilst we have recorded additive effects when 1-MCP and MA bags are used together, we have not tested the full combination of all of the above available tools together. The sequence in which to use these tools also has not been fully investigated – should fruit be treated with 1-MCP before they are pre-conditioned, or vice versa or

alternatively is pre-conditioning necessary if 1-MCP is used? The answers to these questions are currently not known. A rating of the key factors and management tools to extend storage life is presented in Table 1.

21.4 Short-term Storage (maximum 3 weeks)

Preliminary results indicate that short-term storage life was greatly increased when fruit were held at 15°C compared with 20°C. Fruit can be held for up to 21 days at 15°C. For cv. Fuyu, little or no chilling injury occurs when fruit are cool-stored at 15°C. In contrast, we found that 'Jiro' was susceptible to chilling injury even when held at 15ºC.

21.5 Long-term storage (1-3 months)

We found that 'Fuyu' fruit from all regions of Australia, when stored at 0°C for more than 2 weeks, suffered chilling injury. The symptoms of chilling injury are internal gelling. Chilling injury could be greatly reduced or eliminated entirely through the use of 1-MCP and combinations of 1-MCP and MA bags (see Chapter 21).

21.6 1-MCP

1-MCP is applied at a concentration of 0.50 – 1.0 µl/L for 24 hours. Our research and that of NZ, Japanese and Korean researchers indicates a treatment temperature of 15º-20°C. Treatment with 1-MCP alone allowed a storage life of 3 weeks at 15°C and 4 weeks at 0°C with a 15-20 day shelf life after removal from storage and little or no chilling injury. 1-MCP, when used in combination with MA bags, potentially increases storage life at 0°C to 2-3 months (see Chapters 18, 20). This technology appears promising and will enable Australian growers to sea-freight persimmons to Asian markets.

Tentative storage periods for Australian persimmon, and technologies needed to achieve them, are presented in Table 2 and Figures 1-3.

21.7 Within region and between regional differences

Irrespective of storage temperature, fruit from wetter coastal regions may have only up to two weeks cool storage life, but this varies quite considerably from farm to farm. The reasons for these variations are not fully known. Partly, it appears to be due to variations in micro-climates and soil fertility but also partly due to differences in orchard management. In contrast, fruit grown in southern states may be stored for two to three months, and in some cases may be as long as five months, similar to the storage life of fruit in Japan.

TABLE 1.

Tentative rating of key factors and management tools affecting cool storage life.

Factor	Rating*	Comments
Temperature	10	Fruit will store for three times longer at 0°C vs. 15°C but they are susceptible to chilling injury at 0°C
Regional source of fruit	10	Fruit from drier inland and southern production regions stores longer than coastal Queensland fruit. However, even within regions there are large variations in storage life.
1-MCP+MA bags	10	Maximum storage life of up to 3 months at 0°C is achieved with this combination. Chilling injury is nearly eliminated by not completely.
1-MCP	8	The most useful tool in extending storage life (up to double) at both 0°C and 15°C. Treatment prevents most chilling injury.
Variety	7	Unfortunately most commercial varieties such as 'Jiro' and 'Fuyu' are highly sensitive to chilling injury at 0°C and 'Jiro' is sensitive to chilling injury even at 15°C. Some varieties are resistant to chilling injury.
MA bags	5	MA bags may extend storage life by 30-50%. Type of bag is important to develop correct gas concentrations. MA bags do not prevent chilling injury.
Ethylene absorbents	2	Absorbents used in MA bags appear to have a minor effect – may extend storage life by 10-20%. Rates need to be increased.
Pre-conditioning	?	This practice requires further investigation. Early studies show that it can reduce the expression of blemish damage and may reduce CI.

*Rating scale 1-10, 1=least important, 10=most important.

TABLE 2.

Tentative cool storage periods for Australian persimmon. Storage durations are best estimates and may vary between orchards within a region. Assumes a 7 day shelf life at ambient after removal from cool storage.

Region	Storage duration	Storage temperature		Application of 1-MCP		Use of MA bags**	
		15°C	0°C	No	Yes	No	Yes
Coastal Qld and Coastal NSW	1 week	√	X	X	X	X	X
	2-3 weeks	√	X	X	√	X	X
	4-5 weeks*	-	-	-	-	-	-
	6 weeks*	-	-	-	-	-	-
	8 weeks*	-	-	-	-	-	-
Inland Qld/NSW >200km	1 week	√	X	X	X	X	X
	2-3 weeks	√	X	X	√	X	X
	4-5 weeks	√	√	X	√	X	X
	6 weeks	X	√	X	√	X	√
	8 weeks	X	√	X	√	X	√
Vic, SA	1 week	√	X	X	X	X	X
	2-3 weeks	√	X	X	X	X	X
	4-5 weeks	√	X	X	√	X	X
	6 weeks	X	√	X	√	X	√
	8 weeks	X	√	X	√	X	√
	12 weeks	X	X	X	X	X	X

* - Option not available

** Amcor L297,L296 bag or LifeSpan® L342 bag

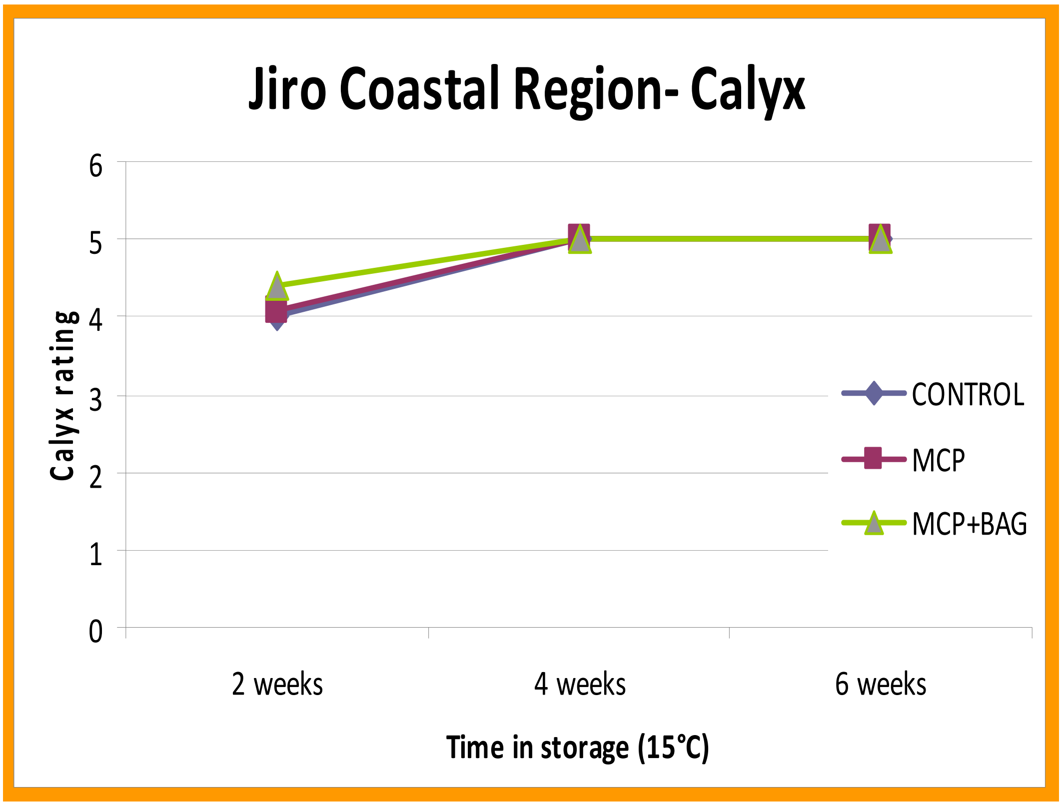
21.8 Regional storage options

The most recent Australian persimmon postharvest trials evaluated a range of storage methods for Fuyu and Jiro from major growing regions. Short/intermediate storage at 15ºC and long-term storage at 0ºC were evaluated in combination with treatment with SmartFresh™(1-MCP) alone and in combination with modified atmosphere (MA) bags (LifeSpan® L296). Based on these trials changes in calyx quality, blemish, colour, firmness, chilling injury (gelling) and internal blackening can be observed for different storage methods and provide a guide to potential storage life in different growing regions.

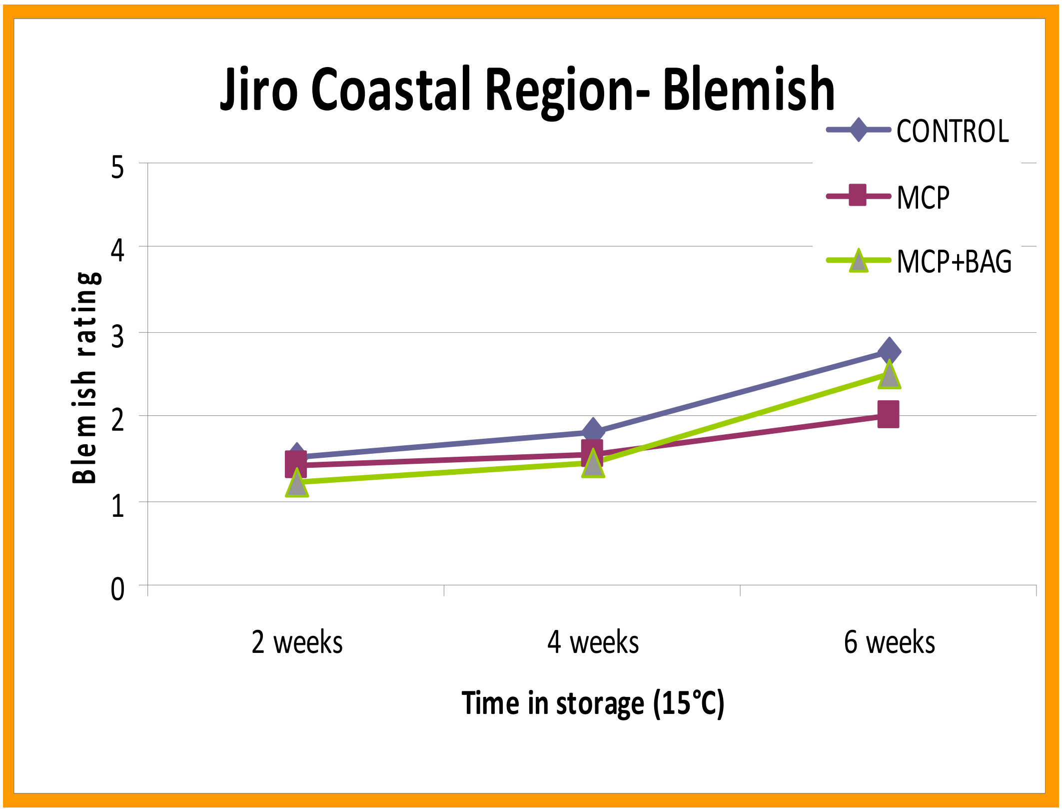
Cultivars Jiro and Fuyu were evaluated from coastal and inland regions. Fuyu from southern Australia were evaluated in 2015. All graphs below represent data after being removed from storage and held at ambient temperature (20°C) for 7 days. For example data for 6 weeks has been stored for 6 weeks and rated after 7 days at 20°C (ambient).

Regional Storage Options for Jiro

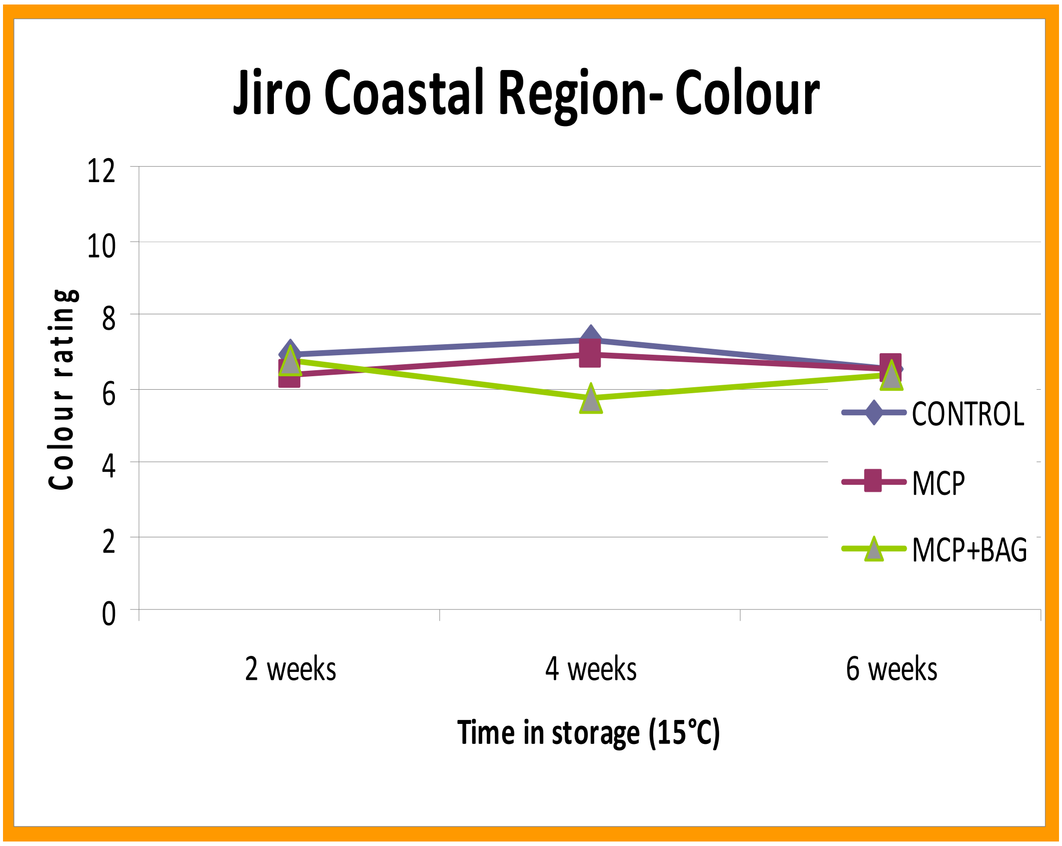
Coastal Region- Jiro stored at 15°C

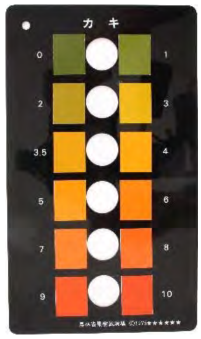


1= healthy
5= severely diseased or damaged

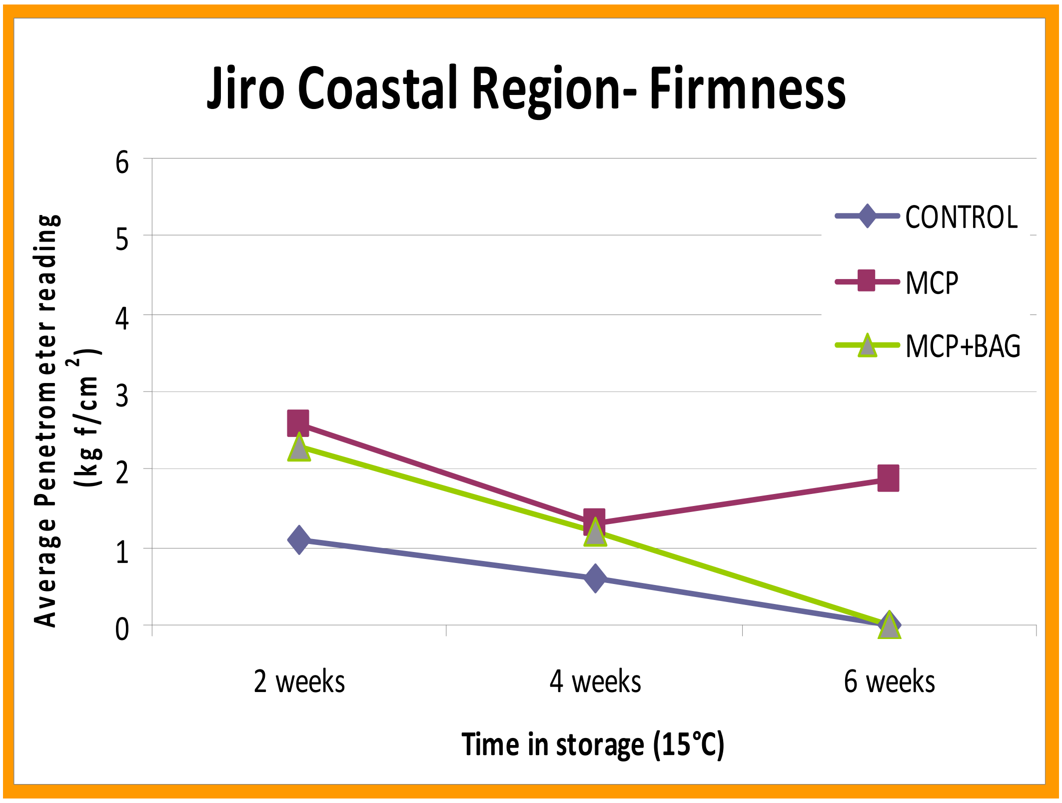


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

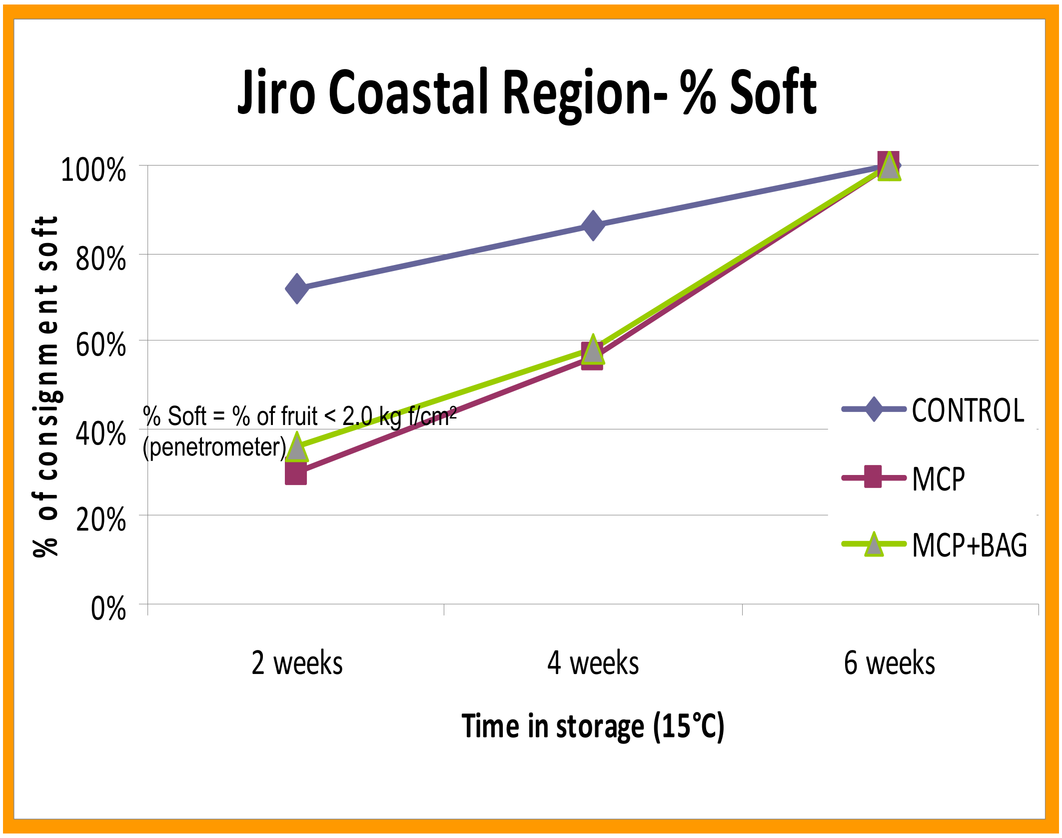




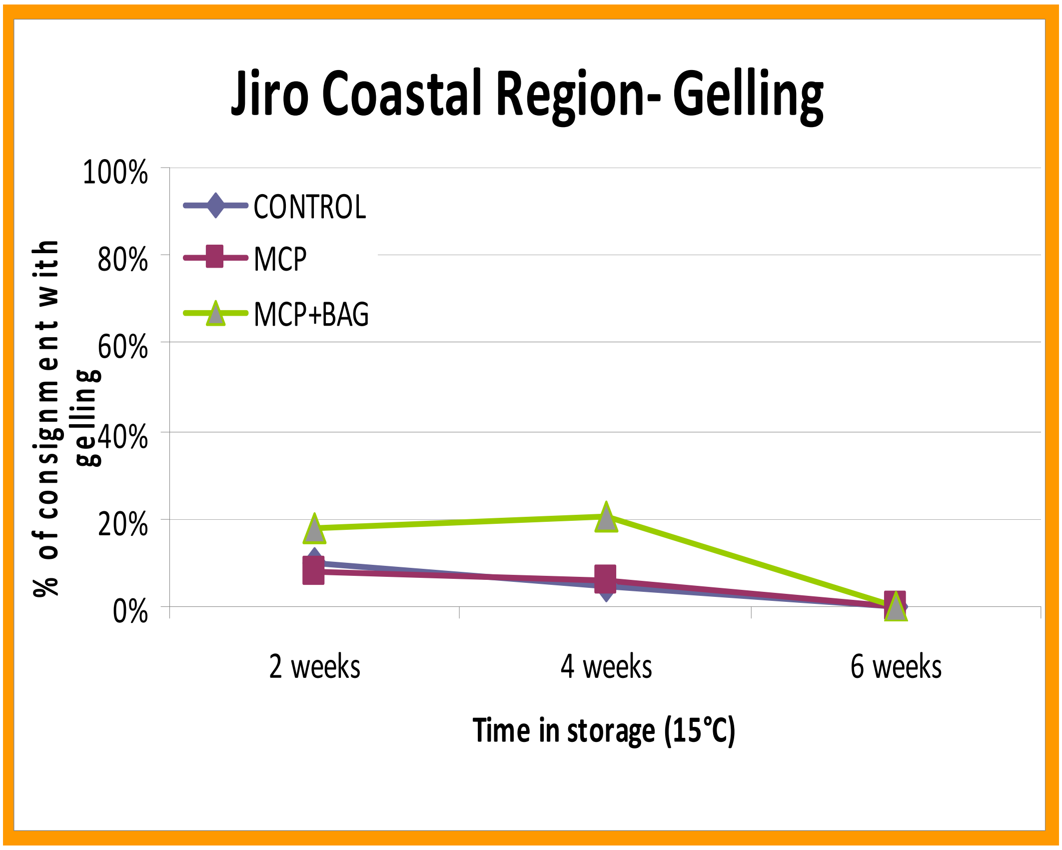
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart



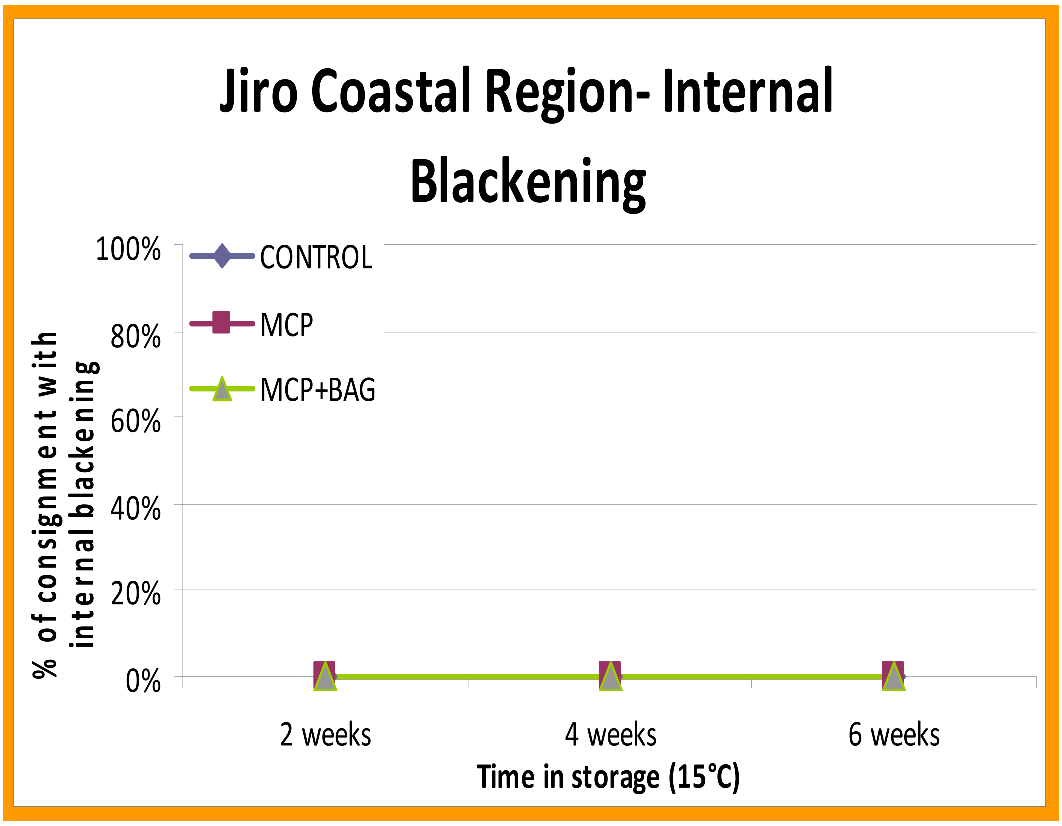
Firmness, using an Effegi penetrometer with an 8mm tip



Jiro Coastal Region- % Soft
100%
80%
60%
40%
20%
0%
% of consignment soft
% Soft = % of fruit < 2.0 kg f/cm²
(penetrometer)
CONTROL
MCP
MCP+BAG
2 weeks
4 weeks
6 weeks
Time in storage (15°C)



Jiro Coastal Region- Gelling
100%
80%
60%
40%
20%
0%
% of consignment with gelling
CONTROL
MCP
MCP+BAG
2 weeks
4 weeks
6 weeks
Time in storage (15°C)



Summary

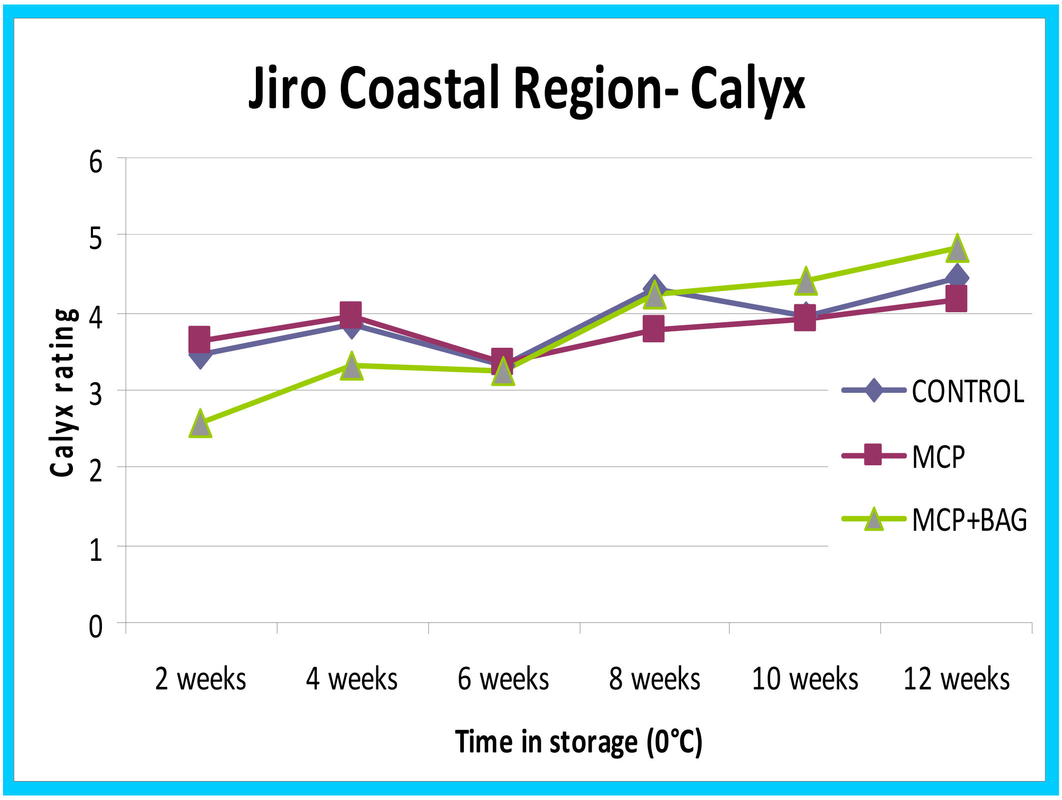
Calyx, blemish and colour didn't vary greatly between treatments at 15°C. Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) was observed in 1-MCP treated fruit; however the use of MA bags increased the level of gelling. No internal blackening was observed.

Recommended storage duration for coastal Jiro at 15°C

Jiro from coastal regions can be stored for up to two weeks at 15°C when treated with 1-MCP with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

Coastal Region- Jiro stored at 0°C



1= healthy
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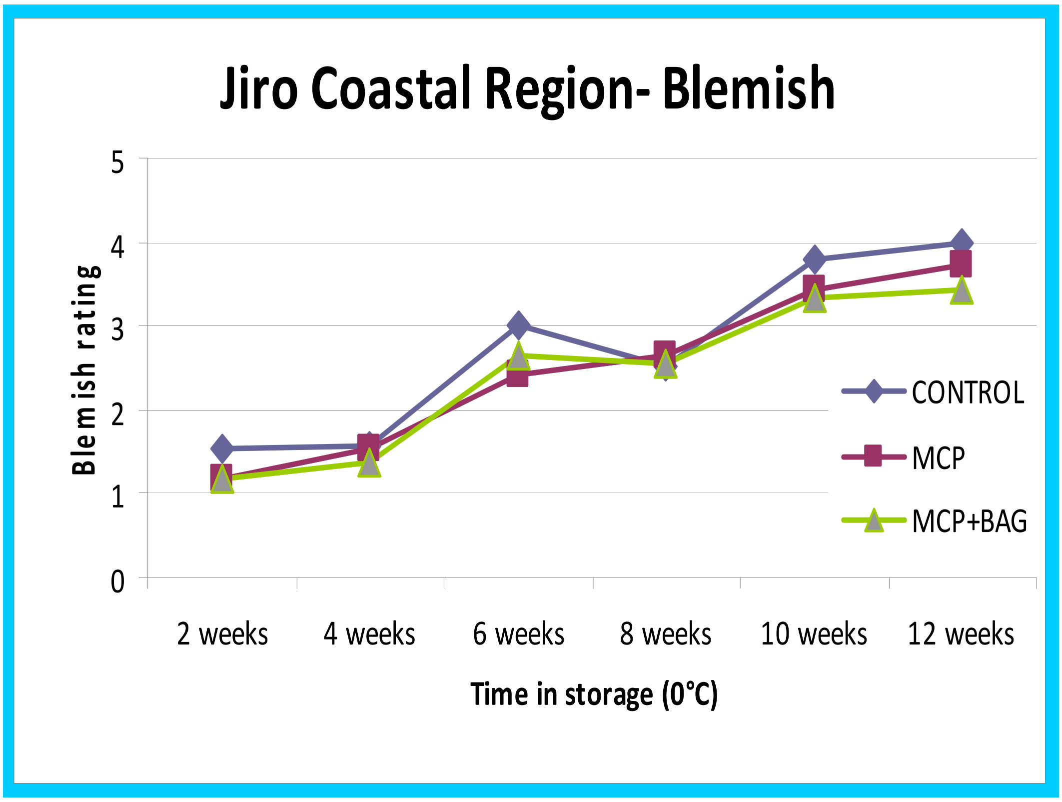

0 – no blemish (0 blemish)
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2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
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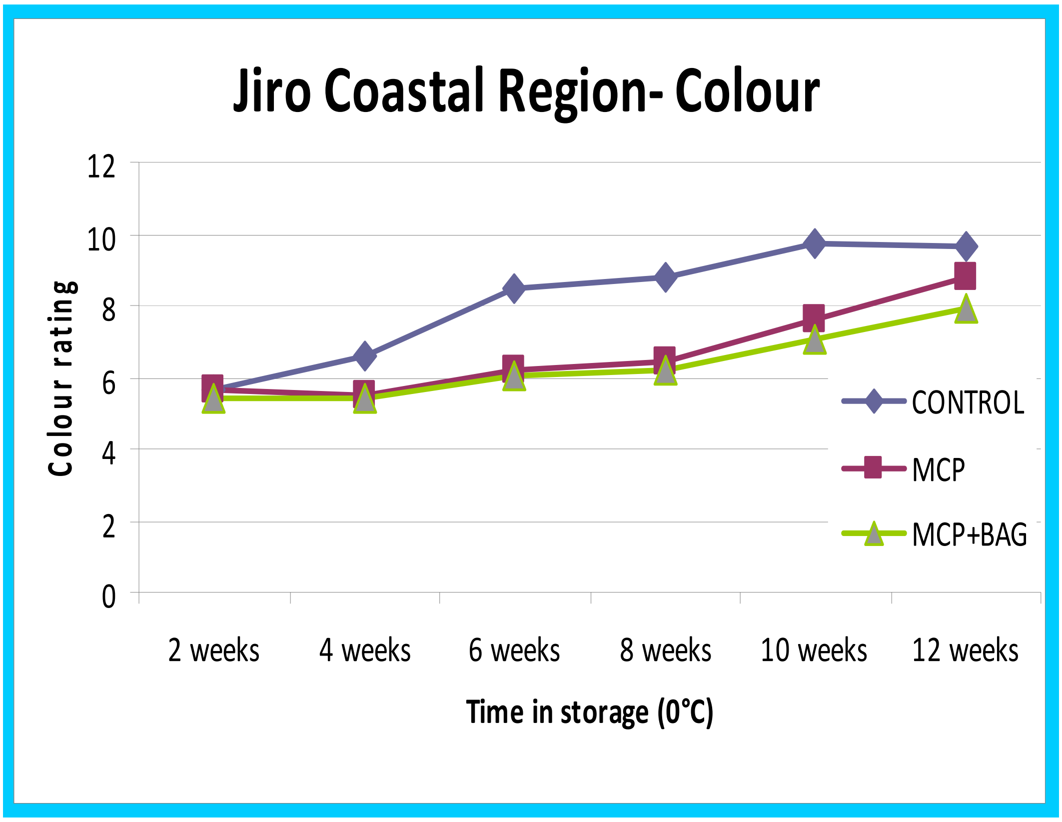
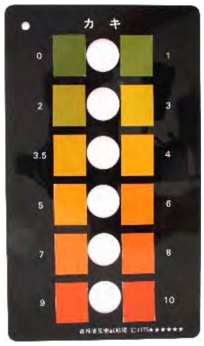
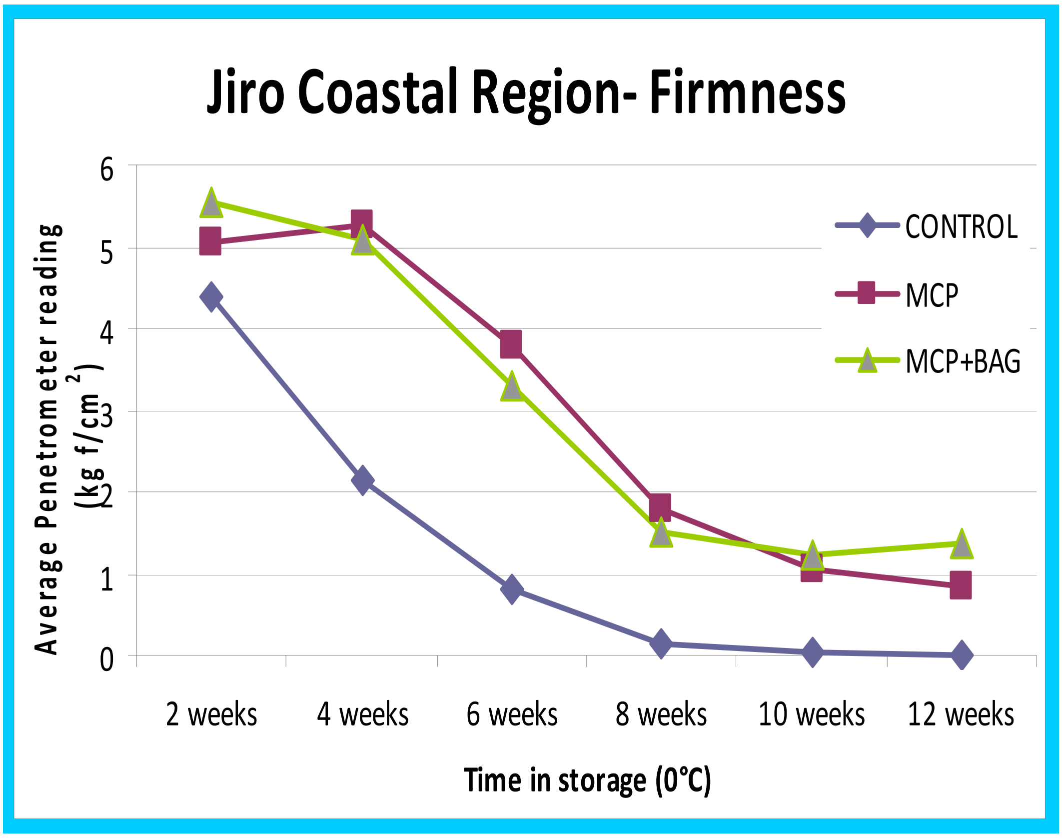
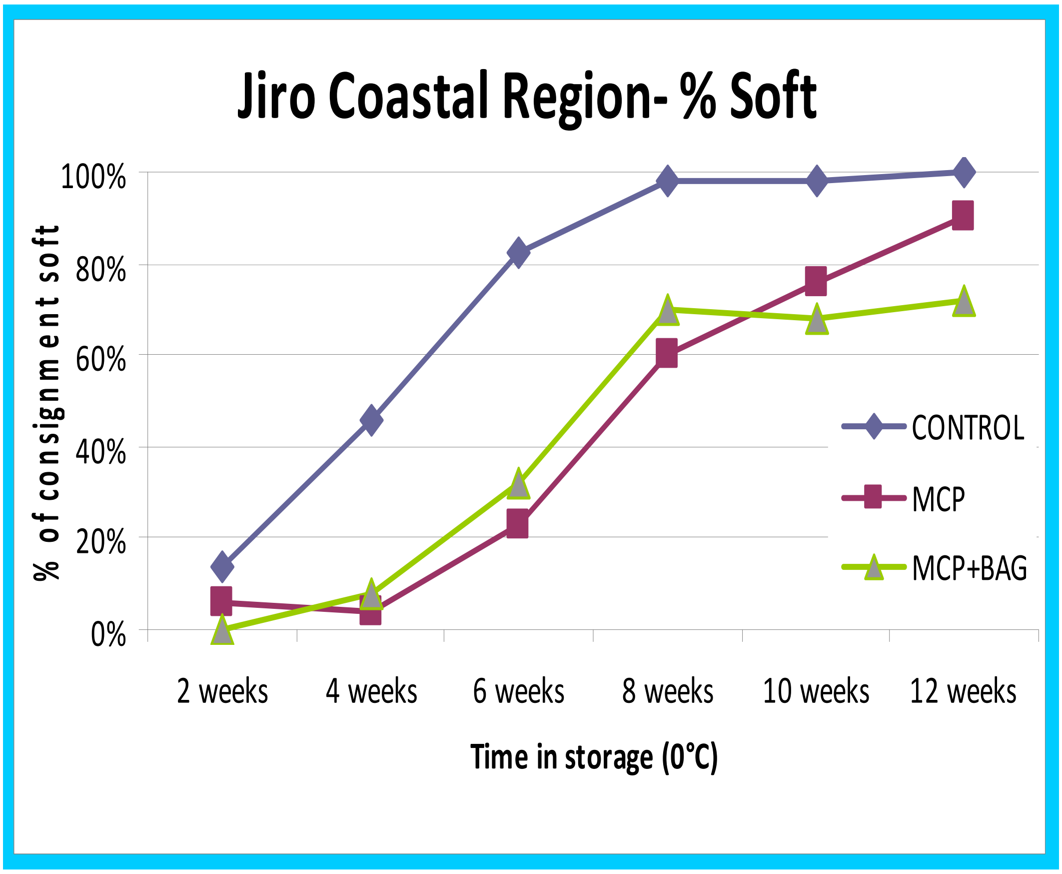




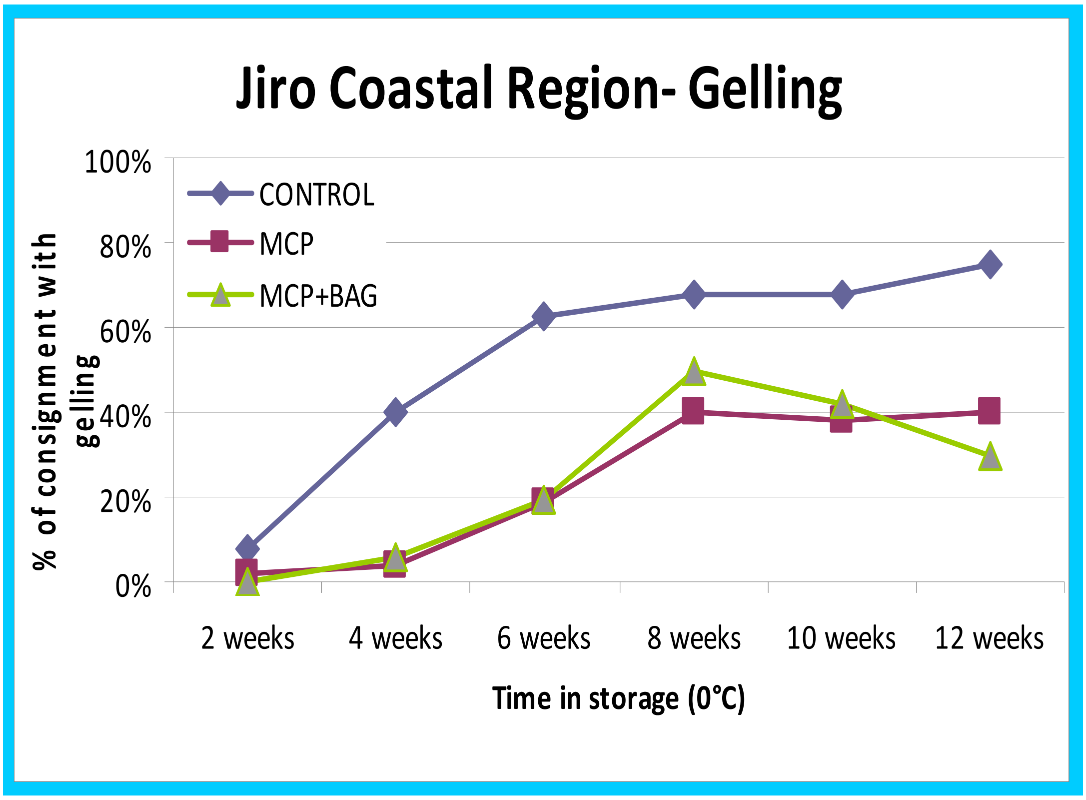
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

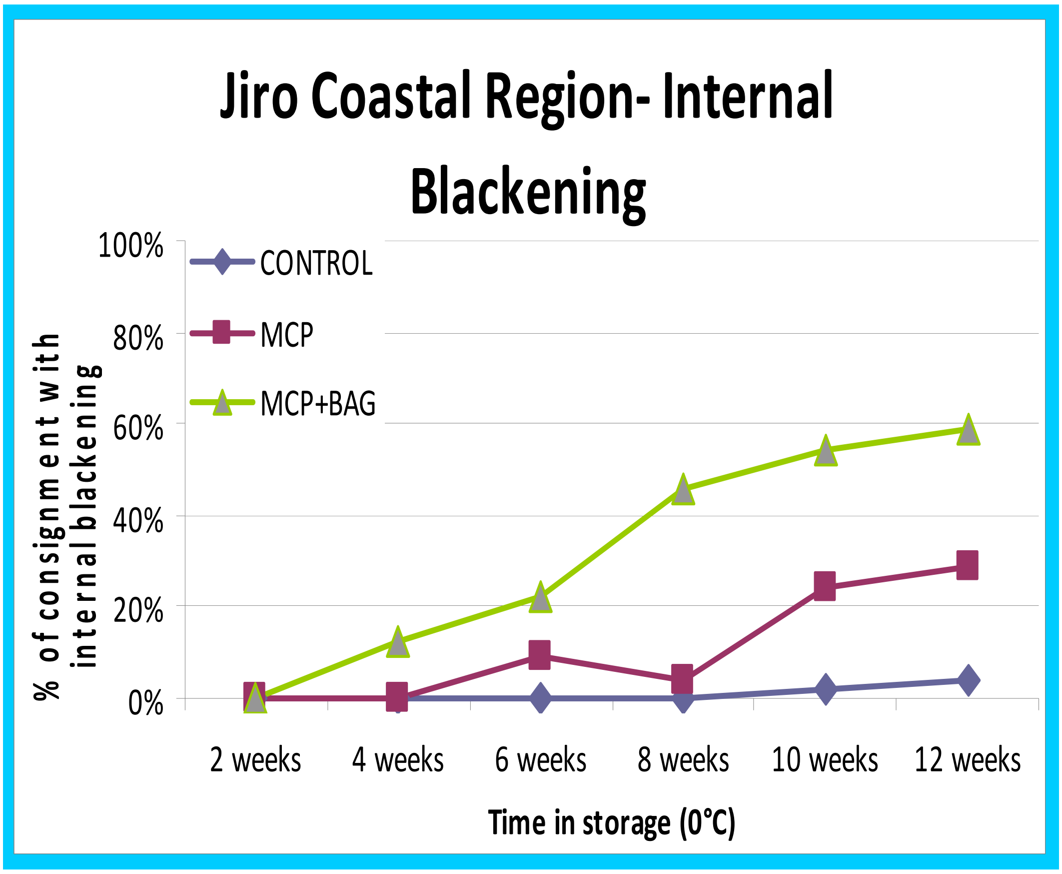


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm^2 (penetrometer)





Summary

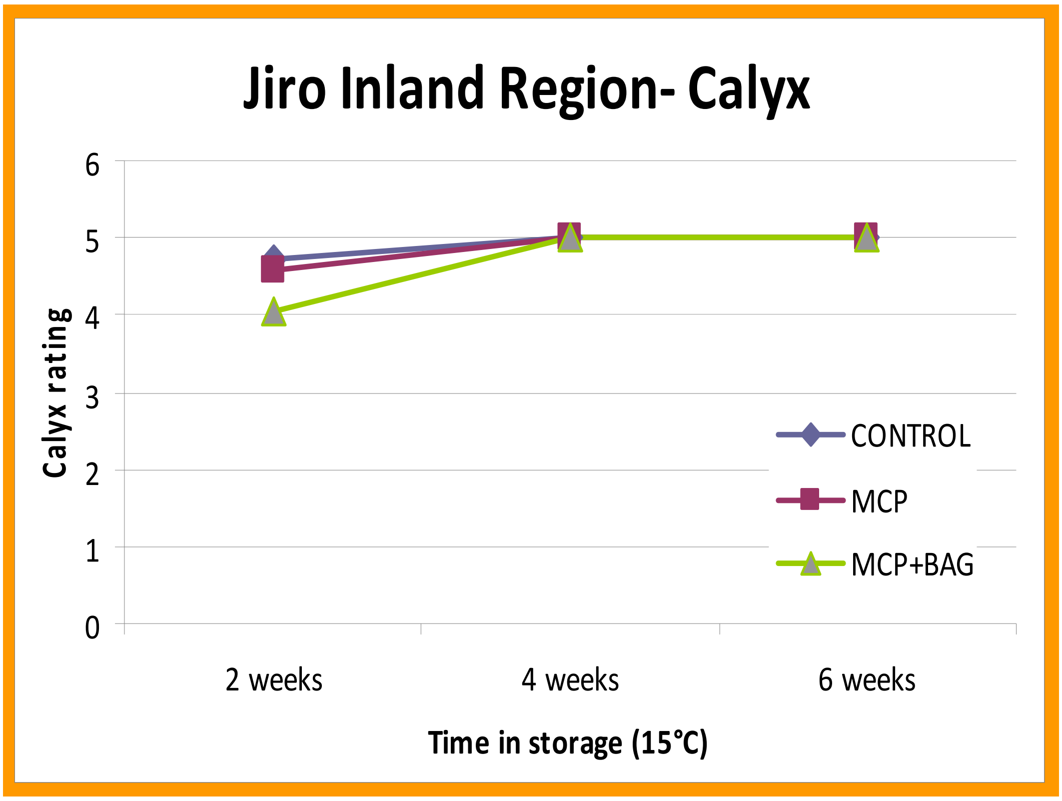
Jiro treated with 1-MCP alone and in combination with MA bags maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 6 weeks for fruit treated with 1-MCP alone or in combination with MA bags. Untreated fruit rapidly softened after 2 weeks and incurred high levels of gelling. Chilling injury (gelling) remained below 10% for 4 weeks in fruit treated with 1-MCP. A large amount of internal blackening was observed in fruit stored in MA bags + 1-MCP.

Recommended storage duration for coastal Jiro at 0°C

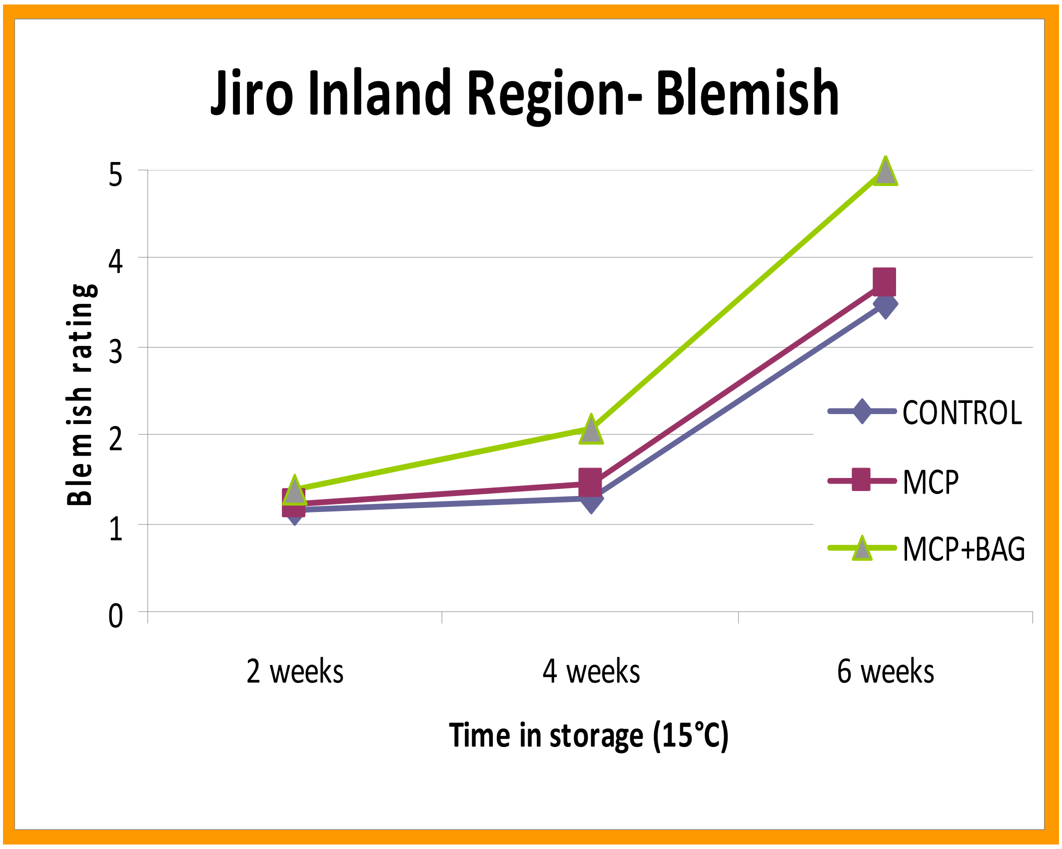
Jiro from coastal regions can be stored between 4 and 6 weeks when treated with 1-MCP with and expected shelf life of 7 days at ambient temperature. Do not use MA bags for Jiro stored at 0°C.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

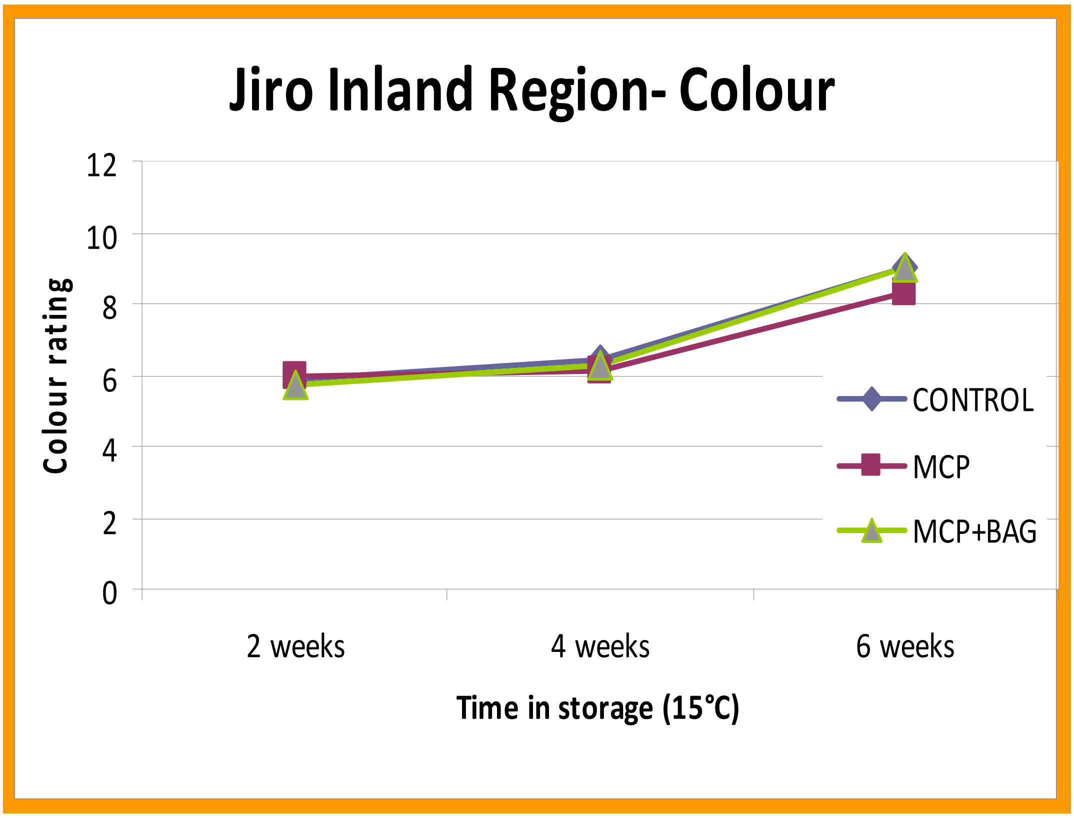
Inland Region- Jiro stored at 15°C

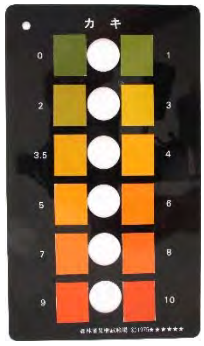


1= healthy
5= severely diseased or damaged

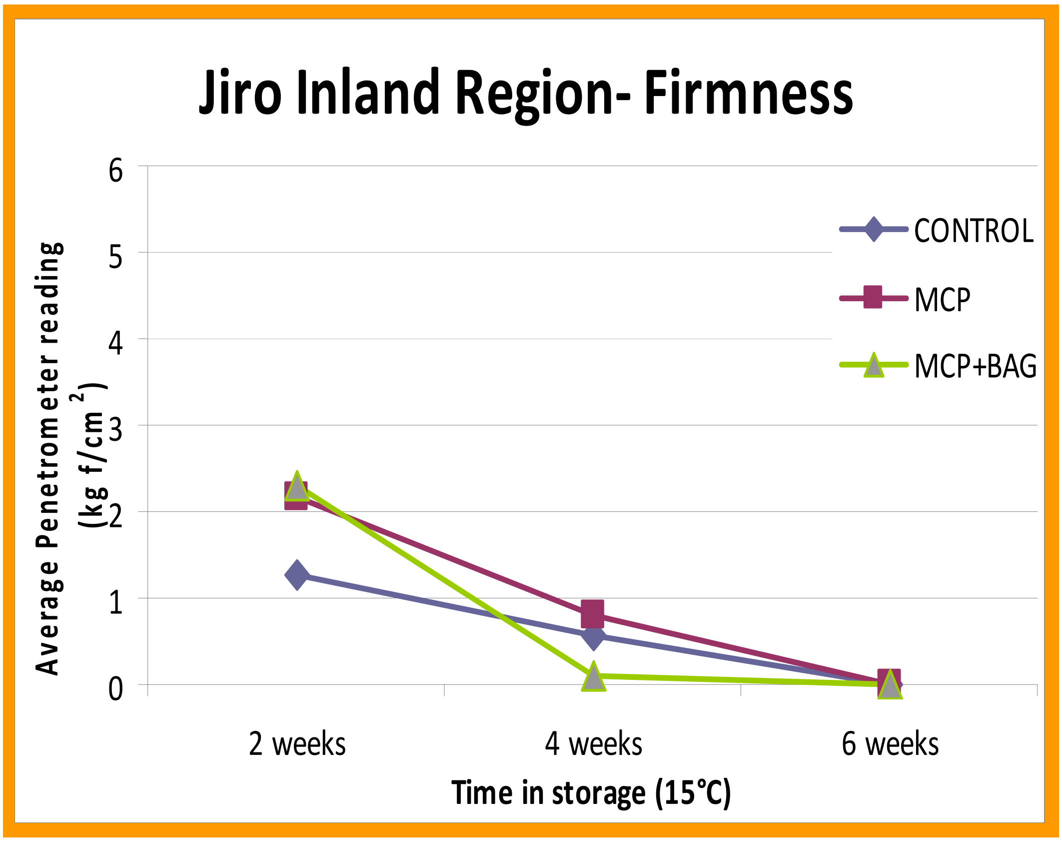


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

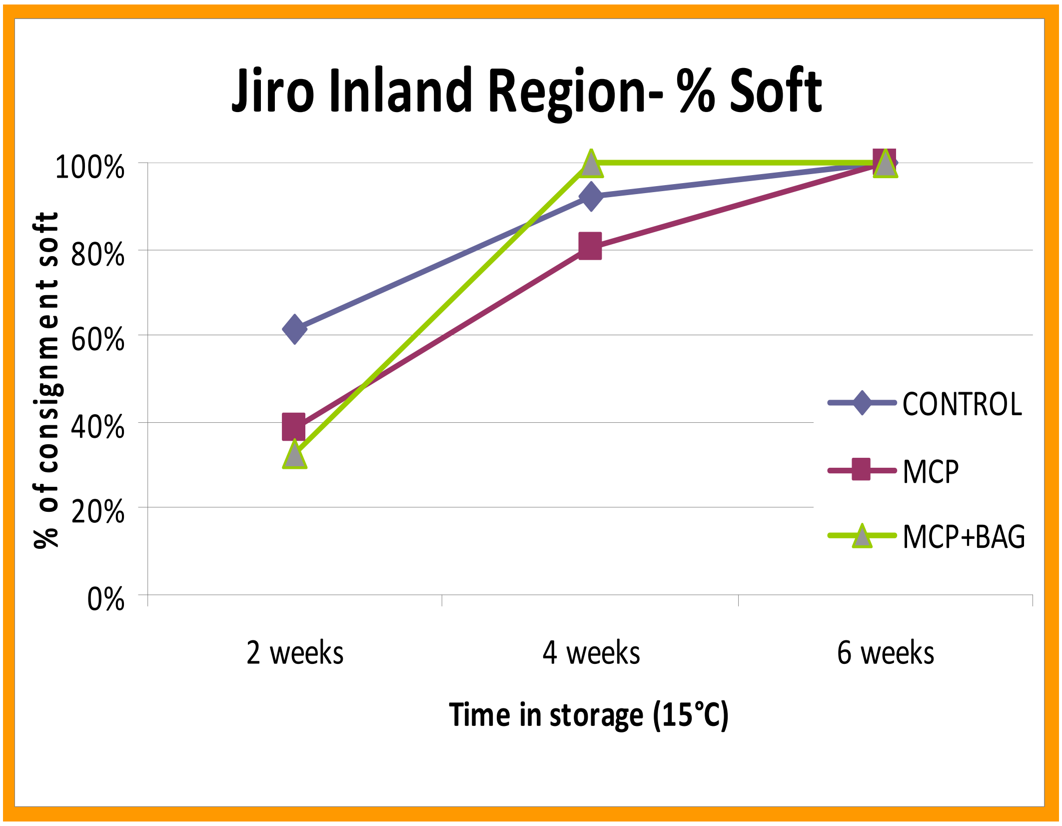




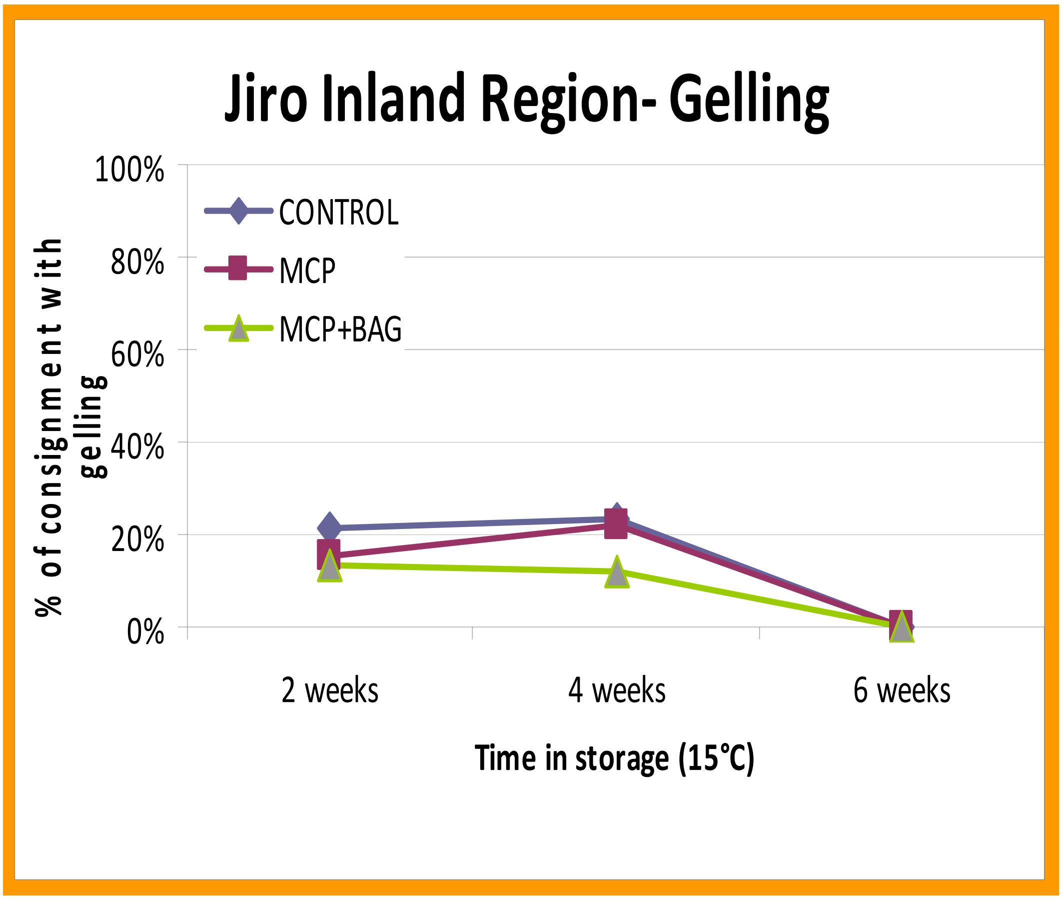
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

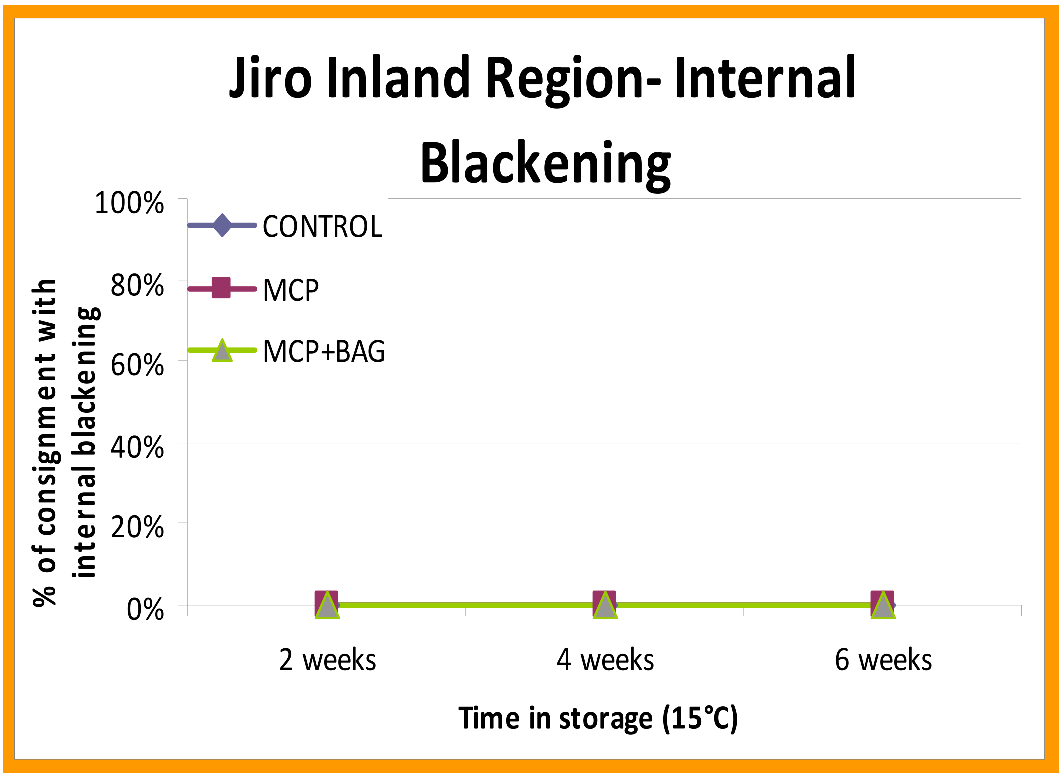


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm^2 (penetrometer)





Summary

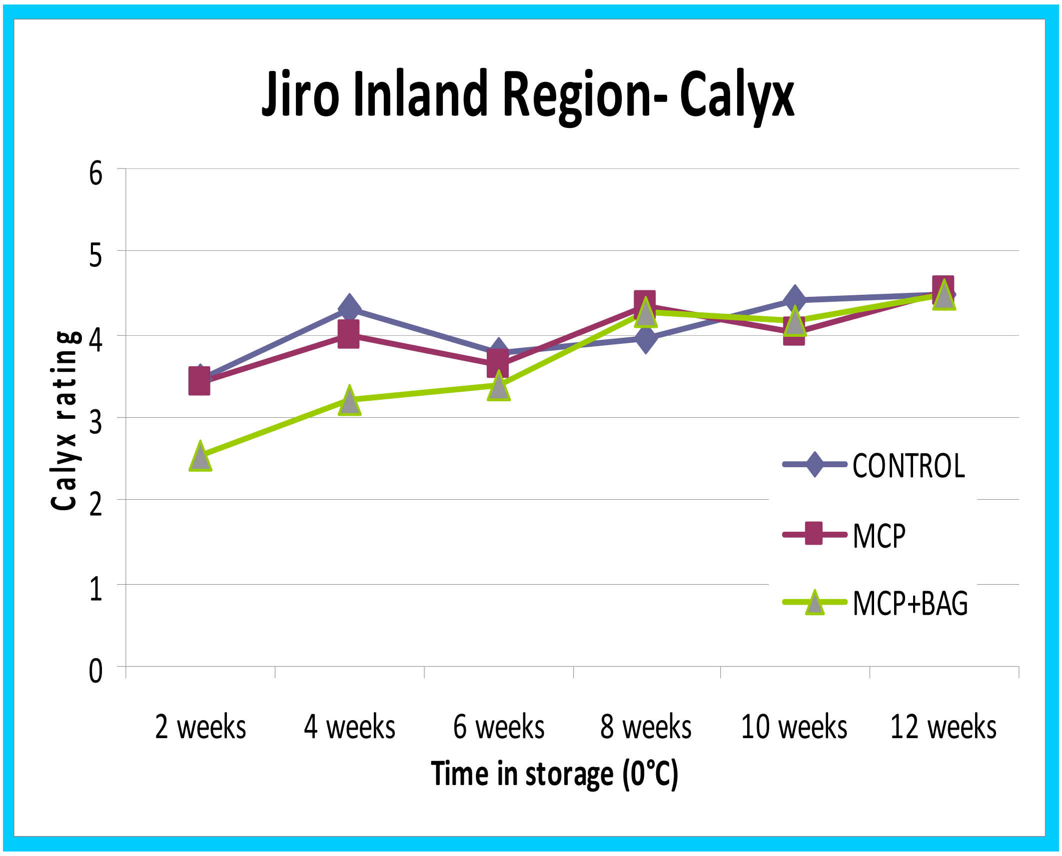
Fruit treated with 1-MCP maintained firmness longer than untreated fruit at 2 weeks, however there was no advantage gained by using MA bags. Chilling injury (gelling) was evident in all treatments however no internal blackening was observed.

Recommended storage duration for inland Jiro at 15°C

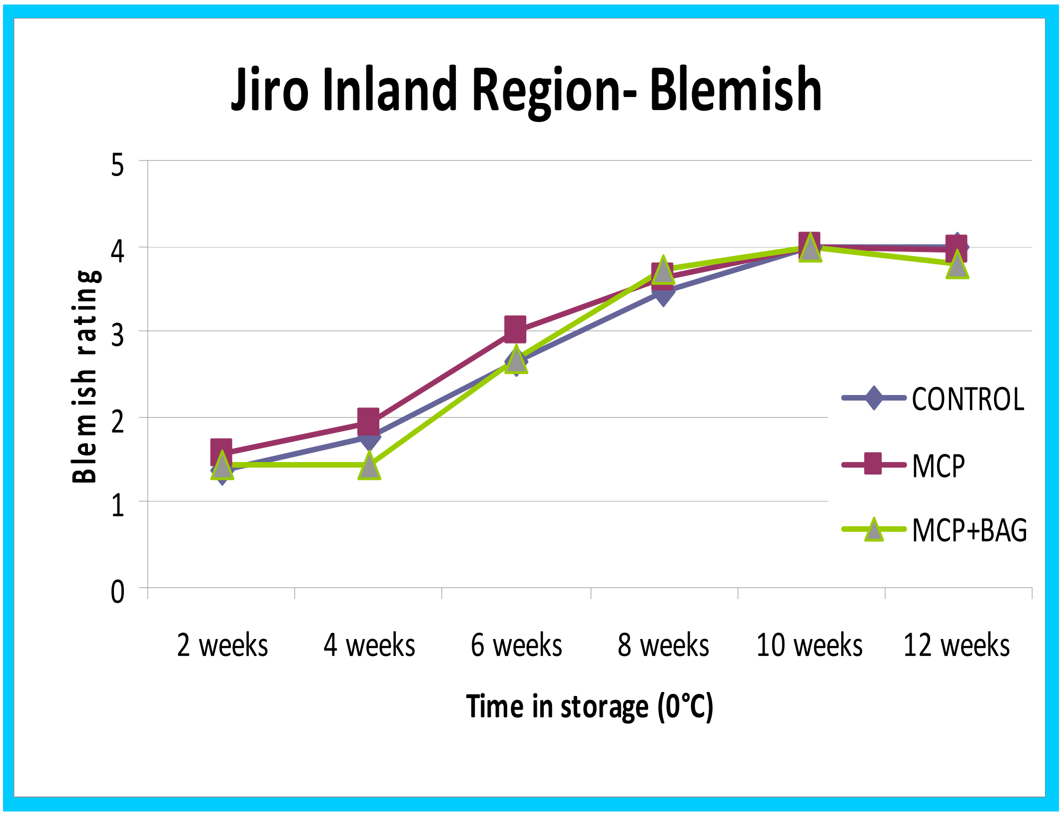
Jiro from inland regions can be stored for up to 2 weeks at 15°C when treated with 1-MCP, with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

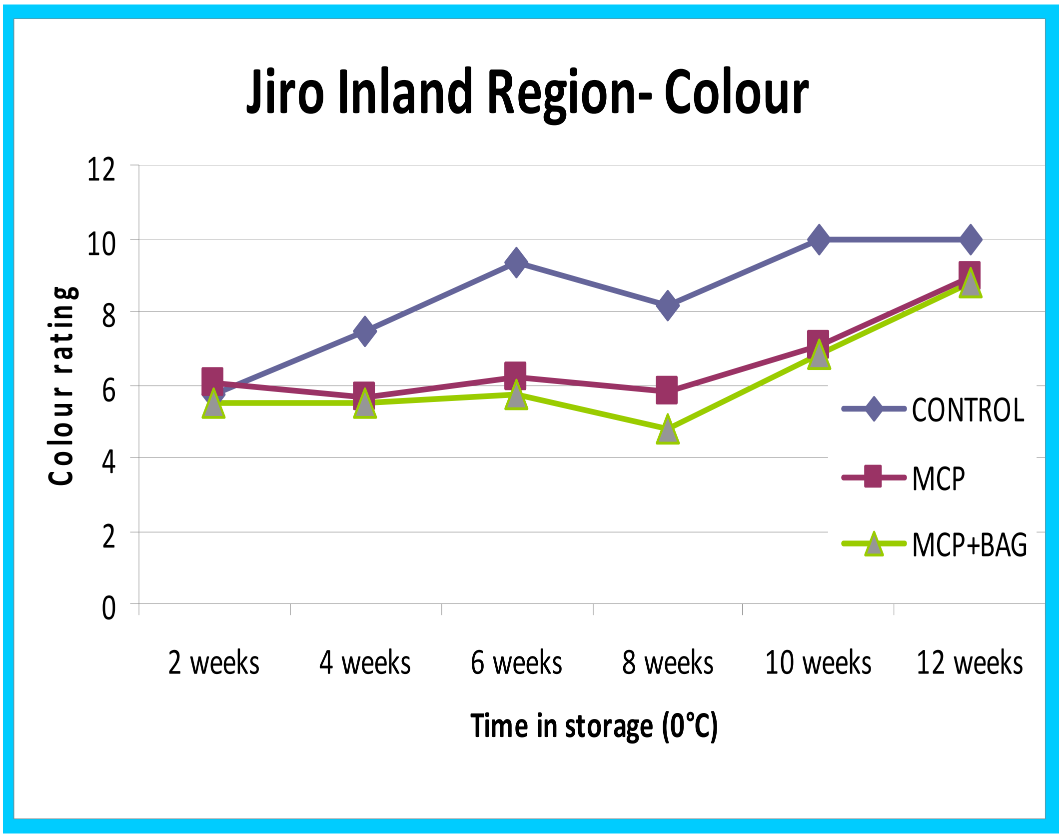
Inland Region- Jiro stored at 0°C

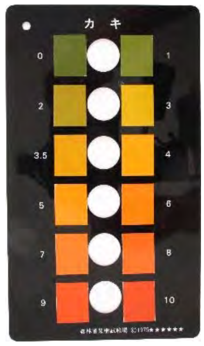


1= healthy
5= severely diseased or damaged

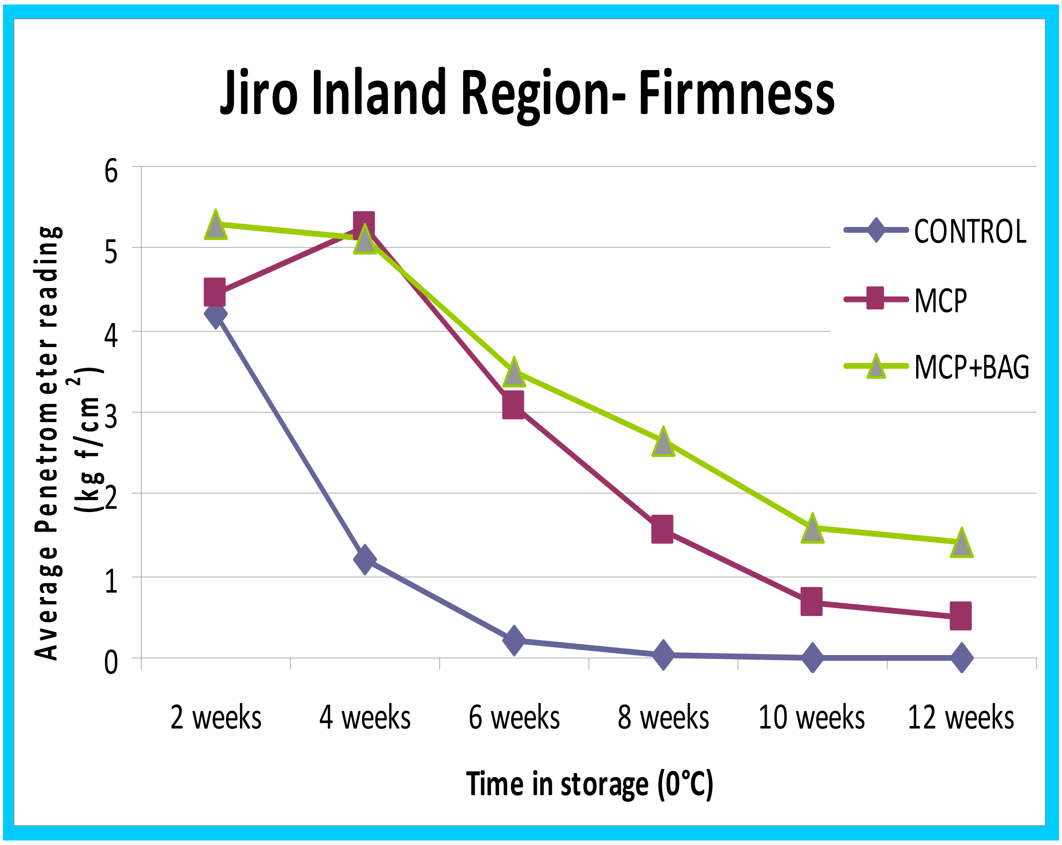


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

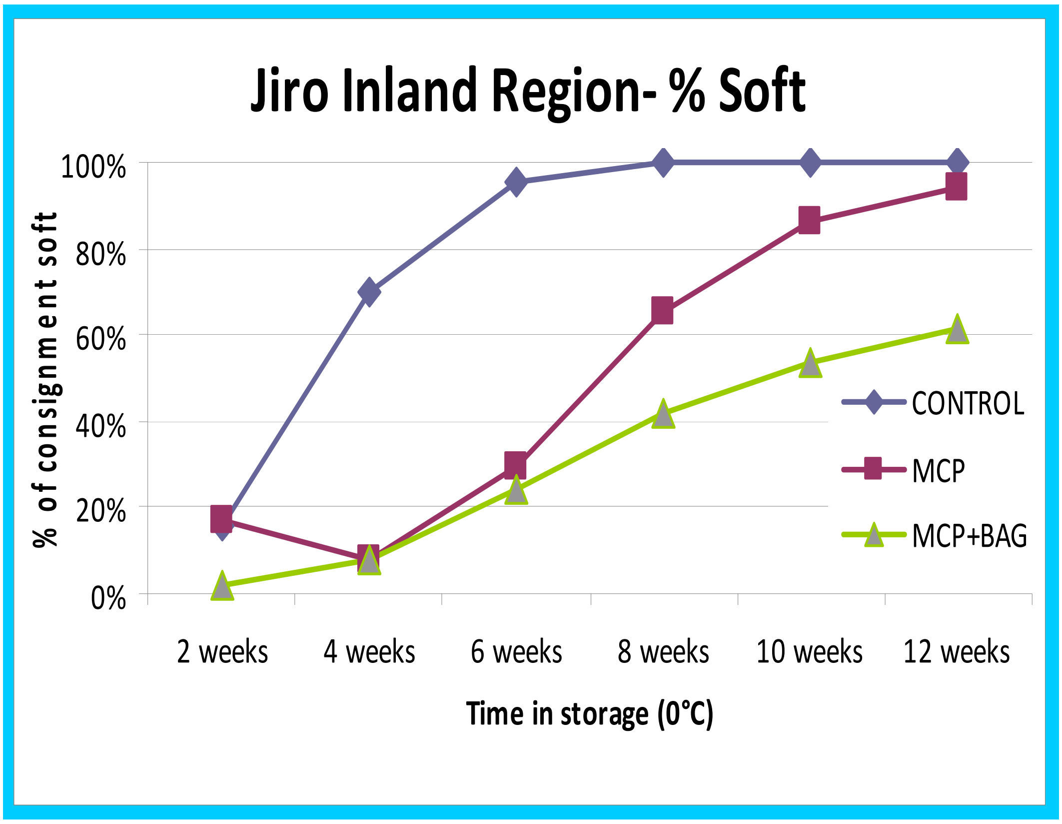




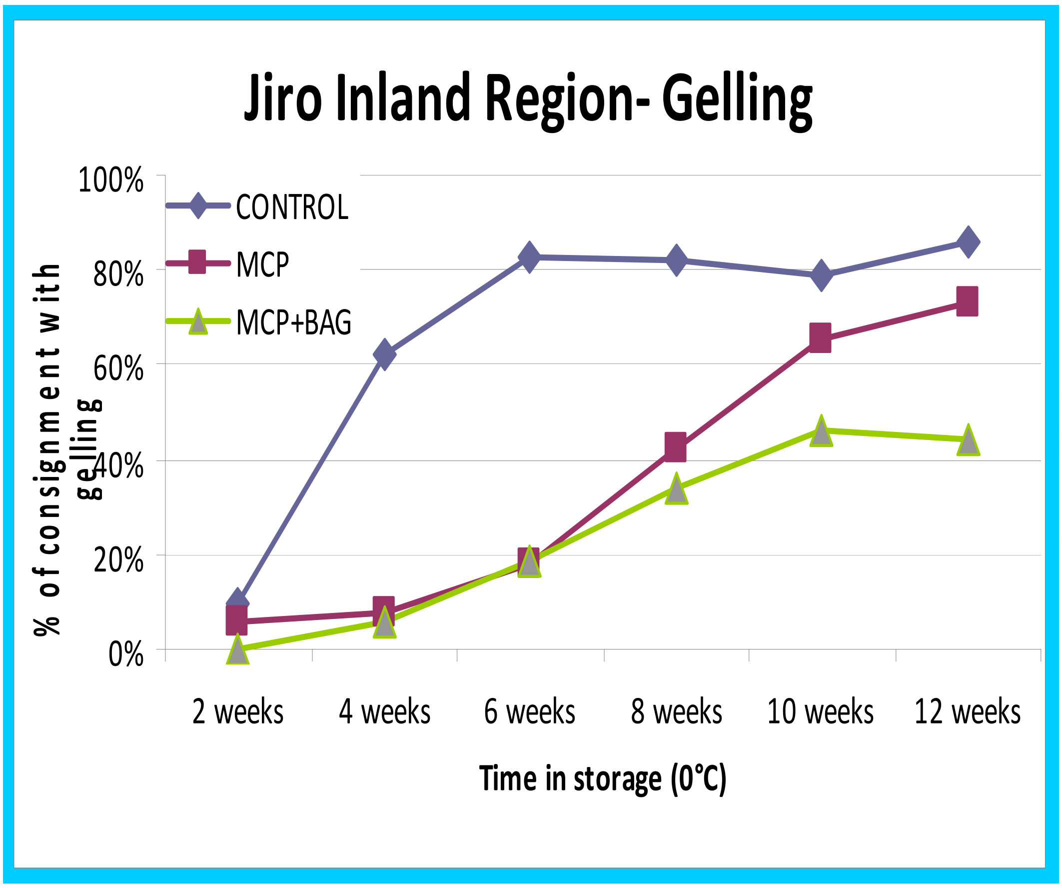
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

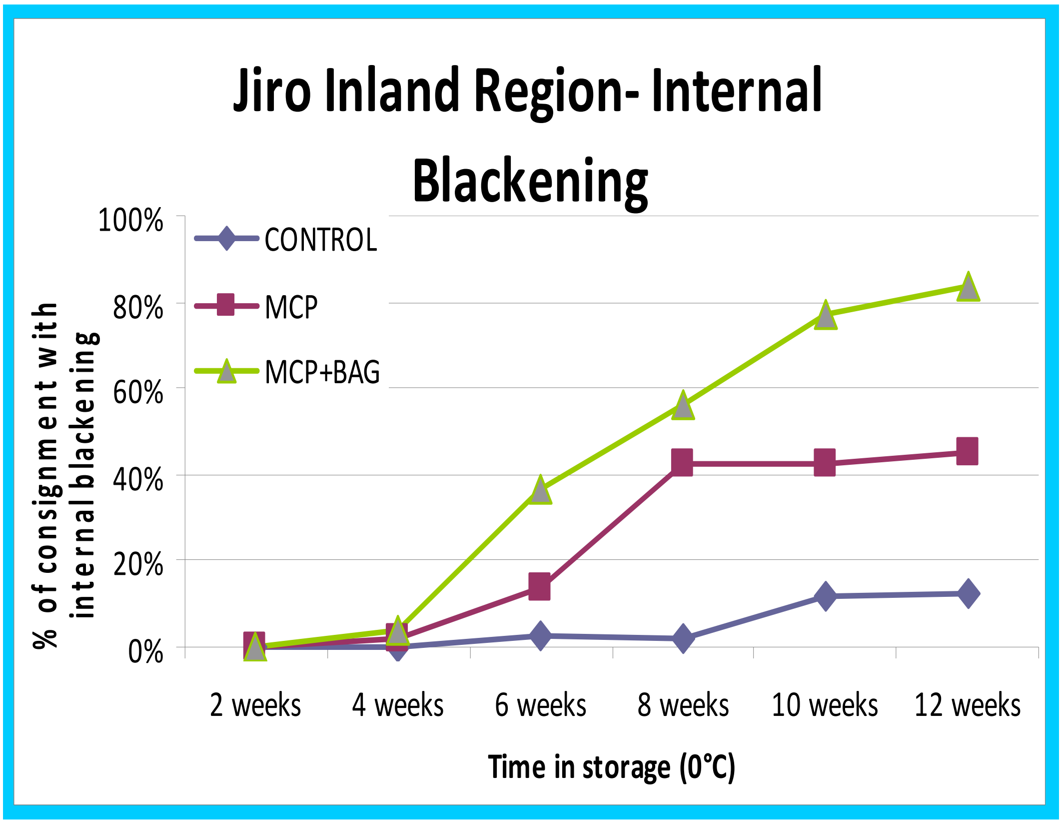


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm[2] (penetrometer)





Summary

Jiro treated with 1-MCP alone or in combination with MA bags maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 6 weeks for 1-MCP treated fruit and 8 weeks for fruit treated with 1-MCP and MA bags. Chilling injury (gelling) was reduced by 1-MCP and MA bag treatments. High levels of internal blackening were observed in 1-MCP treated fruit, especially in MA bags.

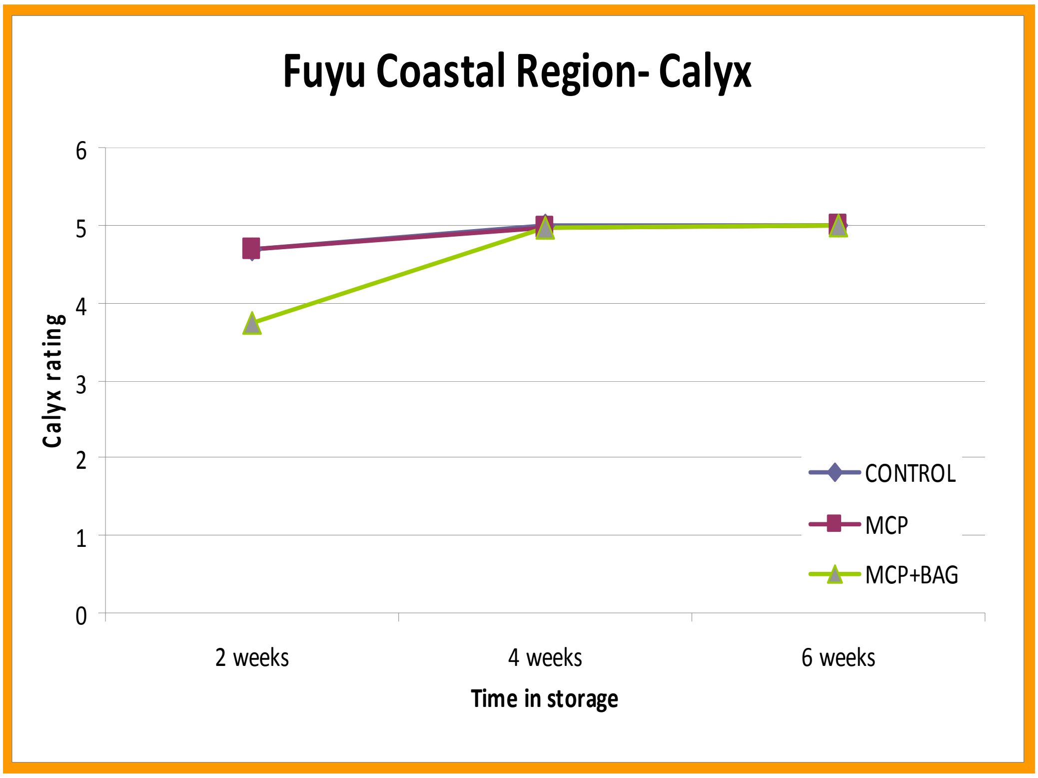
Recommended storage duration for inland Jiro at 0°C

JIro from inland regions can be stored for 6 weeks when treated with 1-MCP with and expected shelf life of 7 days at ambient temperature. Do not use MA bags for Jiro stored at 0°C.

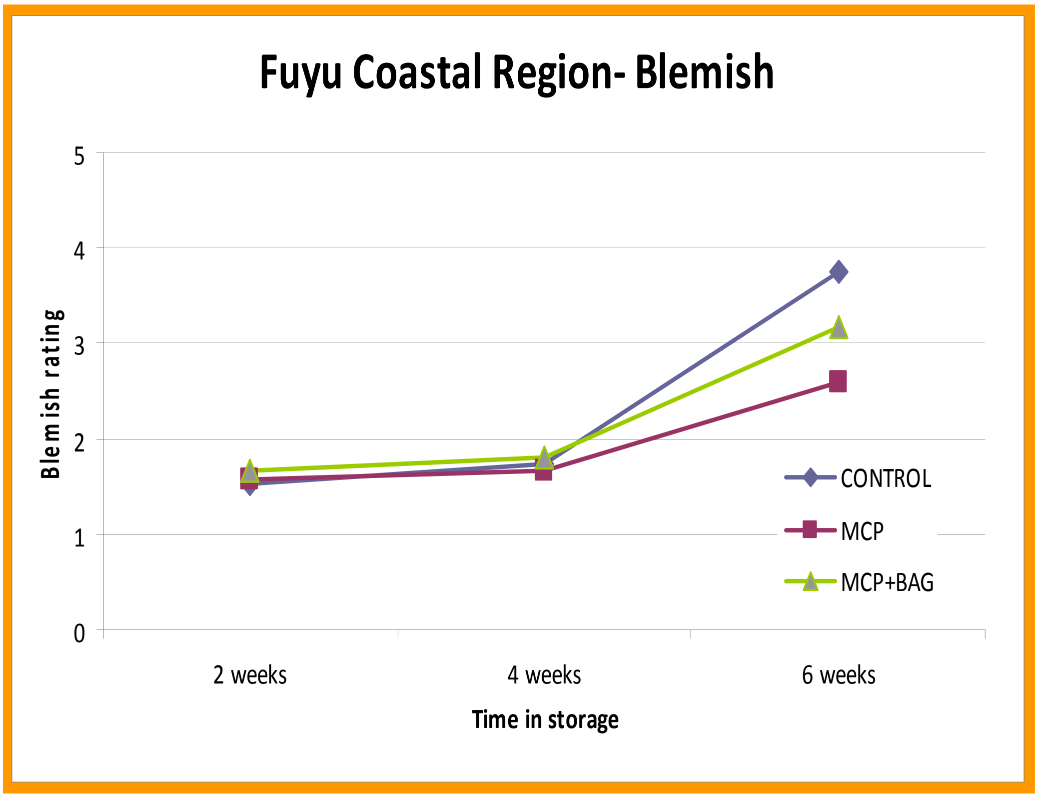
Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

Regional Storage Options for Fuyu

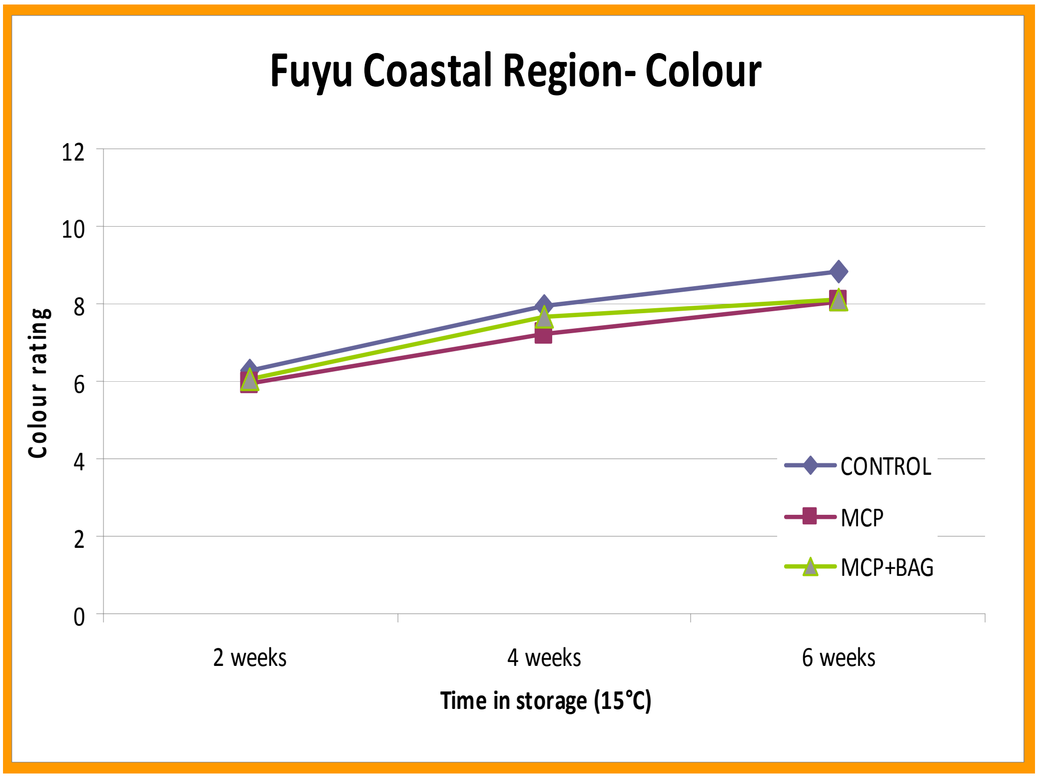
Coastal Region- Fuyu stored at 15°C

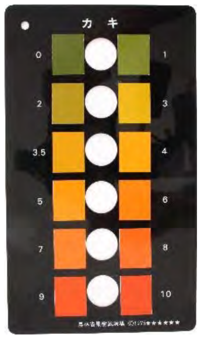


1= healthy
5= severely diseased or damaged

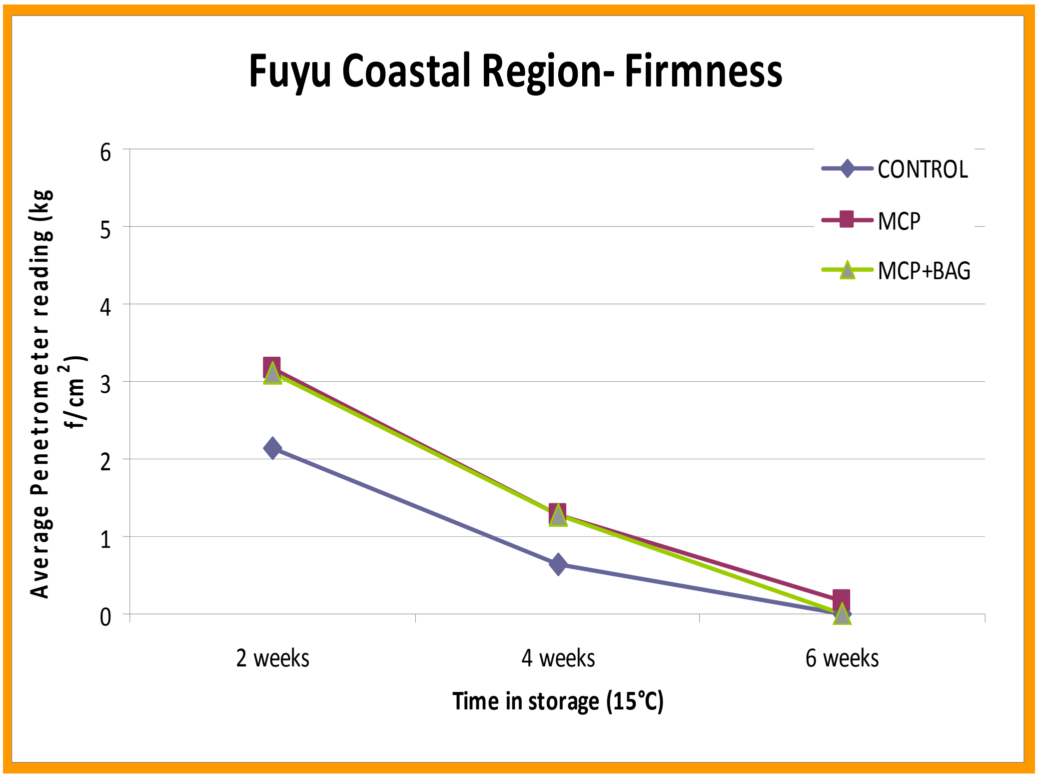


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

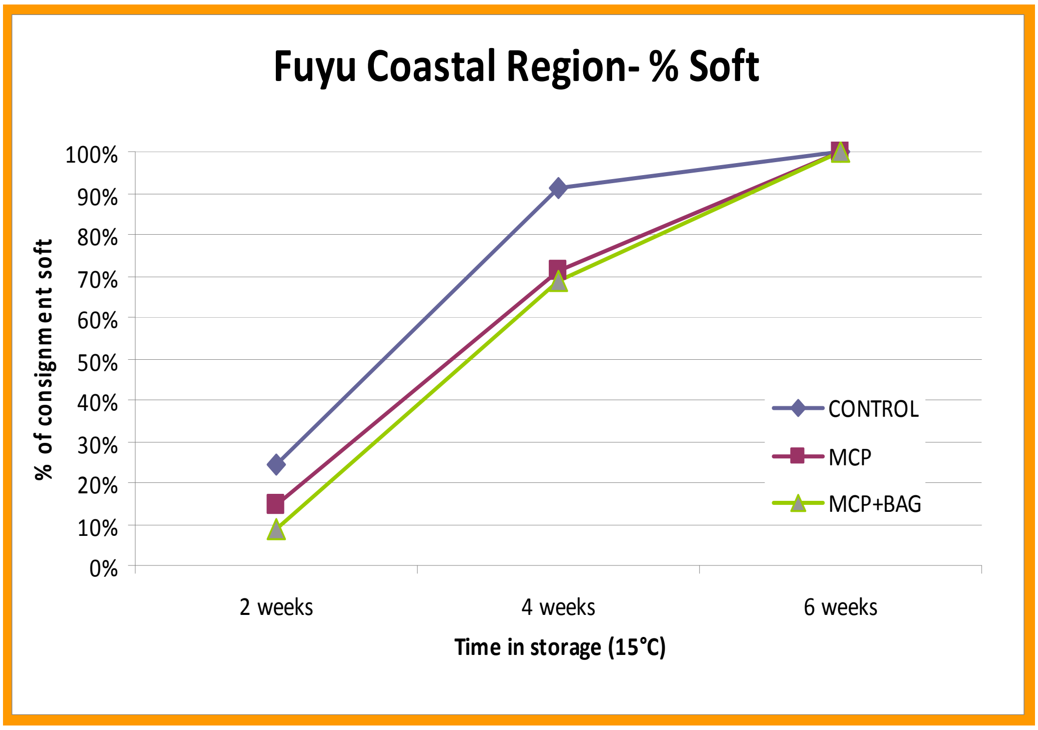




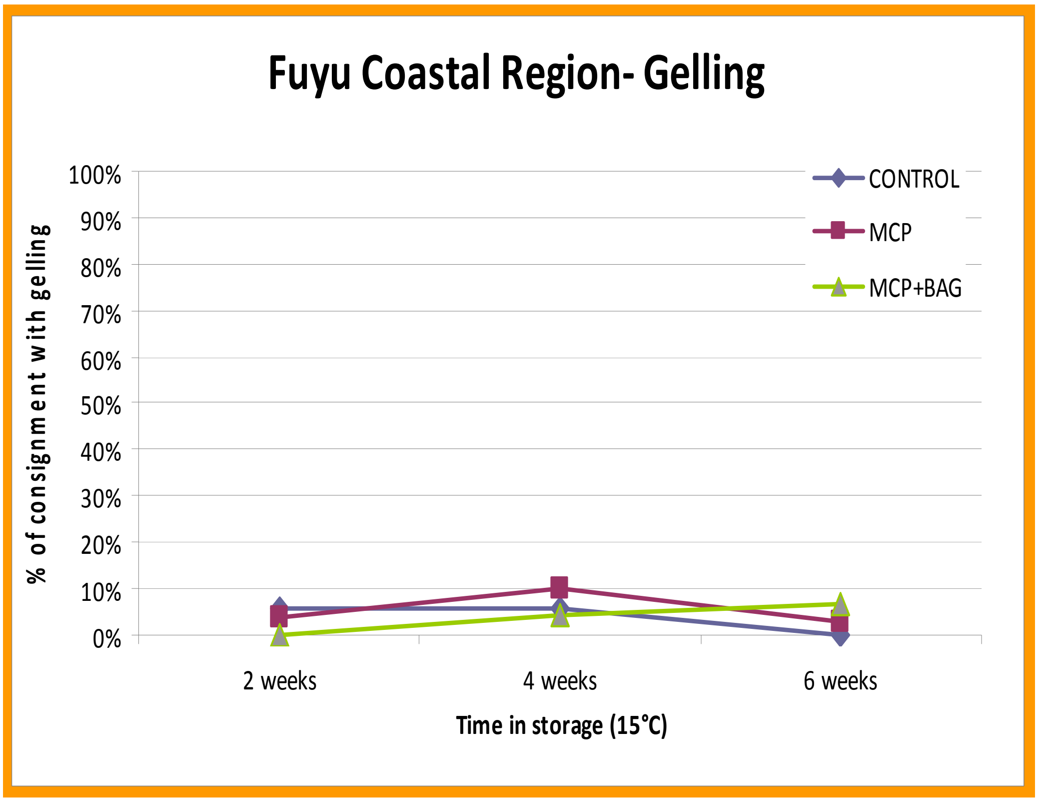
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

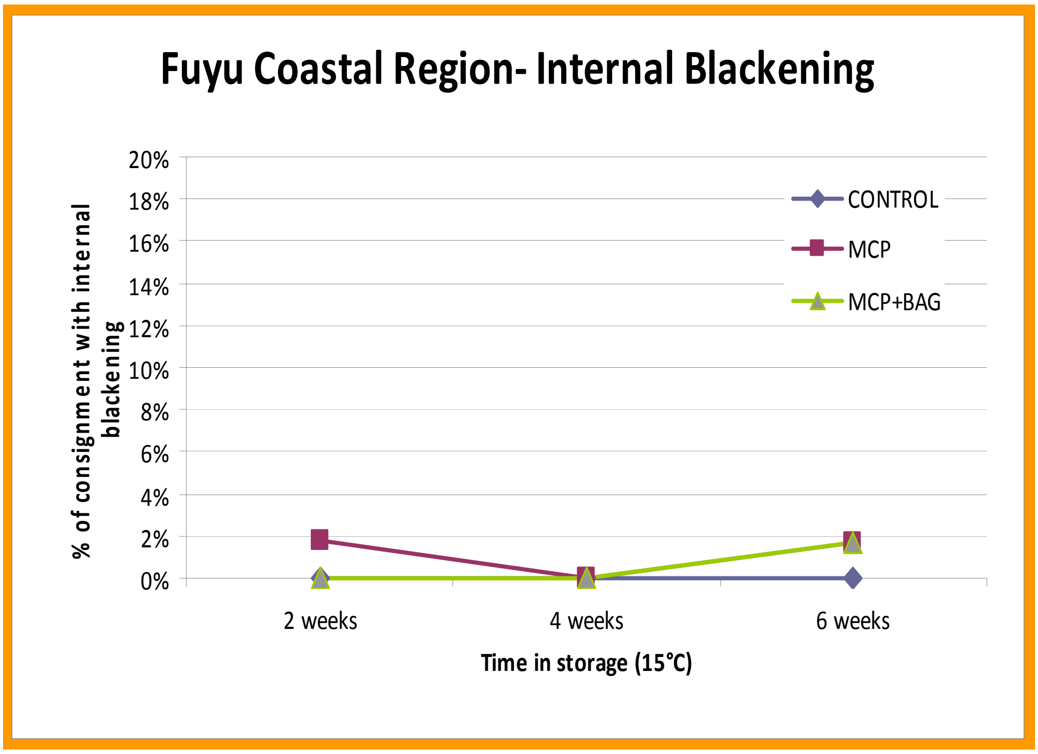


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm^2 (penetrometer)





Summary

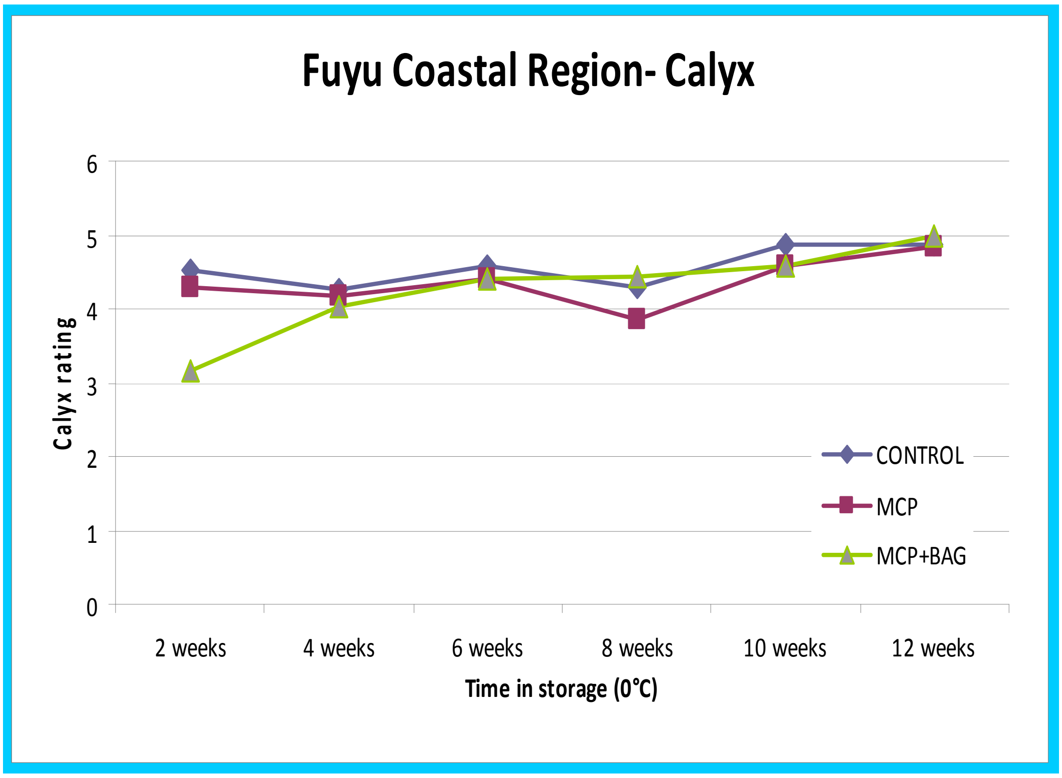
Calyx, blemish and colour didn't vary greatly between treatments at 15°C. Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) and internal blackening were observed.

Recommended storage duration for coastal Fuyu at 15°C

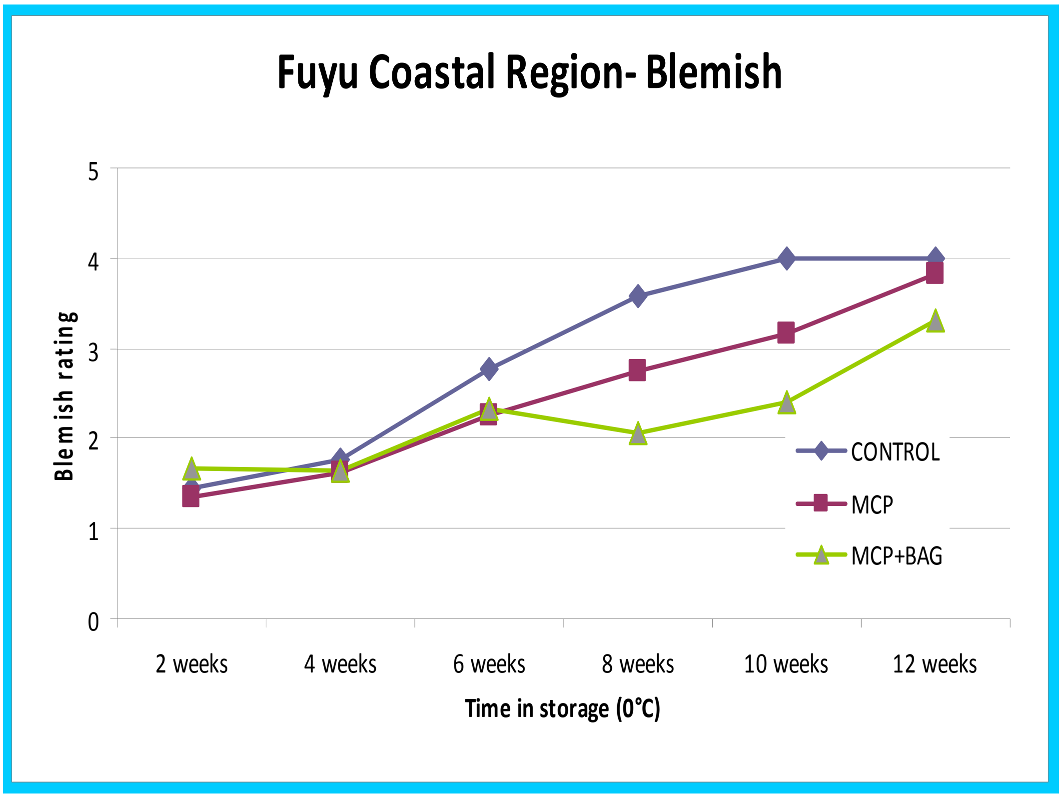
Fuyu from coastal regions can be stored for up to two weeks at 15°C when treated with 1-MCP with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

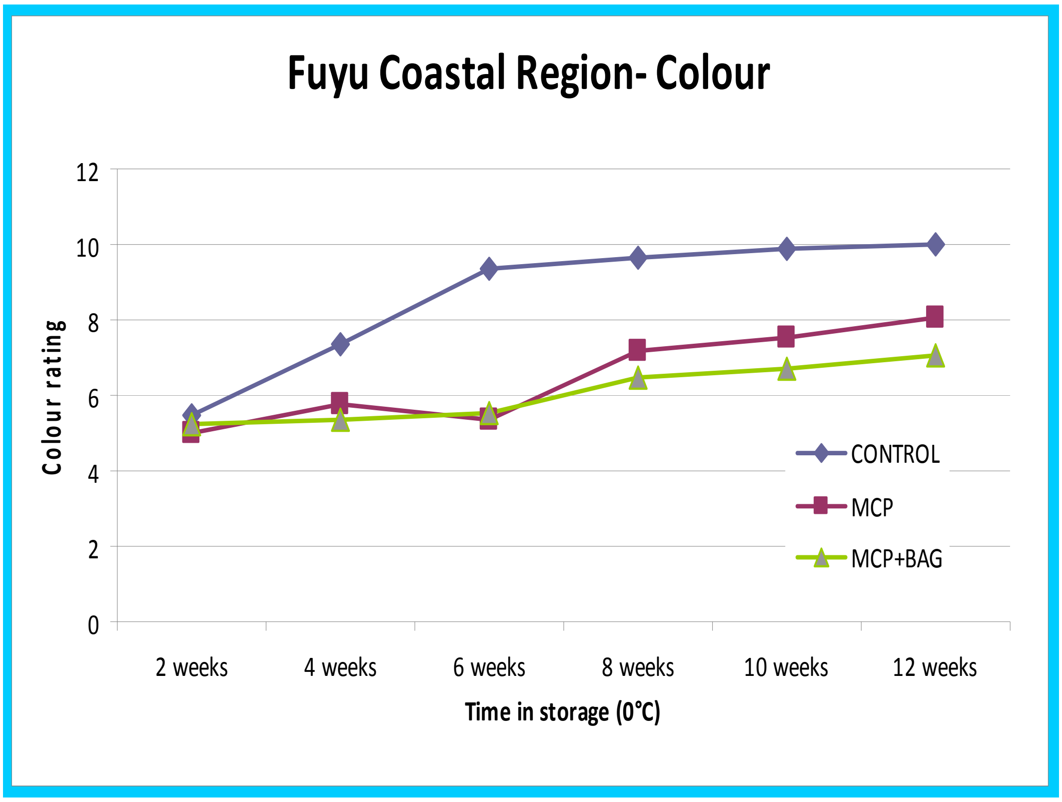
Coastal Region- Fuyu stored at 0°C

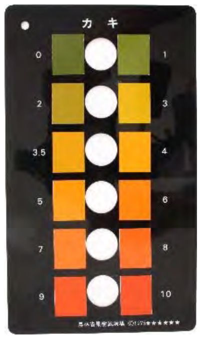


1= healthy
5= severely diseased or damaged

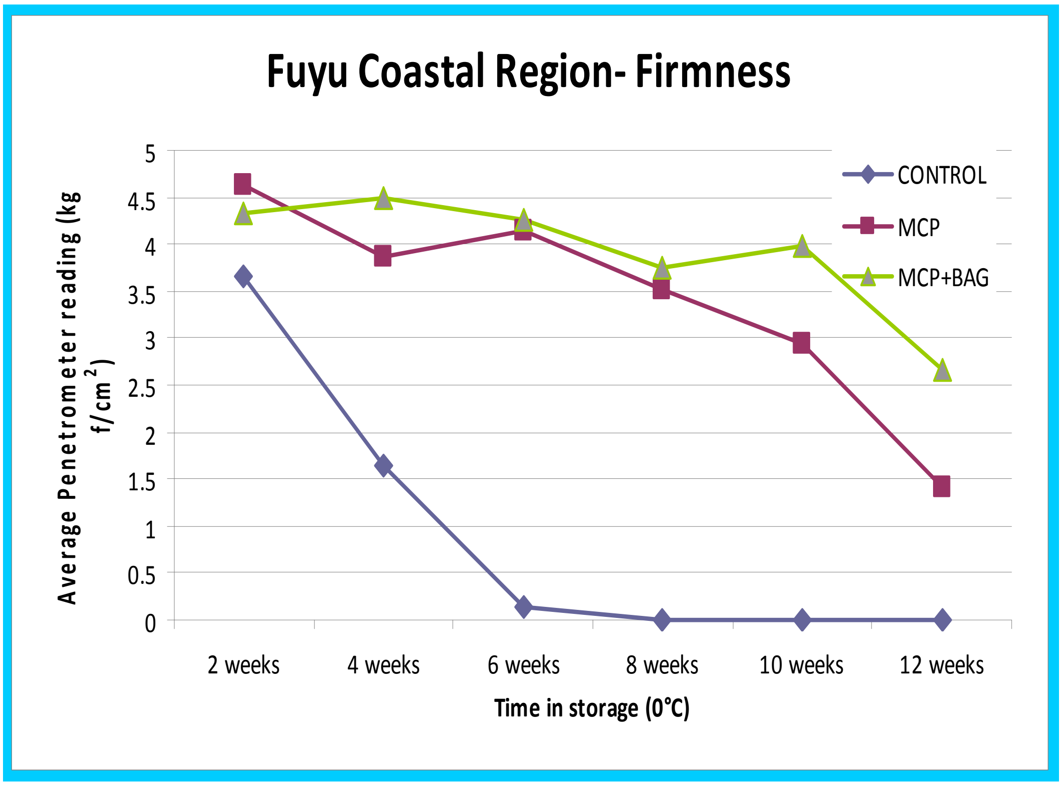


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

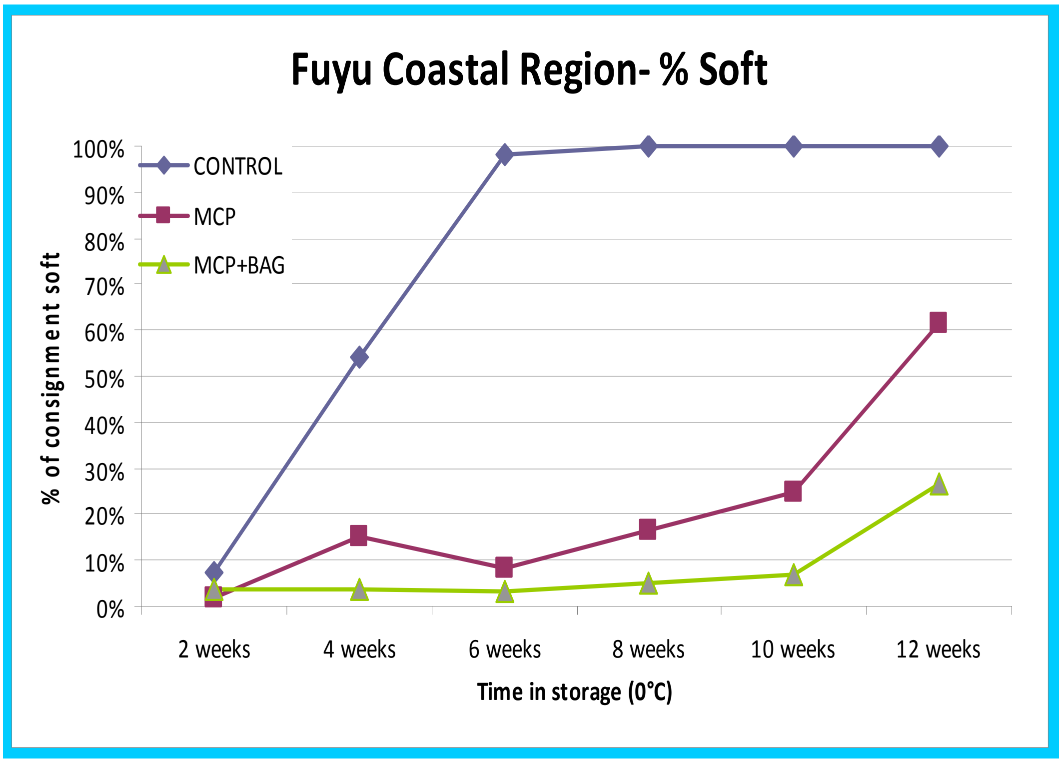




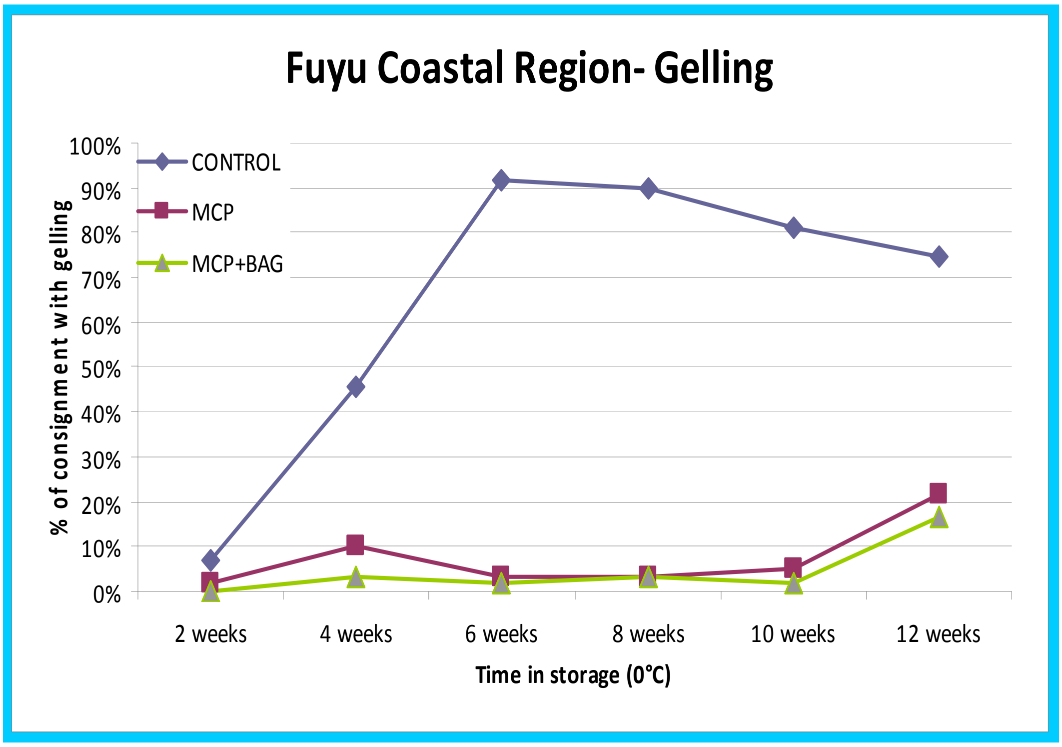
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

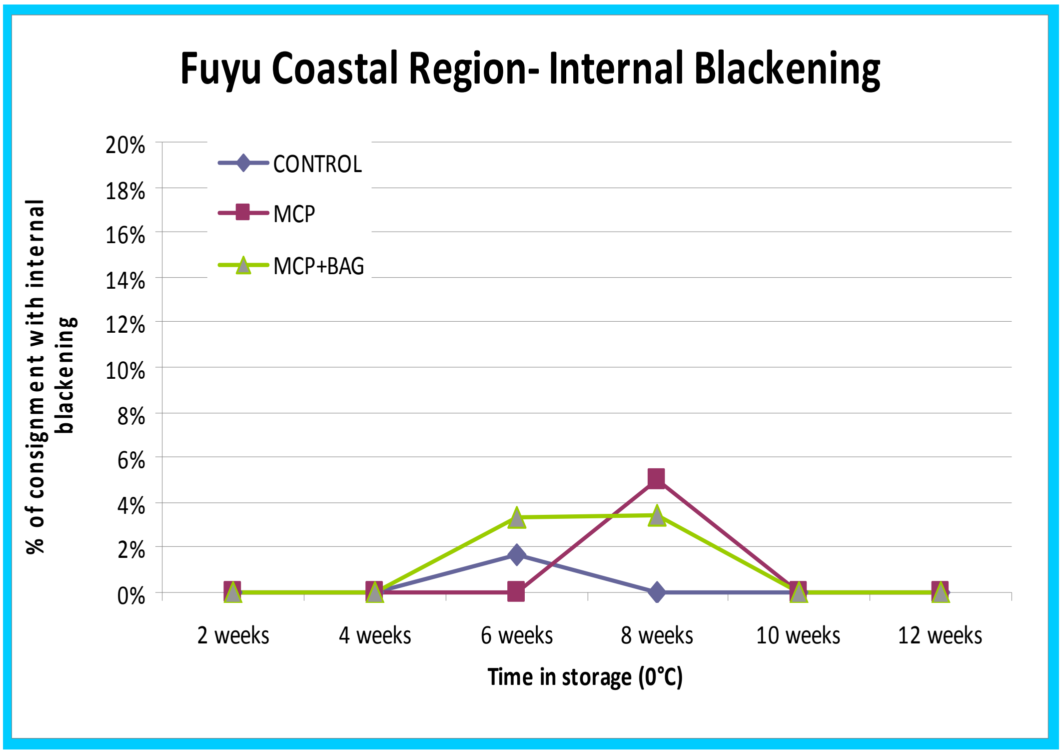


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm^2 (penetrometer)





Summary

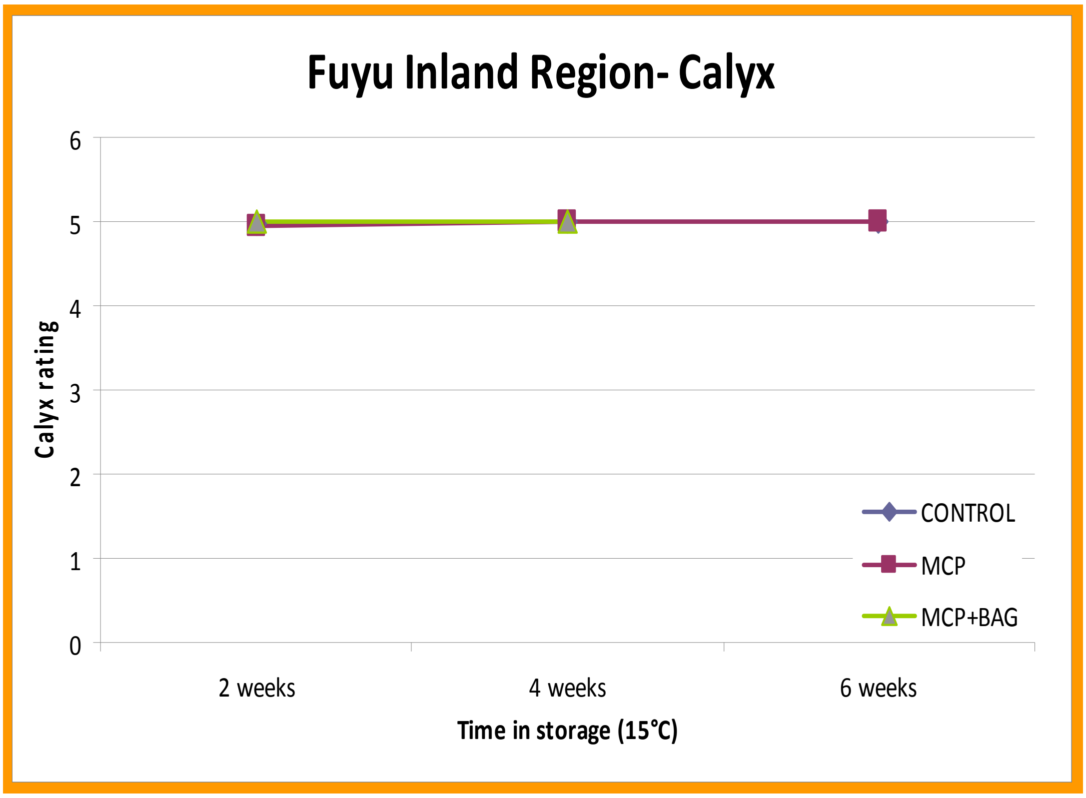
Fuyu treated with 1-MCP alone and in combination with MA bags reduces blemishing and maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 10 weeks for 1-MCP treated fruit and 12 weeks for fruit treated with 1-MCP and MA bags. Untreated fruit rapidly softened after 2 weeks and incurred high levels of gelling. Chilling injury (gelling) remained below 10% for 10 weeks in fruit treated with 1-MCP. Small amounts of internal blackening was observed in 1-MCP treated fruit but generally stayed below 5%.

Recommended storage duration for coastal Fuyu at 0°C

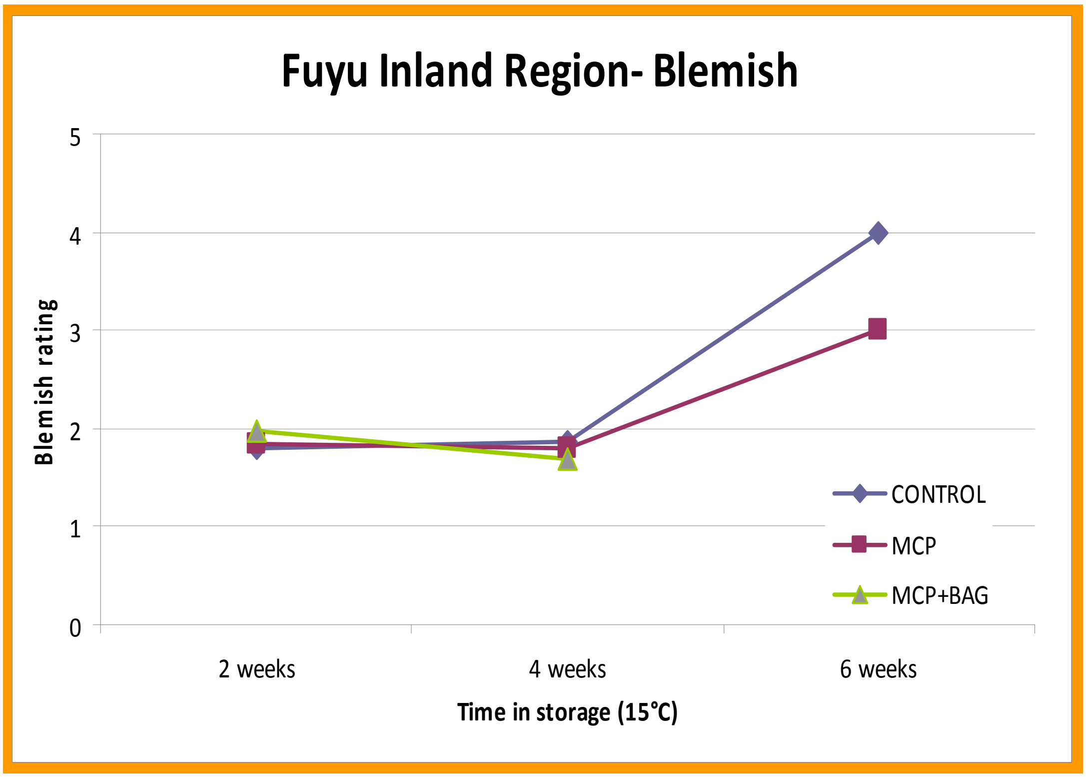
Fuyu from coastal regions can be stored for 8 weeks when treated with 1-MCP and 10 weeks when using a combination of 1-MCP and MA bags with and expected shelf life of 7 days at ambient temperature.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

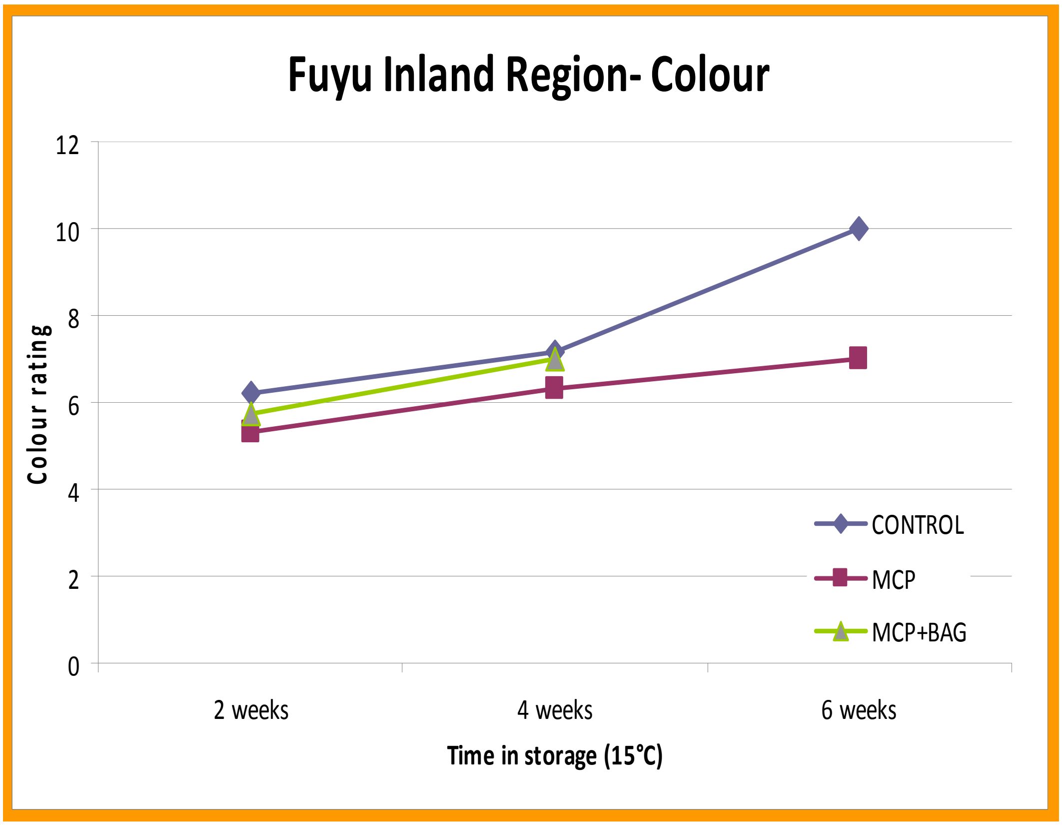
Inland Region- Fuyu stored at 15°C

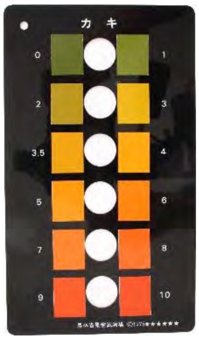


1= healthy
5= severely diseased or damaged

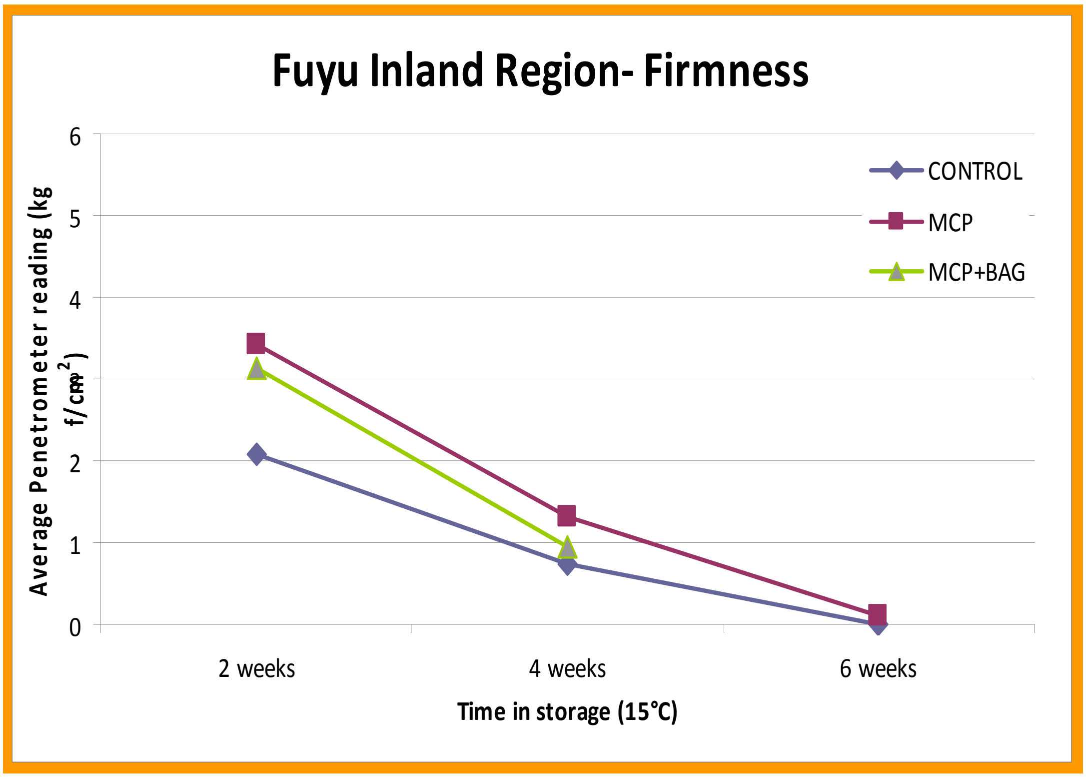


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

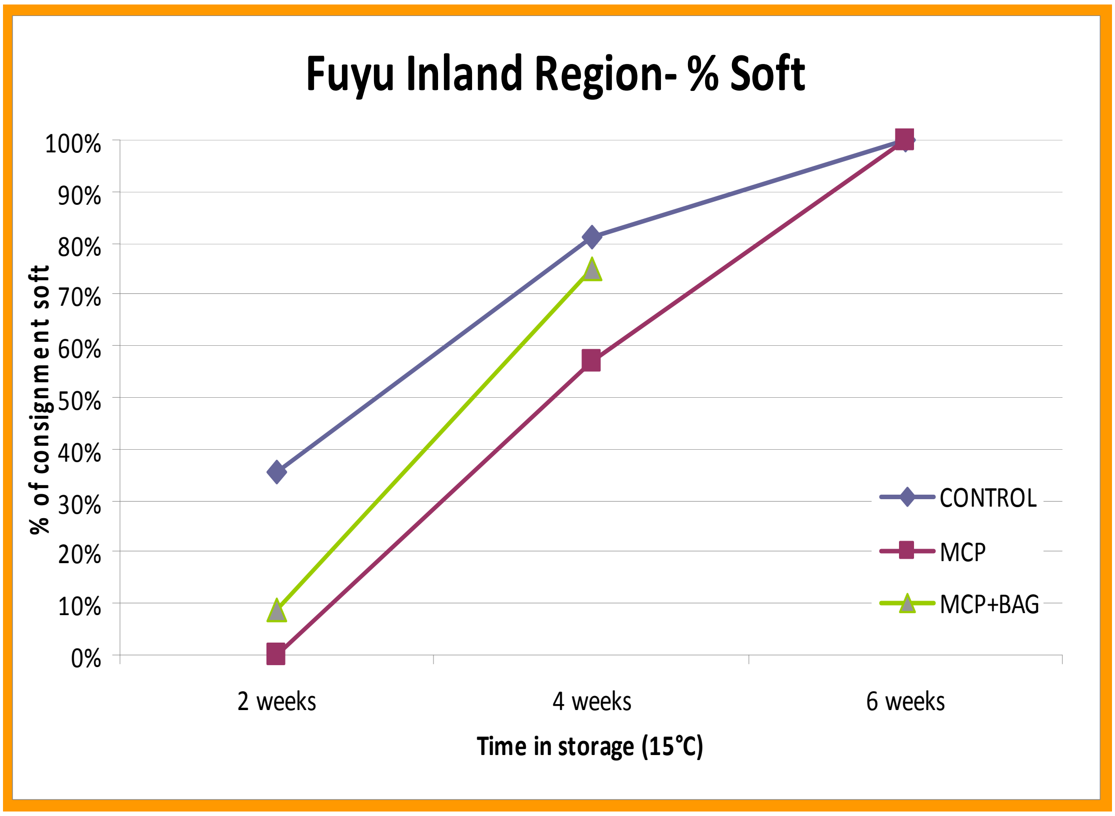


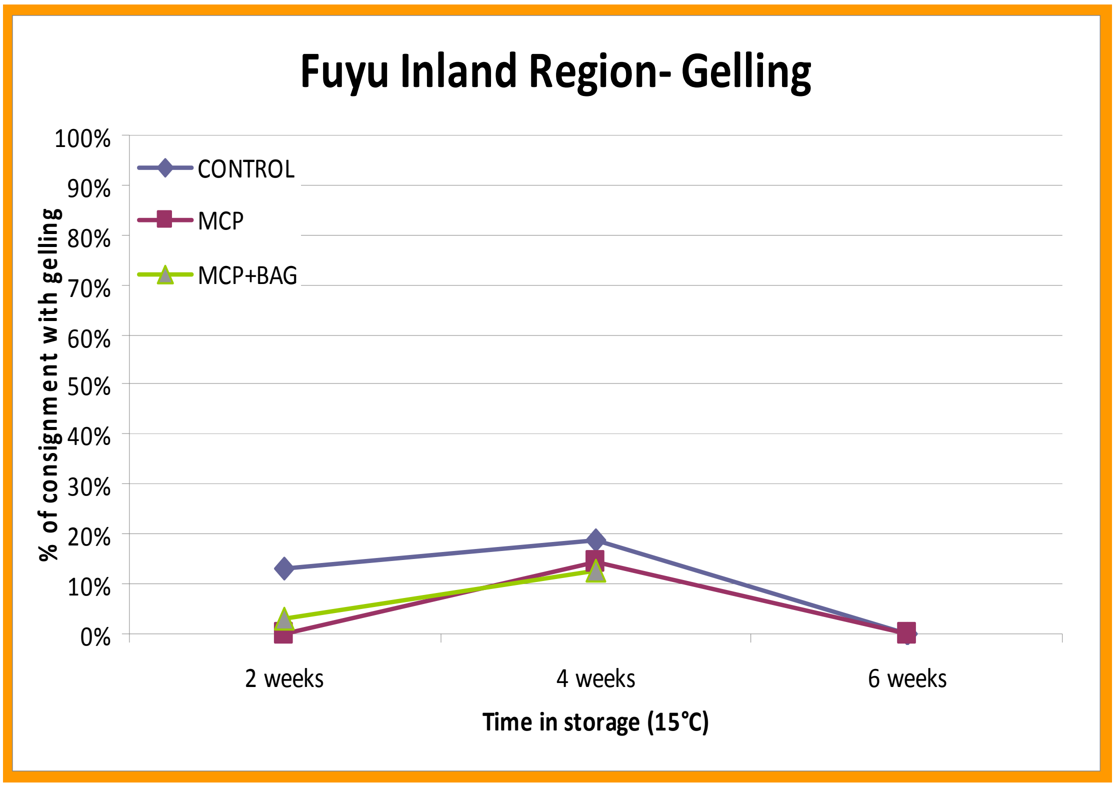


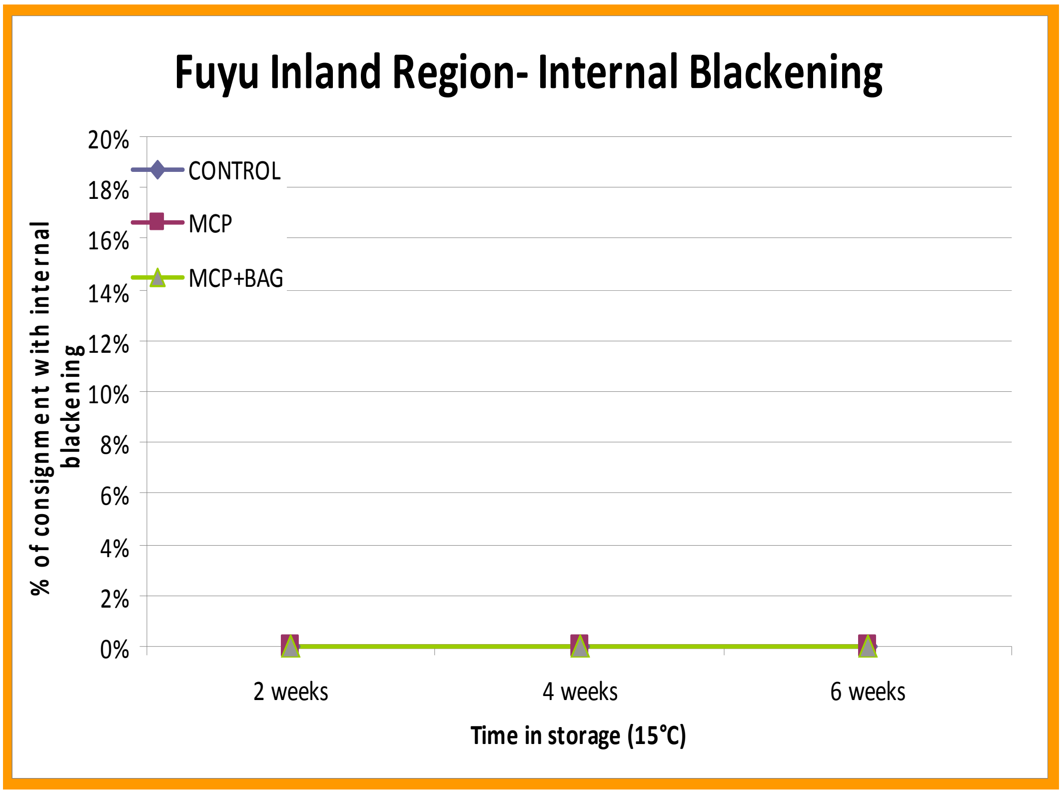
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart



Firmness, using an Effegi penetrometer with an 8mm tip


Fuyu Inland Region- % Soft
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of consignment soft
CONTROL
MCP
MCP+BAG
2 weeks
4 weeks
6 weeks
Time in storage (15°C)


Fuyu Inland Region- Gelling
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of consignment with gelling
CONTROL
MCP
MCP+BAG
2 weeks
4 weeks
6 weeks
Time in storage (15°C)



Summary

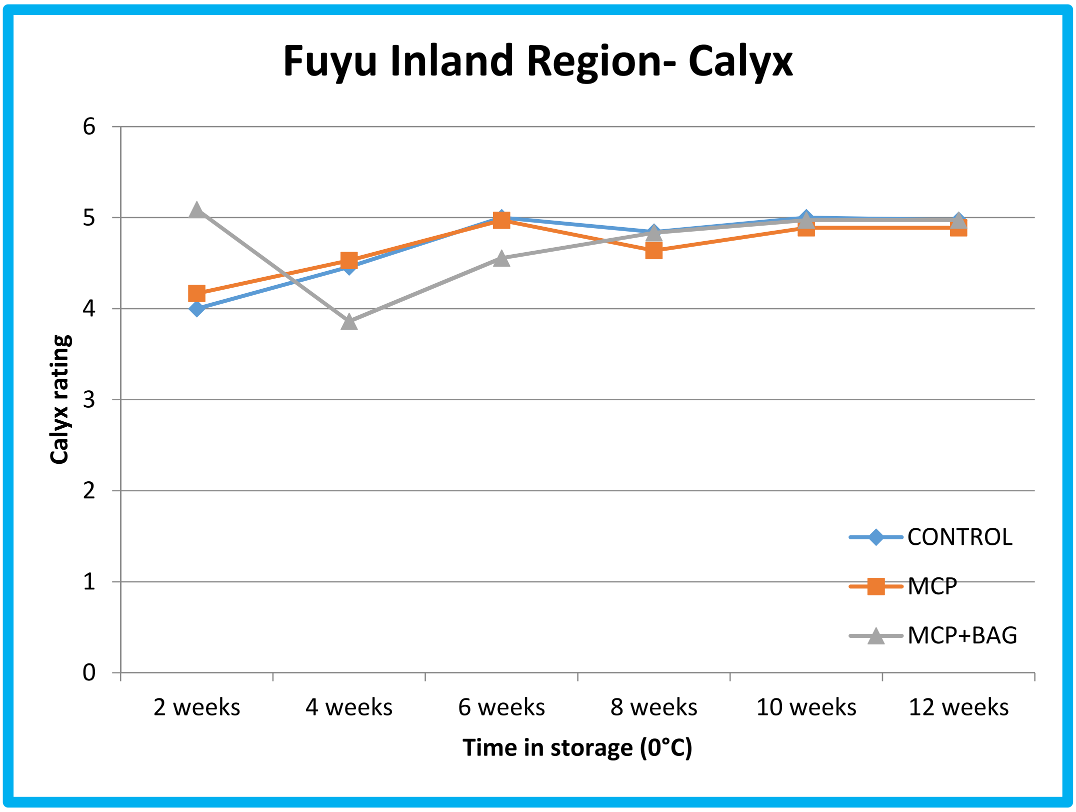
Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) and no internal blackening were observed.

Recommended storage duration for inland Fuyu at 15°C

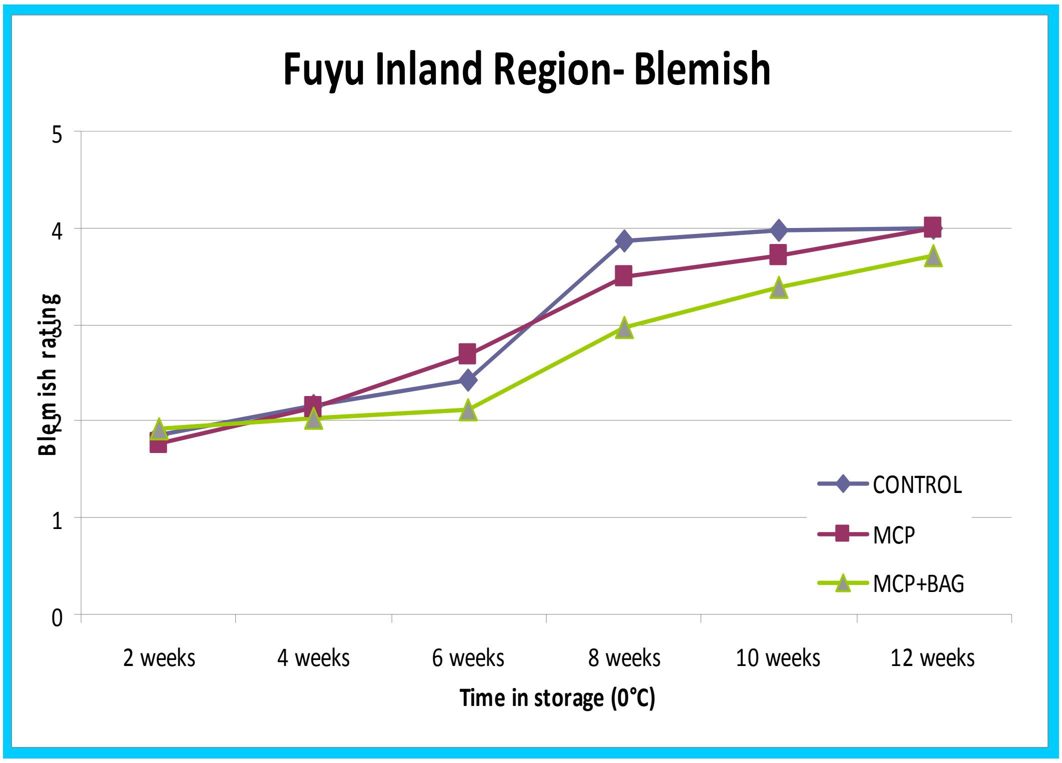
Fuyu from inland regions can be stored for up to 3 weeks at 15°C when treated with 1-MCP, with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

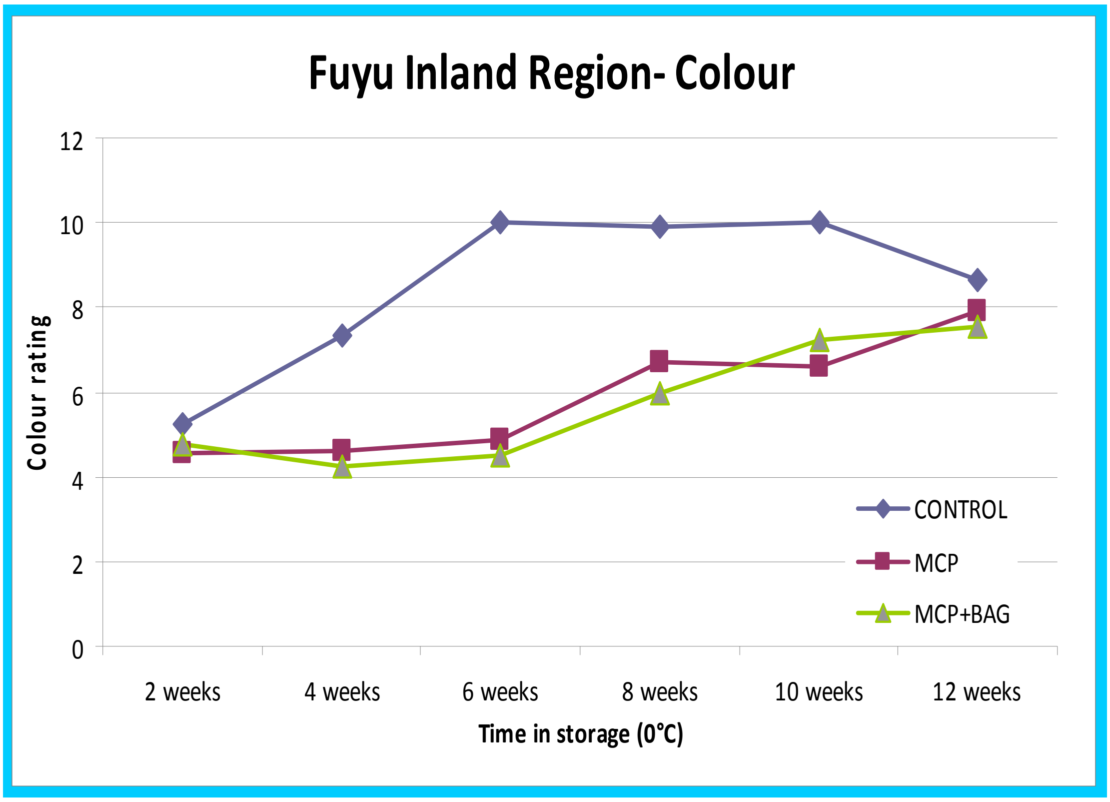
Inland Region- Fuyu stored at 0ºC

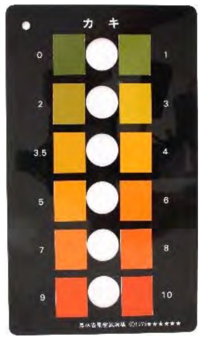


1= healthy
5= severely diseased or damaged

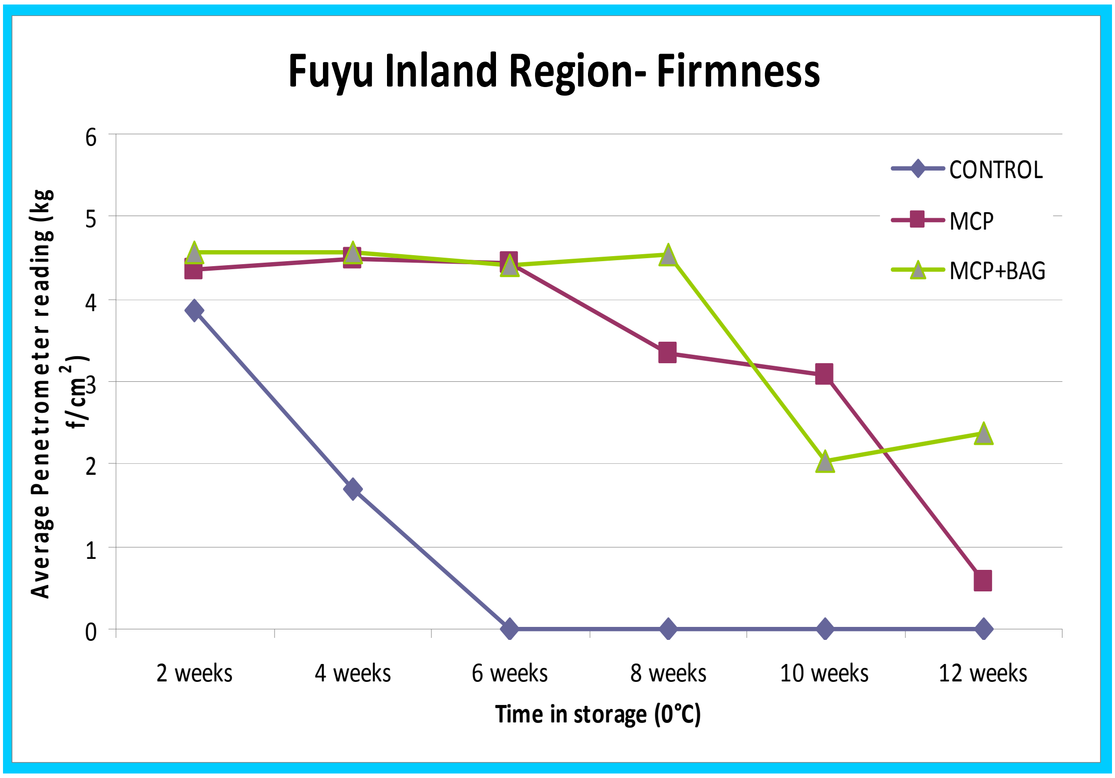


0 – no blemish (0 blemish)
1- trace (<10% blemish)
2 – slight (11-25% blemish)
3 – moderate (26-50% blemish)
4 – severe (>51% blemish)

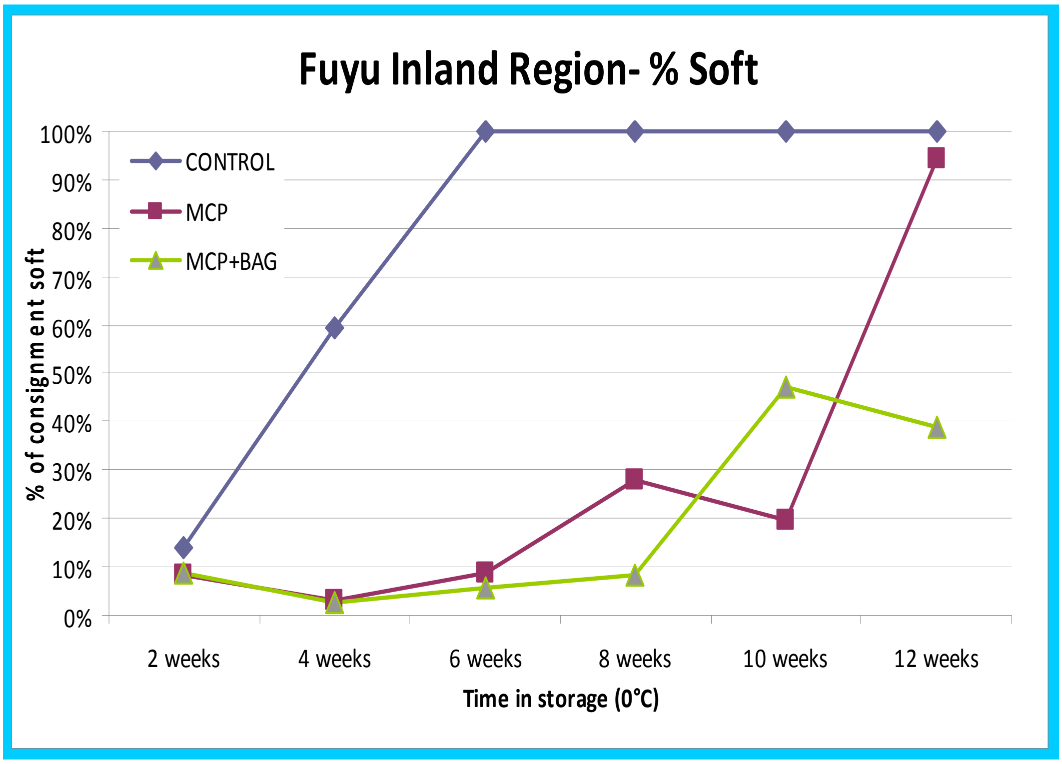




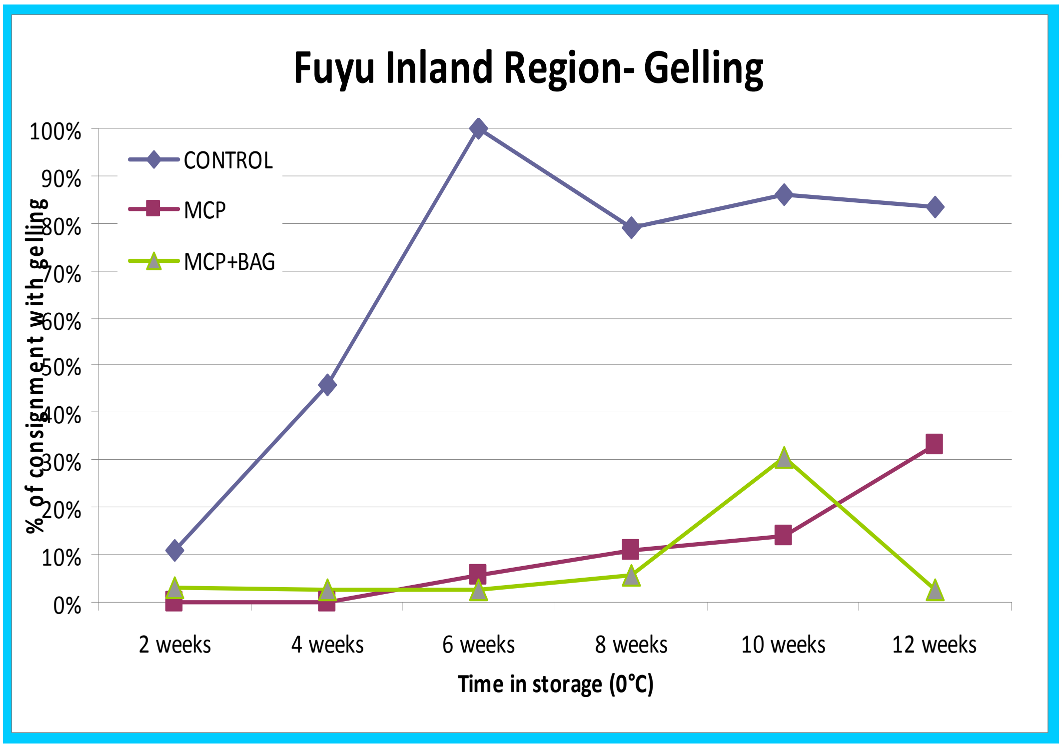
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

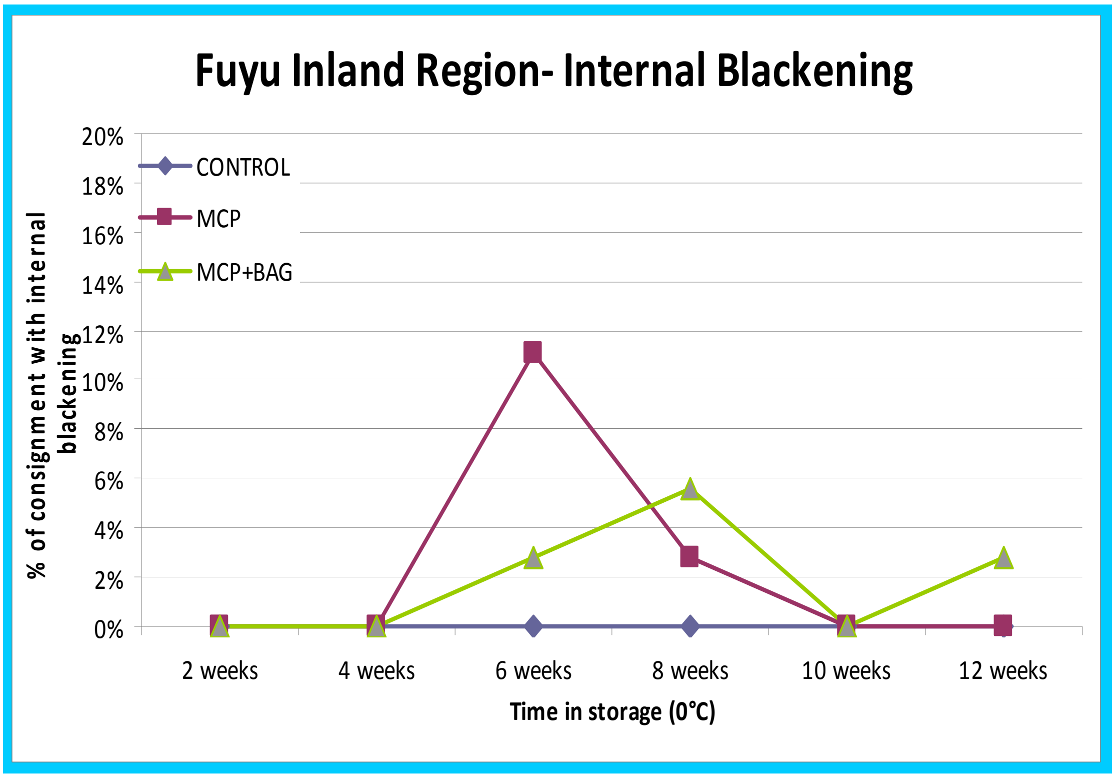


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm²
(penetrometer)





Summary

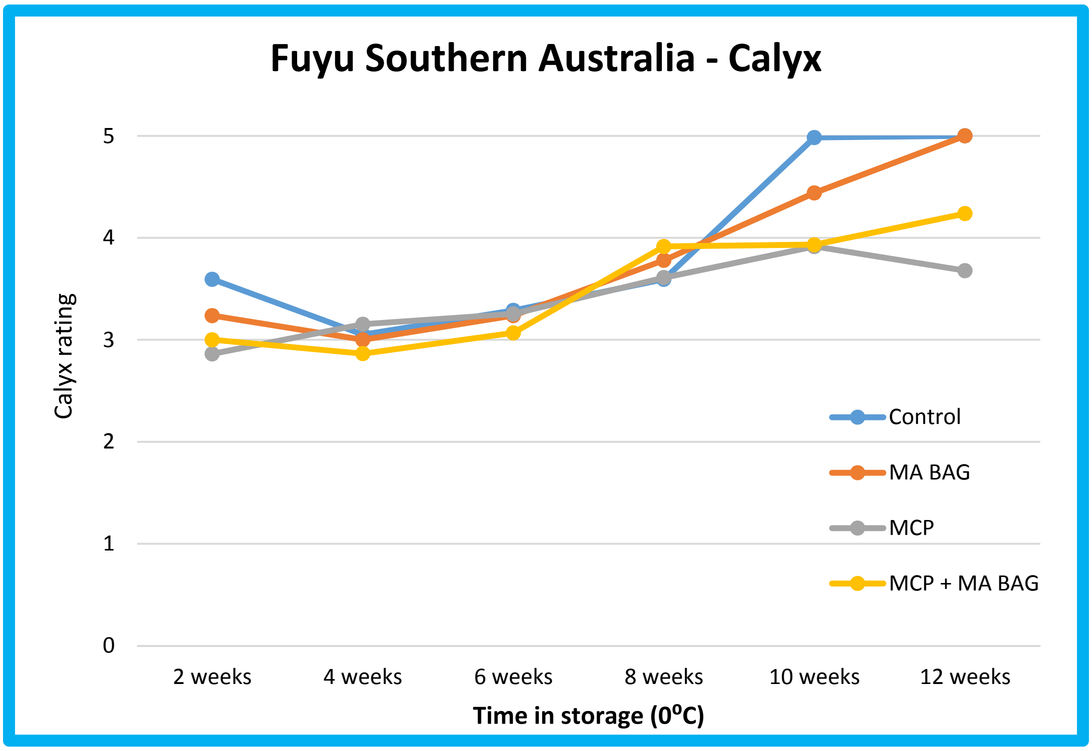
Fuyu treated with 1-MCP alone or in combination with MA bags reduces blemishing and maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 10 weeks for 1-MCP treated fruit and 8 weeks for fruit treated with 1-MCP and MA bags. Chilling injury (gelling) remained below 10% for 6 weeks using 1-MCP and MA bags and 8 weeks using 1-MCP alone. Small amounts of internal blackening were observed in 1-MCP treated.

Recommended storage duration for inland Fuyu at 0°C

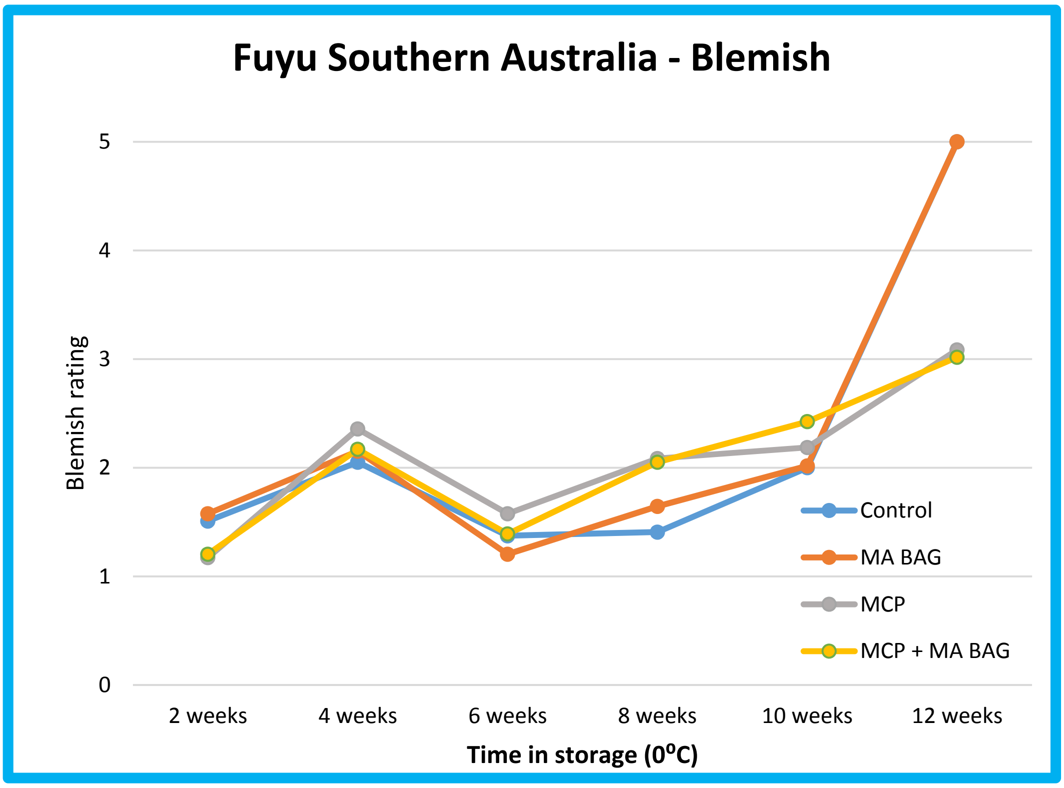
Fuyu from inland regions can be stored for 6-8 weeks when treated with 1-MCP alone or in combination with MA bags with and expected shelf life of 7 days at ambient temperature.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

Southern Australia - Fuyu stored at 0ºC



1= healthy
5= severely diseased or damaged



0 – no blemish (0 blemish)
1- trace (<10% blemish)
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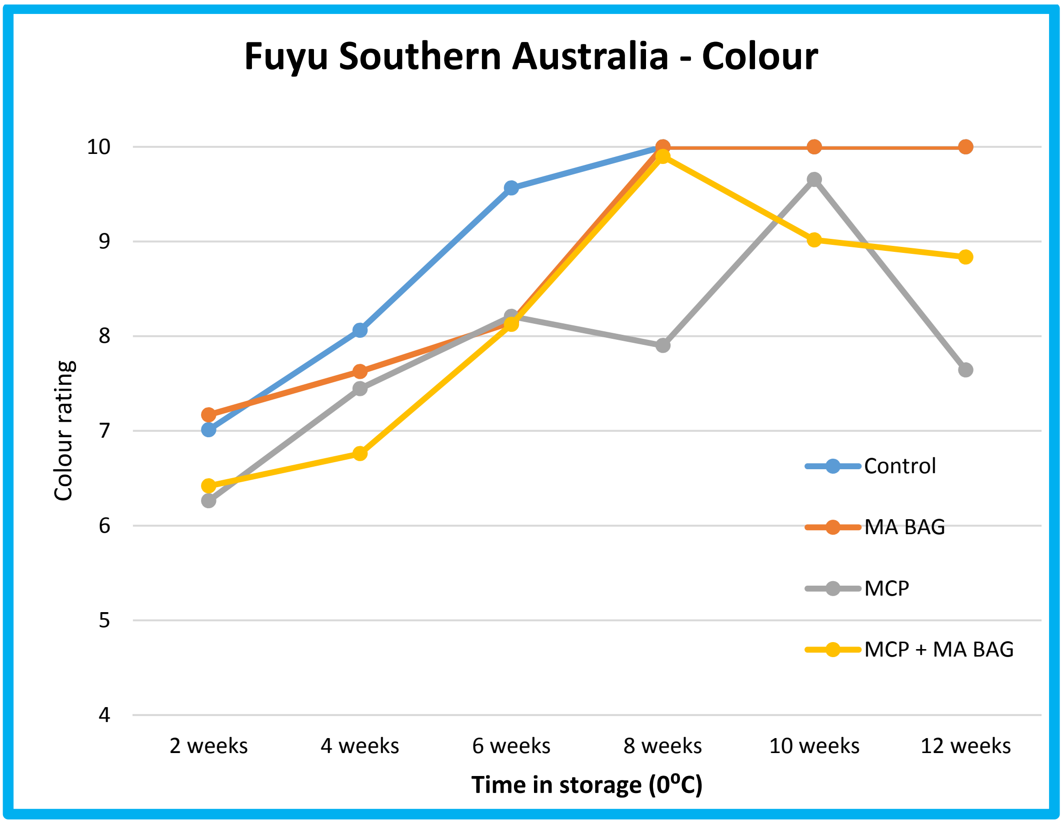
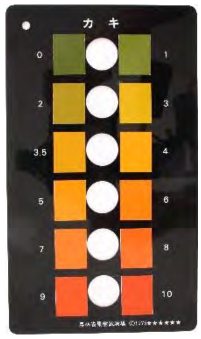
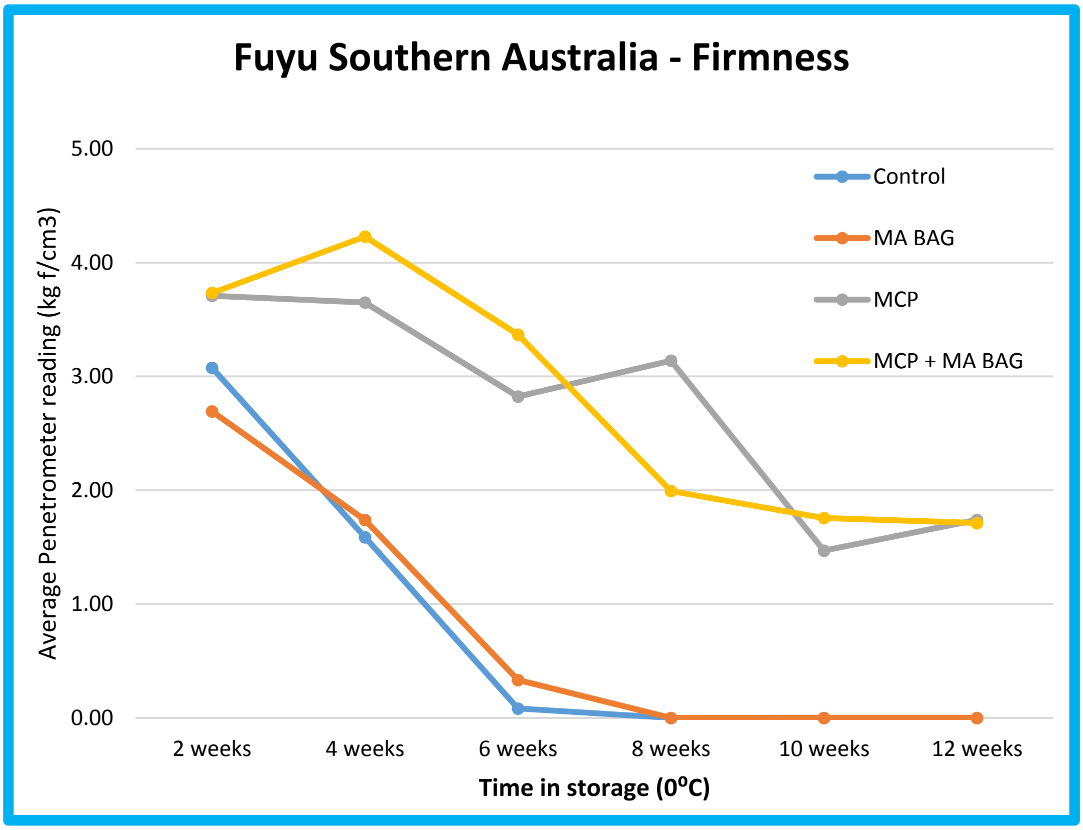
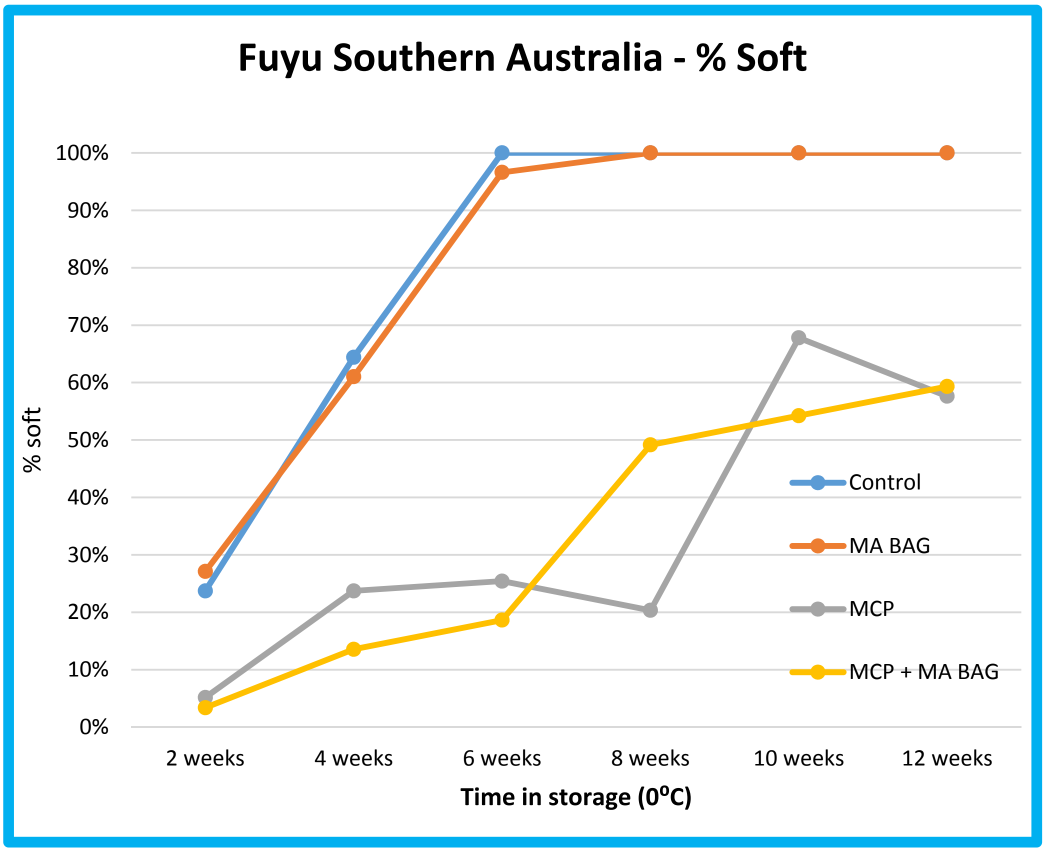




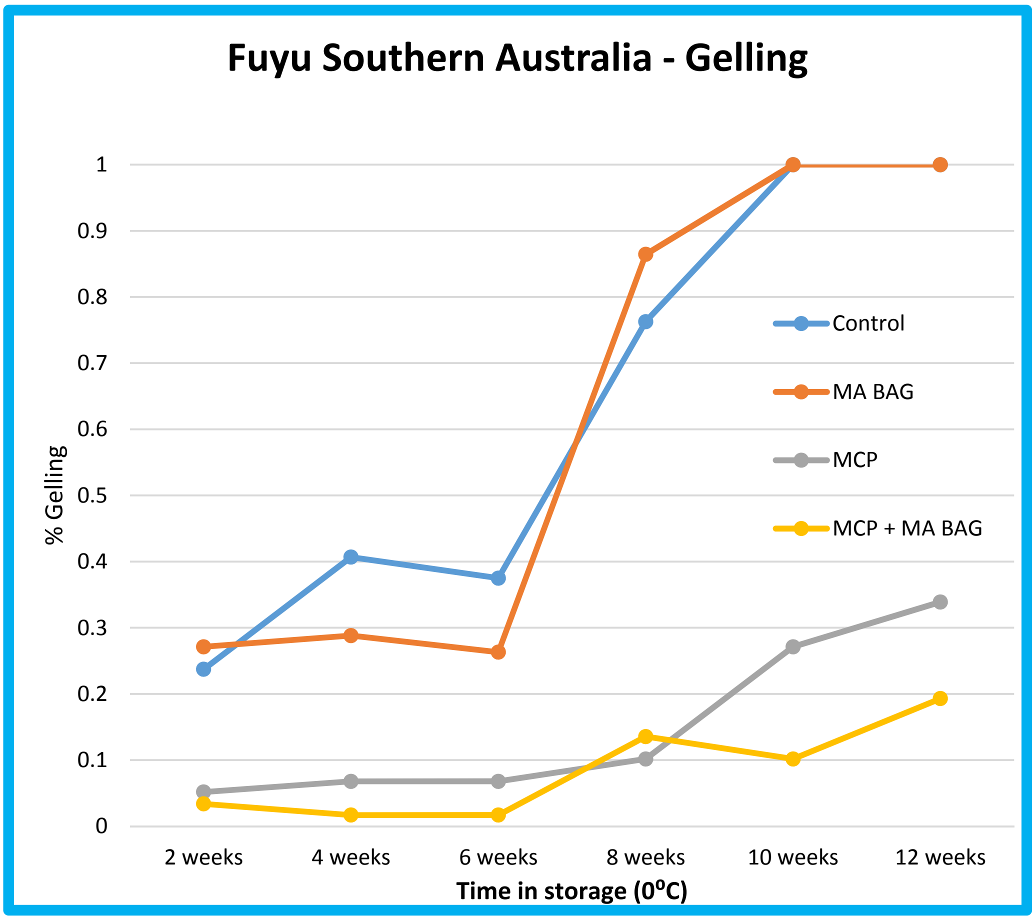
Fruit colour measured three times around the fruit equator using the Japanese persimmon industry colour chart

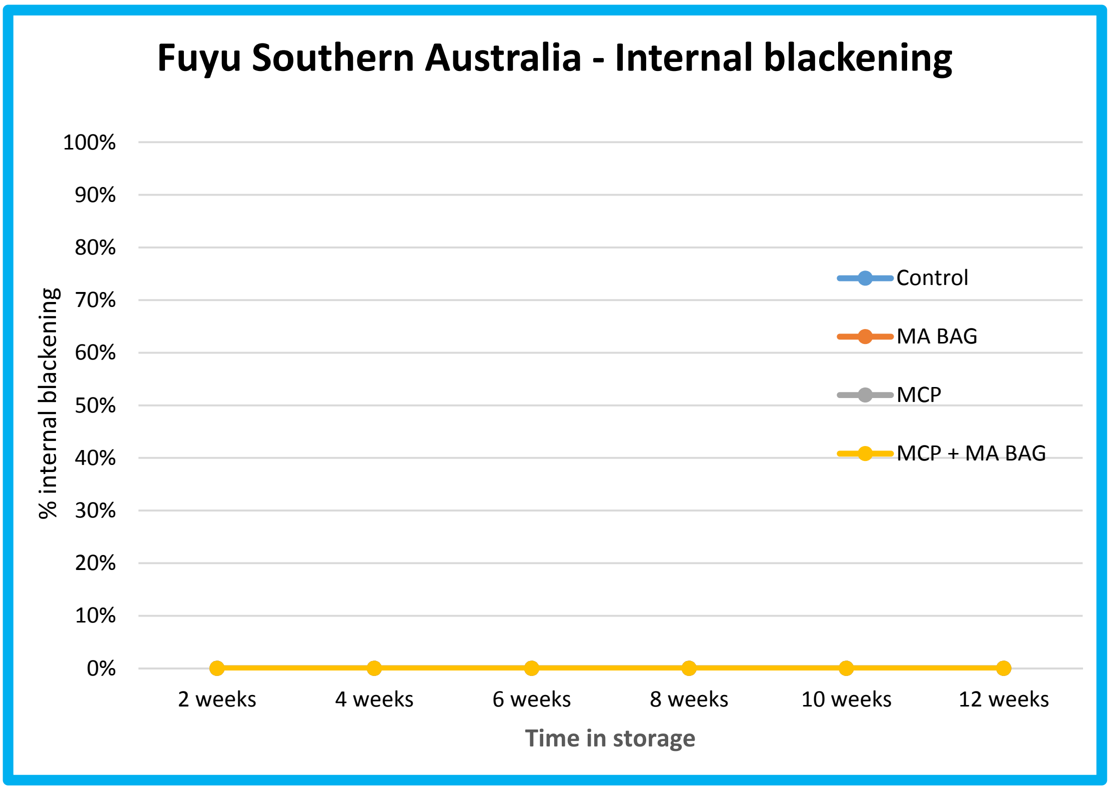


Firmness, using an Effegi penetrometer with an 8mm tip



% Soft = % of fruit < 2.0 kg f/cm^2 (penetrometer)





Summary

Fruit firmness is maintained above 2kg f/cm^2 for 8 weeks for 1-MCP treated fruit with and without MA bags. Chilling injury (gelling) remained below 10% for 8 weeks using 1-MCP and 6 weeks using 1-MCP with MA bags. No internal blackening was observed in any of the treatments over the 12 weeks.

Recommended storage duration for southern Austrlian Fuyu at 0°C

Fuyu from southern Australian can be stored for 6-8 weeks when treated with 1-MCP alone or in combination with MA bags with and expected shelf life of 7 days at ambient temperature.

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

DOMESTIC MARKET – VERY SHORT STORAGE PERIOD (2-5 DAYS)

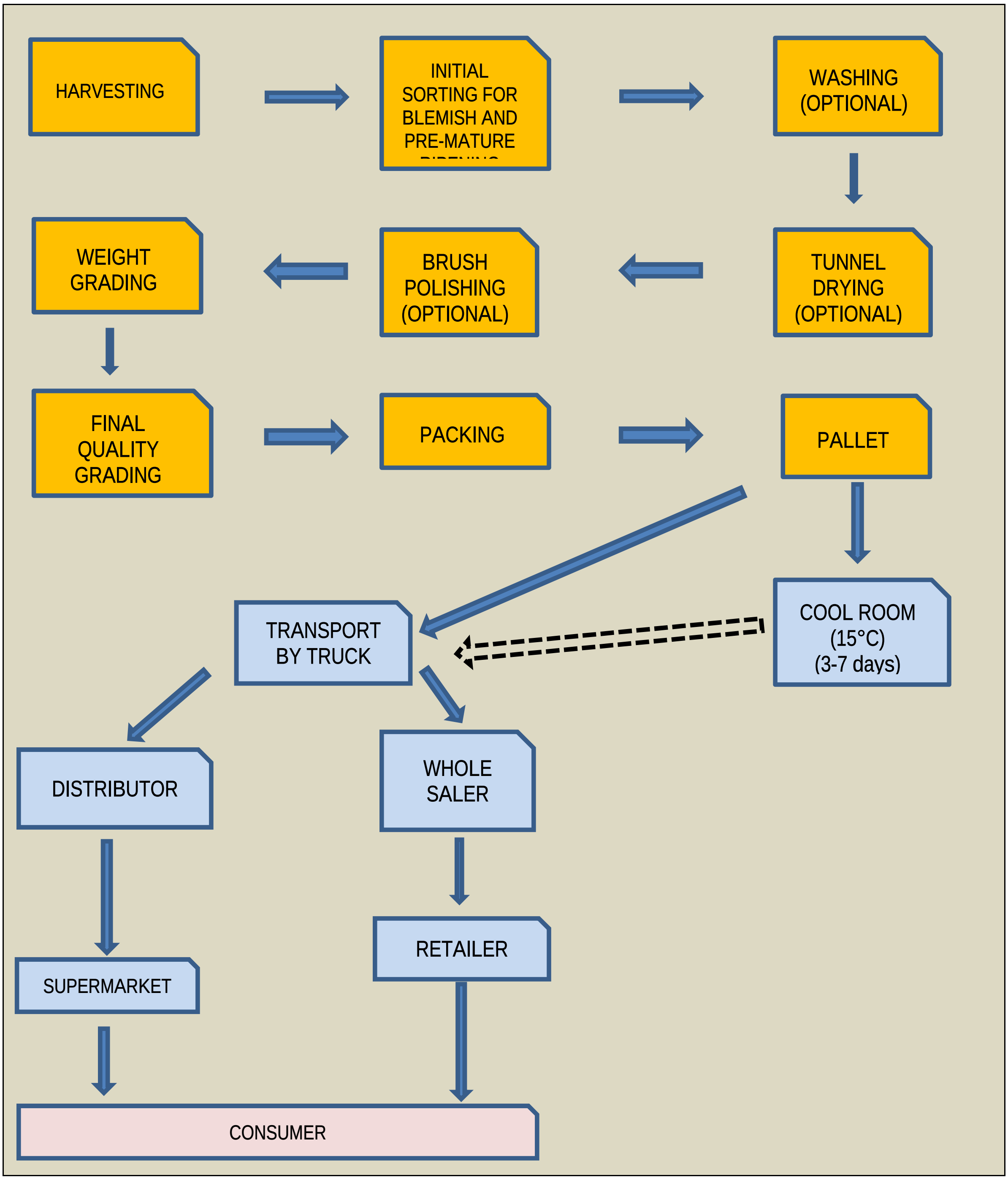


Figure 1. Schematic diagram of the processes and sequences of events from harvesting to consumer – domestic market with and without cool storage. If glove or cloth polishing after weight grading, washing and drying steps would not be needed. If storing fruit for short periods of 3-7 days to avoid glutting, store at 15°C. The cool chain from farm to consumer should be maintained at 15°C.

DOMESTIC MARKET–INTERMEDIATE STORAGE PERIOD (2-3 WEEKS)

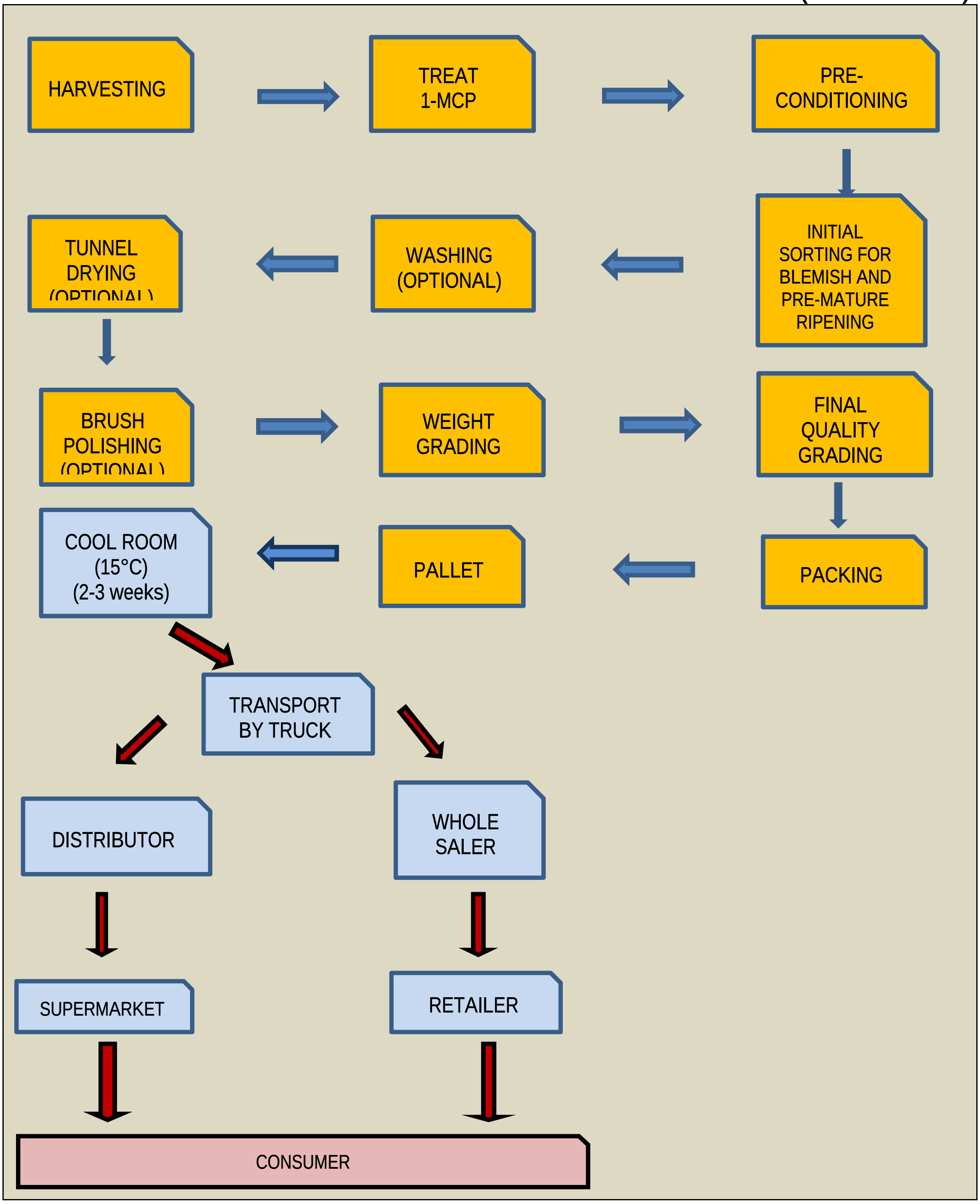


Figure 2. Schematic diagram of the processes and sequences of events form harvesting to consumer – domestic market with moderate cool storage. After harvest, fruit are treated with 1-MCP at 15°. After grading and packing, fruit are stored in the cool room on farm or at the distributors at 15°C. The cool chain from farm to consumer should be maintained at 15°C (boxes in blue).

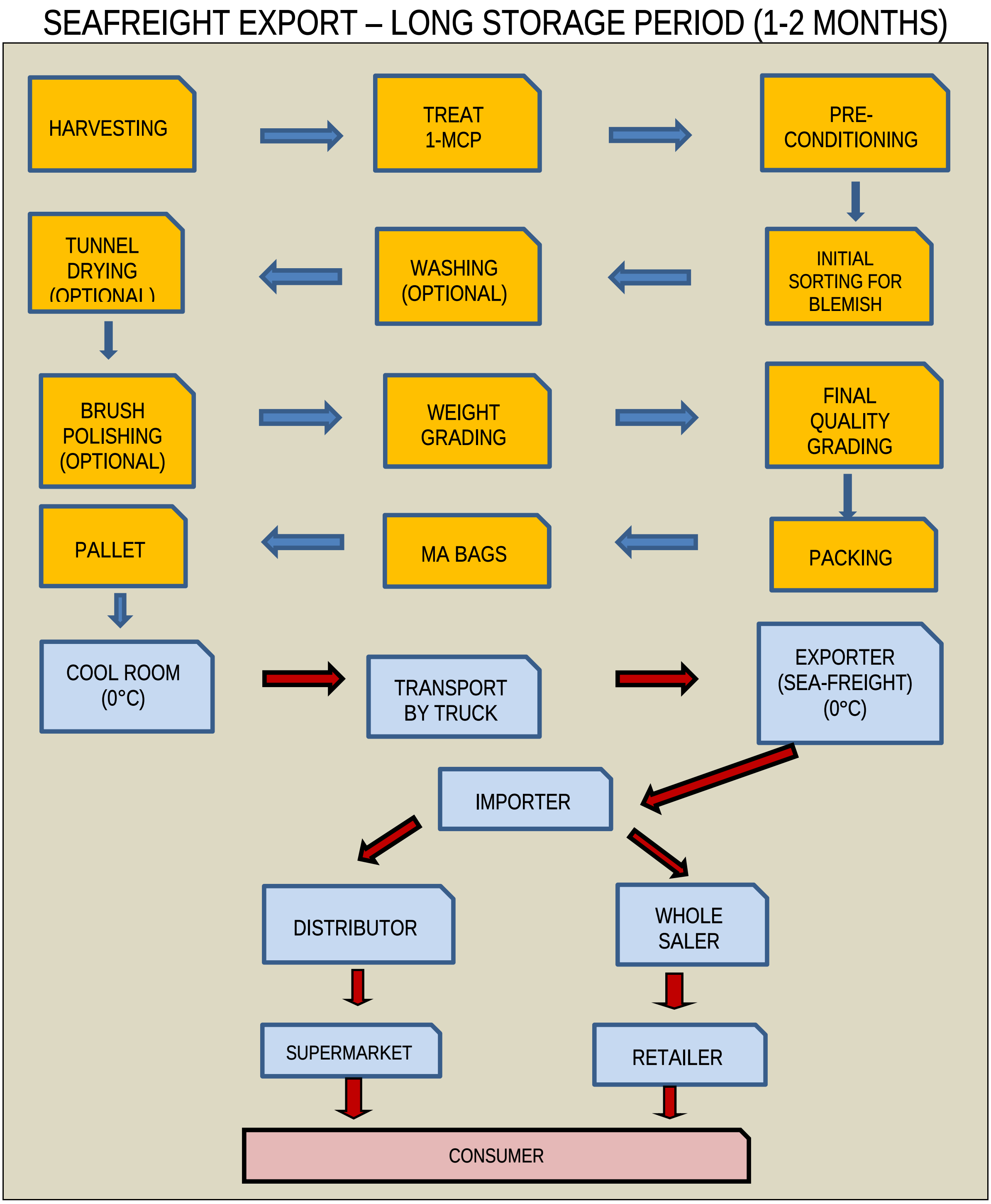


Figure 3. Schematic diagram of the processes and sequences of events form harvesting to consumer –export market with extended cool storage period. After harvest, fruit are treated with 1-MCP at 15°C. After grading and packing, fruit are enclosed in MA bags and transported to exporters for shipment in sea-freight containers at 0°C. The cool chain from farm to consumer should be maintained at 0°C (boxes in blue).

Key points

Growers need to decide if they want to store persimmon fruit for either short, intermediate or long periods

Short-term storage (1-2 weeks) is ideal for alleviating gluts on domestic markets

Long-term storage (1-2 months) is ideal for exports, sea-freighting and cold disinfestation

The grower has four tools that he can use to extend cool storage life and to avoid chilling injury. These are:

- 1-MCP
- MA bags
- Pre-conditioning
- Ethylene absorbents

Of these tools, 1-MCP is the most powerful in extending storage life and preventing chilling injury

Maximum storage life is achieved when MA bags and 1-MCP are used in combination

There are large regional differences in cool storage life – growers need to determine the maximum storage life for their own farms

Growers should trial the use of these postharvest tools on small scale prior to commercial use as there can be large variability between orchards and growing regions.

FORCED-AIR COOLING

Scott Ledger
Formerly with Department of Primary Industries Queensland, Indooroopilly Research Centre

22.1 What is forced-air cooling?

Forced-air cooling is where the cool room air is forced through the container by creating a pressure difference between opposite faces of stacks of vented containers. The cold air moves past the produce inside and removes heat rapidly. Cooling is faster and more even through the stacks than traditional room cooling, where air flow is mainly past the outside of the container.

Highly perishable produce such as persimmon may deteriorate during the supply/value chain if precooling is not effective.

Plate 1. Cool room with forced air fans for rapid and uniform cooling.

22.2 Types of forced-air coolers

A forced-air cooler can be designed for a new cool room or an existing cool room that can be converted to include a forced-air cooler. There are three methods of forced-air cooling:

- tunnel cooling,
- cold wall cooling,
- serpentine cooling.

Serpentine cooling is used for cooling produce in bulk bins and is not discussed in this article.

22.3 Tunnel cooling

Tunnel cooling is suitable for cooling even numbers of bulk bins, pallet loads or floor stacks of containers (Plates 2 and 3).

A row of pallets (or bins or containers) is placed on each side of an air channel that opens into a plenum (large box) mounted with an auxiliary fan. The same number of pallets must be placed in each row.

A reinforced blind is run over and down the end of the air channel (Plate 3). The air is pulled through the containers into the air channel and back through the plenum and auxiliary fan to the cooling unit. When open top containers are cooled, the top of the containers must be covered either separately or by a full width blind.

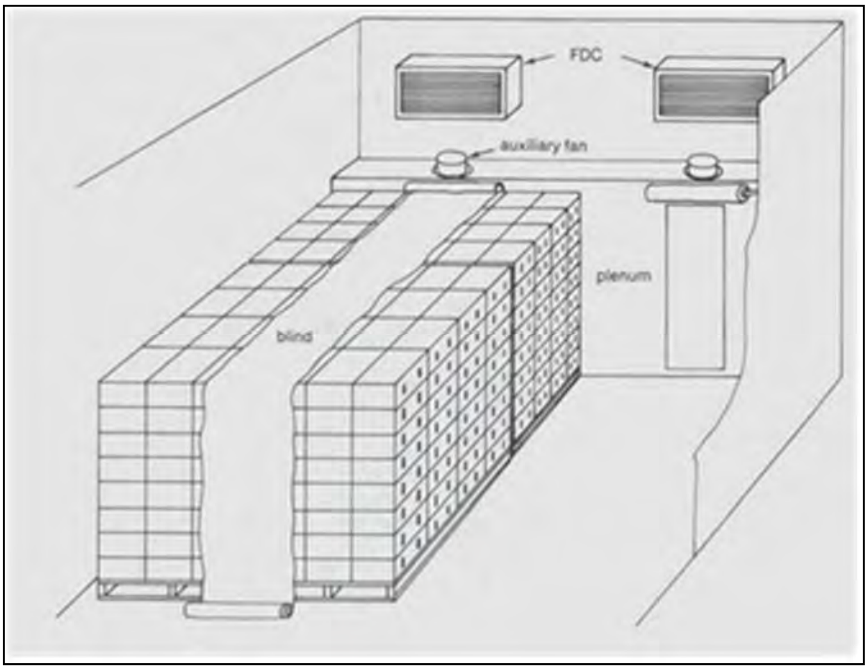


Plate 2. Tunnel cooling.

Plate 3. Tunnel cooling showing reinforced blind which is run over and down the end of the air channel

22.4 Cold wall cooling

Cold wall cooling is suitable for cooling single pallets or stacks of bulk bins and containers (Plate 4). The pallet (or bin or container stack) is placed against an opening of similar width in the plenum. Air is pulled through the containers directly into the plenum and back through the auxiliary fan to the cooling unit. The pallets must only be one deep against the plenum.

For both methods, the auxiliary fan should always be positioned so that the warm air is directed to the back of the cooling unit. The plenum with auxiliary fan can be a fixed structure or a portable box. Multiple openings and fans can be placed in a fixed plenum, with the openings covered when not in use.

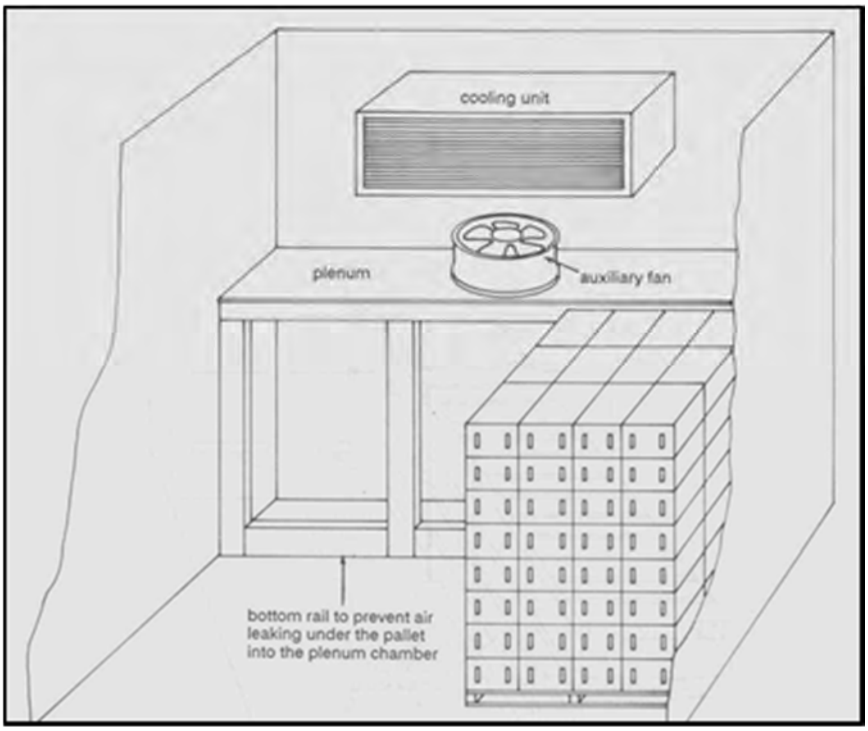


Plate 4. Cold wall cooling.

22.5 Essential design information

Types of produce to be cooled

Is the forced-air cooler to be used for just persimmon or for other produce? The type of produce affects the selection of refrigeration equipment.

Produce weight and volume

This is required for determining room size, refrigeration capacity and auxiliary fan requirements.

Type of container and method of stacking

What type of container is used – single or multiple layers, crates, styros or carton? Are the containers to be stacked on the floor or racks or palletised? If palletised, are they stacked 6 or 8 or 12 per layer and are the pallets placed in parallel rows or directly against the plenum? This information is required for determining room size, plenum design, and the auxiliary fan requirements.

For effective forced-air cooling, the container vent area must be at least 4% of the area of the vented wall. Increasing the vent area is beneficial up to the point where the container strength begins to suffer. For pallet loads and floor stacks with more than one container wide, the vents have to align to allow air to flow through successive containers across the pallet or stack.

Elongated vents are preferable to round holes. Round holes are too easily blocked by the produce. Slots should be as wide as possible within the limits of the container strength. Wide slots minimise the reduction of vent area when containers are misaligned on pallets or in floor stacks.
Where horizontal vents are used along the top edge, the container should also have venting along the bottom edge or in the base.

Cooling time

The desired cooling time determines the product load on the refrigeration system and auxiliary fan requirements. This in turn determines the dimensions of the supply and return air channels for tunnel cooling, a factor in calculating room size. A cooling time of 8 to 12 hours is sufficient for cooling persimmon.

Forklift, reach truck or pallet jack

When handling pallets, allow at least 4.3 meters for turning a forklift, 2.7 meters for a reach truck, and 1.8 meters for a pallet jack.

Stack height.

The stack height and the depth of the cooling unit determine the internal height of the cool room. For some auxiliary fans, additional height may be needed to allow for the depth of the fan casing.

Depth of plenum

The depth of the plenum (front to back) must be allowed for when calculating room dimensions. The plenum has to be of sufficient depth and width to accommodate the fan, clear of any structural supports.

Cooling only or cooling plus holding

If the produce is cooled daily and held for a number of days before dispatch, the design must allow for a holding area in addition to the cooling area (Plate 5). Rapid air movement is required for fast cooling but only slow air movement in needed to maintain the temperature of cooled produce. The cooling unit is placed above the forced-air cooler and the holding area is offset. Another alternative is to have separate cooling and holding rooms.

Location and size of doorways

Doorway location is important in facilitating movement of produce to and from the room and within the room. The doorway is frequently located centrally in an end wall. However, locating it in one corner can often facilitate room loading and allow better room space.

When one end of a cool room is used for cooling and the opposite end for holding, it is convenient to locate the doorway at or towards the centre of one long wall. Doorways must be wide enough to lessen the risk of damage to door jambs when moving pallets. If a forklift is used, the doorway height must be sufficient to allow clearance for the forklift mast.

Full room width doorways can reduce the space needed within a room for moving pallets. Paired doors, each a little wider than half the room width and one sliding behind the other, can be used where there is no space beyond the edge of the room to slide a full width door. Alternatively, a full width door may open vertically if there is sufficient clear height above the room.

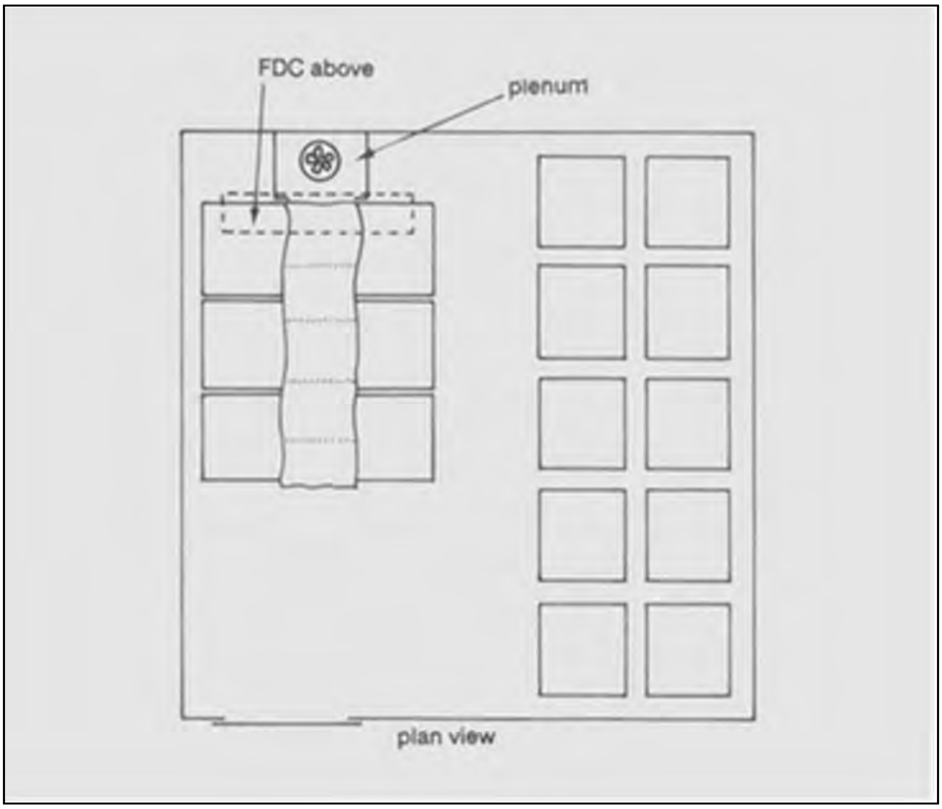


Plate 5. Cooling plus holding.

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22.6 Calculating refrigeration load

The total refrigeration load is the sum of the product load and extraneous heat loads such as wall load and air change load. The wall load depends on the room dimension and the thickness and type of insulation used. As a guide, ⅔ of the refrigeration capacity is needed to cool the produce and the remaining ⅓ for the extraneous heat load.

The refrigeration capacity required to cool the product load is calculated as follows:

- Product load (watts) = $\dfrac{\text{product weight (kg)} \times (t^1\text{-}t^2) \times 1.29}{⅞ \text{ cooling time (hours)}}$

- $(t^1\text{-}t^2)$ = temperature difference (°C) between incoming product and the cool room setting
  ⅞ cooling time = time to cool the product to ⅞ of the difference between initial product temperature and the cool room setting.

Example: Two pallets of persimmon are to be cooled from 27°C to 15°C in a ⅞ cooling time of 12 hours. The container holds 10 kg of fruit and stacks 8 per layer and 10 high on the pallet.

Product load = $\dfrac{2 \times 80 \times 10 \text{ kg} \times 12°C \times 1.29}{⅞ \times 12 \text{ hours}}$

= 2 358 watts

If the refrigeration capacity is not known when adding a forced-air cooler to an existing cool room, a rough estimate can be made as follows:

Refrigeration capacity (watts) = compressor motor horsepower × 1760
or = compressor motor kilowatts × 2360

The amount of refrigeration capacity available to cool the product load will be approximately ⅔ of the total capacity. Using this estimate, the ⅞ cooling time for a specified amount of product can be calculated with the formula above.

22.7 Calculating air flow requirement

The total air quantity required is determined by the total weight of produce to be cooled multiplied by the air flow rate per unit weight for the chosen cooling time. The containers and produce inside create resistance to air movement through the pallet or container stack. The more containers the air is pulled through, the higher the resistance. This resistance is measured as static head of pressure (mm of water).

The auxiliary fan must not only generate the required air flow but must also operate against the static head created. The auxiliary fan requirement is therefore specified as the required air flow quantity and static head rating. When calculating the required air flow, an additional ⅓ air flow is added to allow for air losses leaking around the containers and the pallets.

Information on air flows and static heads for specified cooling times for a range of produce are contained in the publication, “Forced-Air Cooling”. Information on persimmon is not available in this publication.

To cool persimmon in 12 hours in an 8 per layer container, the air flow required is 0.5 litres/second/kg and the static head is 2 mm of water. If the cooling time is decreased to 8 hours, the air flow required increases to 1.0 litres/second/kg and static head to 10 mm of water.

Example: Two pallets of persimmon are to be forced-air cooled in 12 hours. The container holds 10 kg of fruit and stacks 8 per layer and 10 high on the pallet.

Air flowed required = 0.5 litres/second/kg × 2×80×10kg + ⅓ of this amount
= 800 + ⅓×800 litres/second
= 1067 litres/second

The auxiliary fan specification is: - air flow of 1067 litres/second and static head of 2 mm of water.

22.8 Calculating air channel width

For tunnel cooling, the air channels supplying cold air and returning warm air must be wide enough to avoid significant pressure drop in the channels. A significant pressure drop along the length of a return channel (between the 2 rows) can cause uneven air flow through the pallet resulting in differences in cooling times. Information on calculating the width of supply and return air channels is contained in the publication, “Forced-Air Cooling”.

Example: In the example above, both the supply and return air channels would need to be 250 mm wide. That means a gap of 250 mm on the outside of both pallet rows and a 250 mm width for the return channel between the rows. If 2 rows of 2 pallets had to be cooled in 12 hours, 300 mm would be required for the gap on the outside of the pallet rows and 500 mm for the return channel.

Further information

Forced-Air Cooling (1990, second edition). Watkins, J.B. and Ledger, S.N. DPI&F Publications

THE COOL CHAIN

23.1 Importance of the cool chain

A cool chain is a temperature-controlled supply/value chain. Maintaining the cool chain is the responsibility of everyone who handles fresh produce, from producers to retail sales people. A break in the chain, or breakdown in temperature control at any stage, could impact on the final quality of the product.

There can be up to 20% loss of value of product during shipment. Up to one out of every 10 shipments can result in poor product quality out-turn on arrival? Produce is a living, breathing commodity. Once separated from its plant it continues to live on its own resources and produces energy in the form of heat and gives off carbon dioxide. This leads to:

- Ripening
- Weight loss
- Softening
- Colour and texture changes
- Physical degradation, including bruising
- Attack by rots and moulds

In the case of the Australian supply/value chain, persimmons can be moved at least 21 times, involves 9 or more players, and exposes fruit to 15 or more breaks in the cool chain.

Compared to the domestic supply chain the air and sea export chains have more steps, players and cold chain breaks (Table 1).

TABLE 1.
No of players in the supply chain and potential number of breaks (Government of SA).

Description	Domestic	Export air	Export sea
Steps	22	40	33
Players	9	22	22
Cool chain breaks	15	21	18

For persimmon, the ideal cool chain temperature for sending to domestic markets would be 15°C. These fruit temperatures would be obtained in the cool room on farm before road transport to distribution centres.

23.2 Planning and strategies to maintain cool chain

Post-harvest temperature management begins with planning the harvest and field handling. Harvesting when temperatures are too high can cause the produce to rapidly loose quality. Fruit should be not subject to more than 0.5% weigh loss between harvest and beginning of cooling. Therefore, most growers harvest early morning to prevent exposure to excessive heat after harvest. Figure 1 above indicates critical points in the supply chain for export markets where risks to the product quality through maintaining the cool chain, and food safety risks. Therefore, careful planning and strategies need to be put in place to reduce and eliminate risks. Figure 2 shows risks in the domestic supply chain.

Figure 1. Critical points in the export supply chain

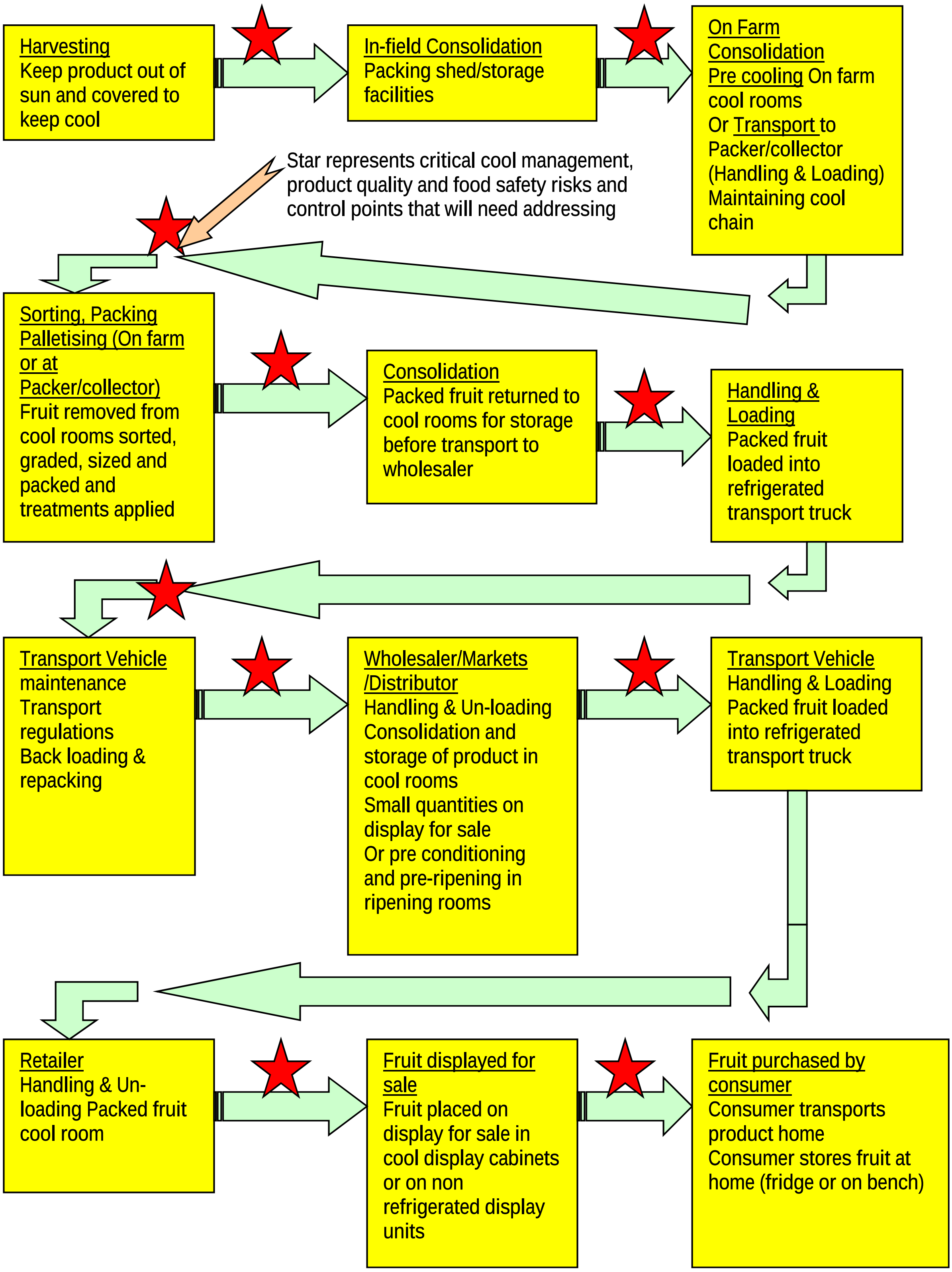


Figure 2. The supply & cool chain of perishable products form paddock to plate for the Australian domestic supply chain.

23.3 Temperature effects on rate of deterioration

The rate of deterioration of perishables increases two to three-fold with every 10°C increase in temperature (Table 2). Temperature has a significant effect on how other internal and external factors influence the commodity, and dramatically affects spore germination and the growth of pathogens.

TABLE 2.
Effect of temperature on the deterioration rate of a non-chilling sensitive commodity.

Temperature (°C)	Assumed Q_{10}*	Relative velocity of deterioration	Relative postharvest-life	Loss per day (%)
0	-	1.0	100	1
10	3.0	3.0	33	3
20	2.5	7.5	13	8
30	2.0	15.0	7	14
40	1.5	22.5	4	25

$$Q_{10} = \frac{\text{Rate of deterioration at temperature T+10°C}}{\text{Rate of deterioration at temperature T}}$$

23.4 In-field and pack-house methods to reduce damage from excessive temperatures

Other methods to protect product form temperature-caused damage are to:

- Make frequent trips between the field and packing shed where temperature cool rooms are located.
- Pack into light coloured containers
- Cover containers with lids and keep out container of the sun and if short field storage is required these must be also shaded. Remember the shade cast by a tree moves with sun during the day.
- Covered field removal produce tractors, trucks, etc. must be used
- Begin cooling as soon as the product arrives at the on farm packing, or produce consolidation shed.
- Consolidation facilities that allow products to be handled in a temperature-controlled environment are essential to maintain the cold chain
- Pick and pack/ palletisation of mixed products need to be done in a controlled temperature environment
- Sealed controlled temperature loading docks to load transport vehicles will minimise temperature fluctuations
- Where temperature controlled loading docks are not available, load trucks directly from cold store under shaded areas

23.5 Product compatibility

Ensure products to be packed together are compatible. In an ideal situation, a container should be loaded with only one type of product.

If products must be loaded together the following matters must be considered:

- sensitivity to ethylene – remember persimmons are very sensitive
- odours
- off-flavours production/sensitivity

Ethylene producing fruit include: ripening avocados, bananas, papaw, tomatoes, custard apples, passionfruit, rockmelons, honeydew melons, apples, pears, stone fruit, figs or guavas.

Fruit and vegetables that do not produce ethylene can be transported with persimmon provided the transport temperature is within the recommended range.

23.6 Monitoring - pulp testing

Pulp testing should be done at all major points in the Cool Chain. Use data loggers throughout the Cool Chain. Electronic thermometers should have a resolution of 0.1°C and be capable of measuring temperatures in the range -5°C to +45°C with an accuracy of ±0.5°C; when measuring a temperature of 0°C, the calibrated accuracy should be ±0.2°C.

Temperature records of produce should be kept, covering the whole period from the time of harvest to the time of export (Plates 1 and 2). Records should be kept of the cooling rate achieved in each cool room.

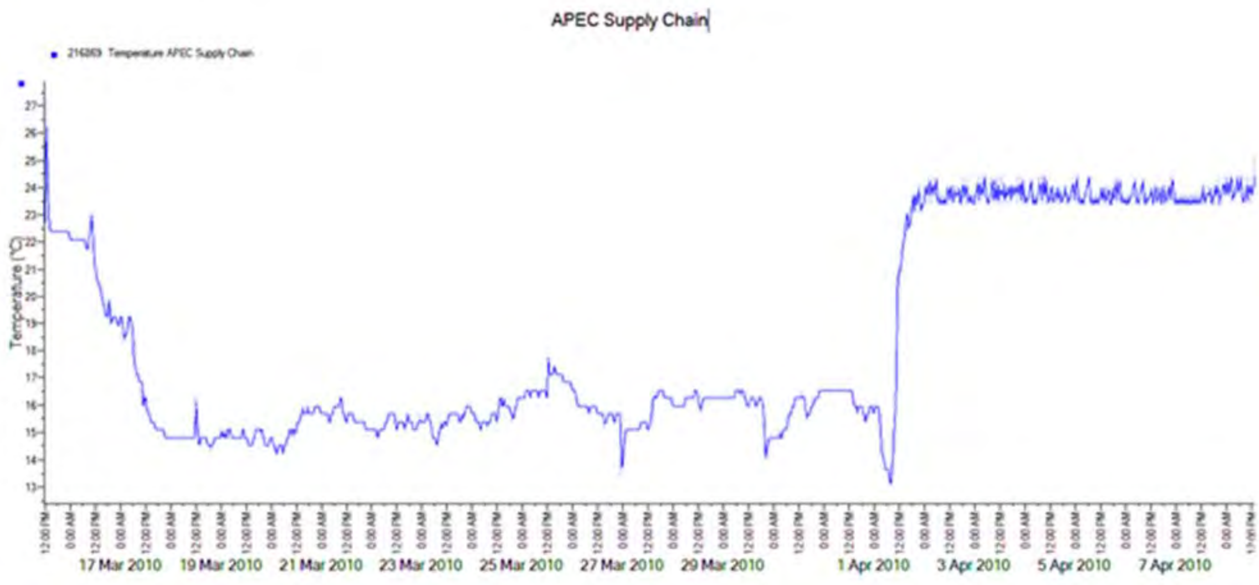
To obtain reliable produce temperatures, the sensing probe must be inserted into the flesh of the produce; pre-cool the probe before use by inserting into another sample of the same piece of fruit.

Produce temperature will vary in packages within the one pallet, and from pallet to pallet, depending on the air circulation in the cool store and the stacking density of the pallets. Produce must be chosen from a number of pallets and at varying packing height locations to obtain temperature variability information.

To obtain an independent record of temperature throughout transport, a self-contained, single-point temperature recorder may be placed in the container. The preferred location for the recorder is in the second package down, at the door end near the centre of the stow or load, and clearly marked with some form of highly visible marking to ensure retrieval on discharge.

If the recorder is placed on top of the load or attached to the ceiling, then the recording will not represent produce temperature but will give information on the performance of the refrigeration unit. Alternatively, a multi-point recorder may be used with temperature sensors placed in the produce as well as in the air.

The recorder on the refrigeration unit on older units records the temperature of the return air, but on some, particularly newer units record the temperature of the delivery air. The accuracy of the recording depends on the care taken during the pre-trip calibration and on any consequential rough handling (e.g. container roughly handled).



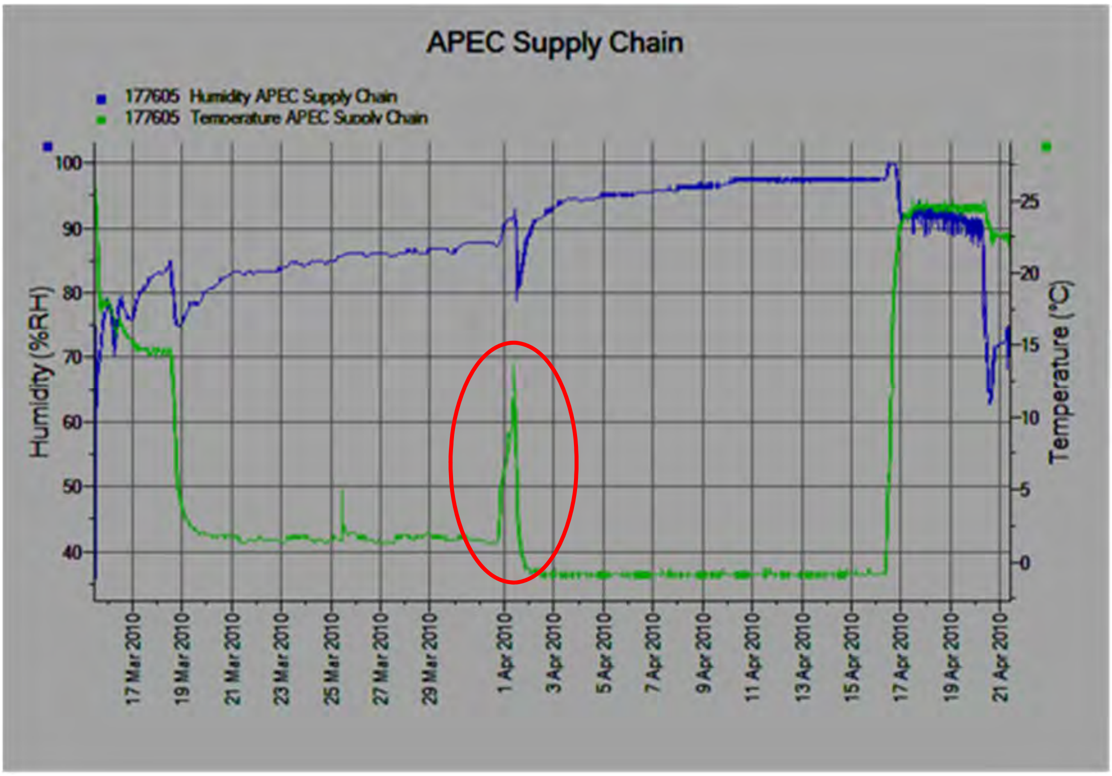


Plate 1. Temperature logger data for trial air-freight shipment of persimmon from south-east Queensland growers to Brisbane to Singapore. Top: fruit held at 15°C. Bottom: fruit held at 0°C. Note: break in cool chain for fruit held at 0°C.

Plate 2. A temperature recorder place in shipments of fruit which can be easily downloaded to show temperature changes during transit.

23.7 Transport trucks

Breaks in the cool chain such as during loading or unloading of trucks or packing of warehouses mean that the cool product will warm up (Jobling, 2001). Warming of only a few degrees can be enough to cause the respiration rate of the product to rise and the oxygen within MA bags to fall below the recommended level (see Chapter 18). If the oxygen level falls too low then anaerobic respiration can be initiated. If this happens alcoholic off flavours develop within the product, making it unmarketable. There is always a risk/benefit when using modified atmosphere packaging, particularly when a low oxygen atmosphere is providing the benefit.

Effective precooling before loading is essential for reliable transport of persimmon. Select your carrier with care and then instruct them as to how you want your product handled, especially as to minimum carrier storage times (both at origin and at destination) and to the vehicle type (Table 3).

Refrigerated trucks and reefer containers are not designed to pull cargo temperatures down - essentially they maintain cargo temperature (Plate 3). A truck or container should not be used to try to cool fruit down. At best it can only reliably maintain fruit at the loading temperature.

During loading and unloading, the load should spend as little time as possible in non-refrigerated conditions – at most 30 minutes. Ideally the loading and unloading platforms should be refrigerated. Good air flow during transport is essential to prevent the heat transfer from outside the vehicle/ container warming the fruit. Travelling at night or early morning reduces heat load on a vehicle that is transporting the product.

Ensure the truck has a working bulkhead and the pallets are stacked so that cold air does not short circuit around the front of the vehicle/container. For example do not leave a gap between the front of the truck and the first pallet as some of the cold delivery air will go directly to the air intake without passing over, around or under the pallets.

When transporting product:

- pallets should be braced or strapped to prevent boxes from leaning against the side walls, or rear doors of the vehicle. Air inflated pillows are convenient and very effective.
- do not obstruct air flow with pallet separators that touch the ceiling, side or floor of the vehicle.

- keep trays on pallets to minimize handling
- restrain loads to minimize movement
- use improved or specialized vehicle suspension
- use refrigerated or insulated vehicles
- keep trays away from truck walls/doors to reduce heat conduction from outside

Minimise ALL transit times, especially non-cold chain delays at holding points, including:

- packing centre
- carriers depot
- container packing depot
- container terminal

There are many instances of carriers and/or drivers loading trucks and then holding in their depot (country/city) without refrigeration. This has led to goods being delivered to container packing depots at unacceptably high temperatures resulting in loss of quality and consequent rejection. Goods may be held by the carrier in their depot for two days with a pulp temperature on delivery to us in excess of *25°C.*

Relative humidity is not usually controlled in refrigerated transport trucks. However if, humidity is added, then absorption by fibreboard containers can occur causing a weakling of packages. Product moisture loss also occur, reducing product quality and shelf life. Therefore, the use of modified atmosphere bags will reduce moisture loss.

TABLE 3.

Maximum travel times for different types of transport trucks.

Truck type	Refrigerated	Maximum travel time	
		10-12°C	0-2°C
Open tray top	No	1 hour	Not recommended
Tautliner	No	3 hours	Not recommended
	Yes	6 hours	3 hours
Insulated van	No	3 hours	1 hours
	Yes	Unlimited	Unlimited
Reefer container	No	3 hours	1 hours
	Yes	Unlimited	Unlimited

Plate 3. Truck with refrigeration unit and insulated walls.

23.8 In store management

The cool chain should be maintained from the grower to the supermarket store. In Korea, individual persimmon fruit in MA bags are displayed in the refrigerated display cabinets (Plates 4 and 5).

Plate 4. Korean persimmon in MA bags held in the refrigerated display cabinets in store.

Plate 5. Persimmon fruit displayed in various types of stores. Note: range in temperatures at which fruit are kept. (Ahn, 2012).

Key points

Growers need to carefully plan the movement of their product along the cool chain

A break in the cold chain generally reduces fruit keeping quality and may cause the development of chilling injury or off favours in fruit held in MA bags

Check product compatibilities – persimmons are very sensitive to ethylene

Monitor temperatures at all points in the cool chain with loggers

Maintain temperatures of fruit in the cool chain at either 0°C or 15°C

HANDLING AND TRANSPORT

24.1 Stacking and palletisation

To prevent spoilage of product through dampness, water, fungal infection it best to place packaged product on wooden pallets. This also improves with ventilations and cooling of the packaged product and moving the product using hand trolleys, trolley jack or fork lifts.

Pallets are to be column stacked with all the same counts where possible 8 per layer trays - 16 layers high with a total of 128 trays on the pallet (Table 1).

When stacking containers, be sure to align them properly. Whenever possible, stack them so that corner matches corner on both the cartons and the pallet.

Most of the strength of corrugated fiberboard containers is in their corners, so an over-hang of only 2 cm will decrease stacking strength by 15 to 34% (Plate 1). Well-aligned stack of cartons has the strongest stacking strength possible (Plates 2 and 3) (Kitinoja and Kader 2002.).

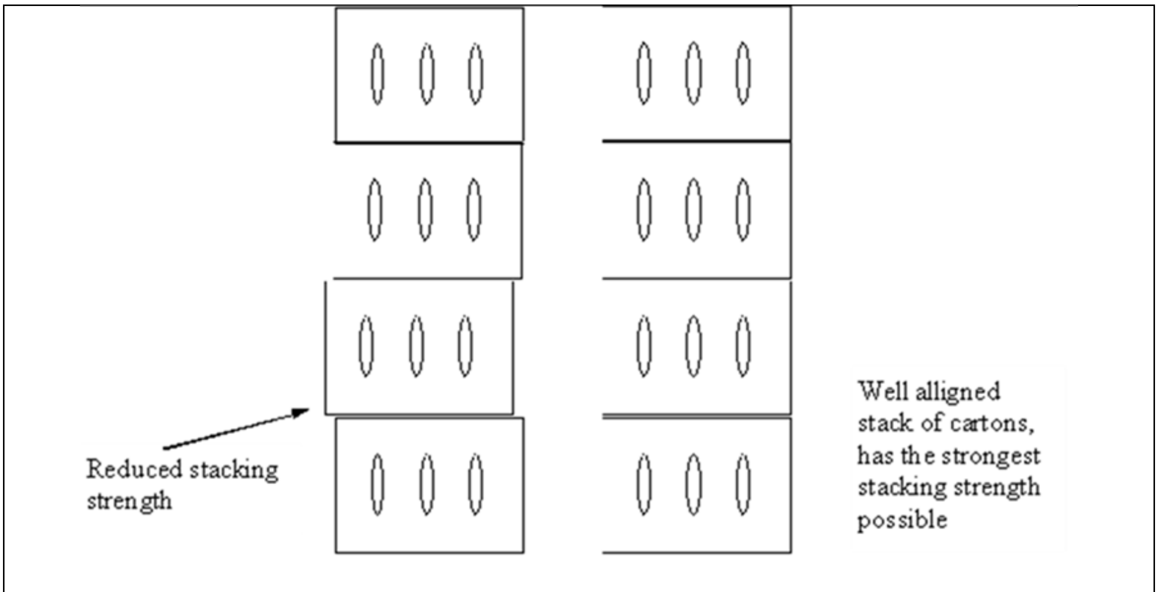


Plate 1. Poor stacked boxes. Source Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops.

Plate 2. 10kg boxes being stacked in layers of 8 on pallet.

TABLE 1.
Packing limits.

Package type	Maximum packing height
P84 tray	18-20 high
P154	12 high

Plate 3. Palletised fruit. Note trays packed to maximum height of 20 trays.

24.2 Strapping

The cartons can be supported with pallet corners and strapping. Please note metal pallet corners and plastic pallet corners should not be used. Woolworths and Coles will not accept pallets stacked using metal or plastic pallet corners

Three straps are required with:

- Bottom - around the second bottom layer
- Top – around the second top layer
- Middle – around the middle layer.

Pallet wrapping using plastic could be used instead of pallet strapping provided air flow is not adversely affected fruit. Wrapping with plastic may increase ethylene concentrations triggering the ripening of persimmon.

Netting allows the product to breathe and allows air movement through pallets, as well as stabilising movement of products during transit (Plate 4). Netting is very suitable for use with persimmon trays and fruit which need to breathe.

Plate 4. Netting used to stabilise trays of persimmon on the pallet.

24.3 Stacking patterns

Produce transported in cartons should also be stacked so as to allow adequate air circulation throughout the load. Plates 5, 6 and 7 illustrate cross-wise offset loading of partial telescopic containers. On the floor of the truck, pallets or other supports should be used to keep the cartons out of direct contact with the floor (Kitinoja and Kader 2002.).

When cartons of various sizes must be loaded together, the larger, heavier containers should be placed on the bottom of the load. Parallel channels should be left for air to move through the length of the load (Kitinoja and Kader 2002.).

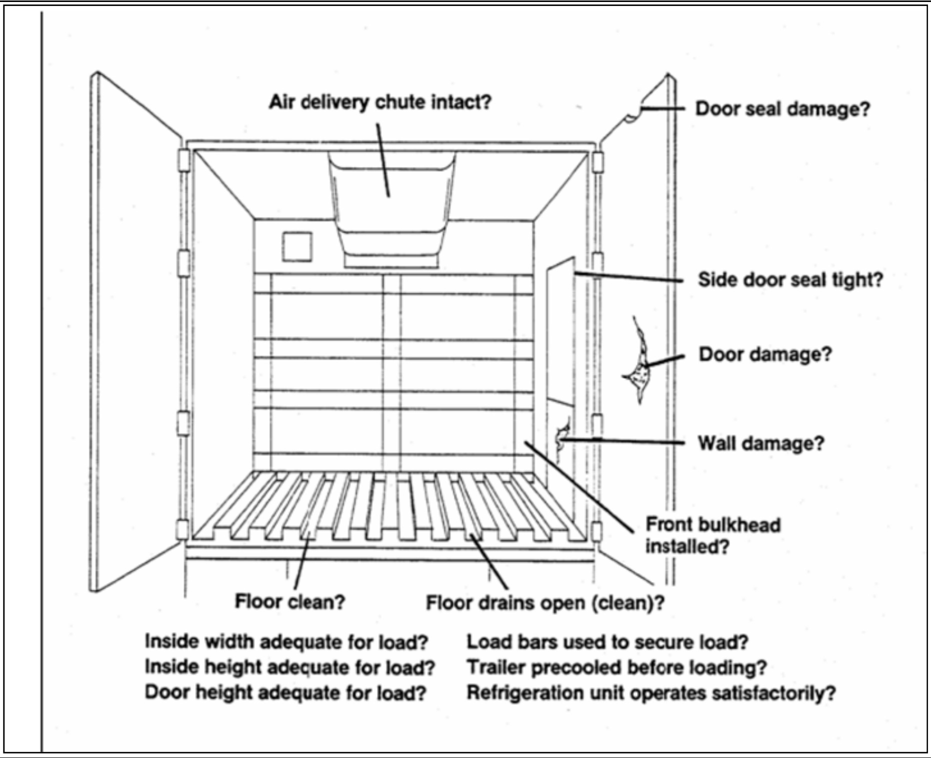


Plate 5. Source: Kasmire, R.F. and Hinsch, R.T. 1987. Maintaining Optimum Transit Temperatures in Refrigerated Truck Shipments of Perishables. University of California Perishables Handling Transportation Supplement No. 2.

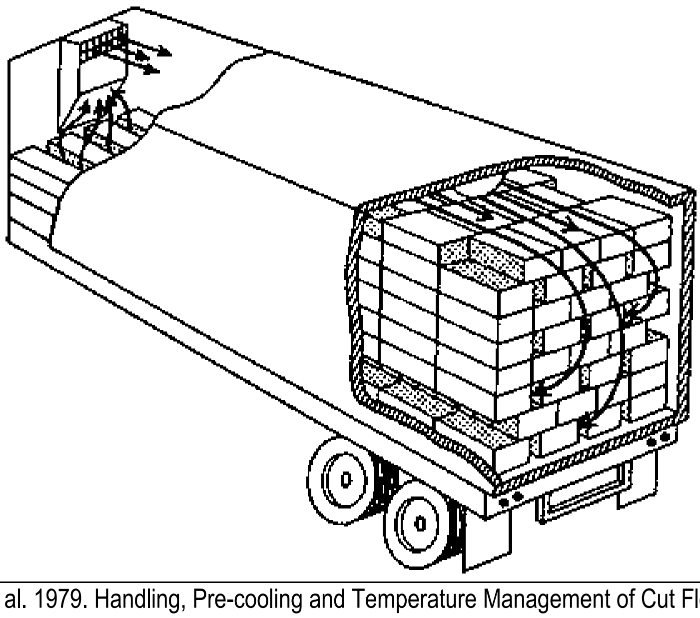


Plate 6. Source: Rij, R et al. 1979. Handling, Pre-cooling and Temperature Management of Cut Flower Crops for Truck Transportation. USDA Science and Education Administration, AAT-W-5, UC Leaflet 21058.

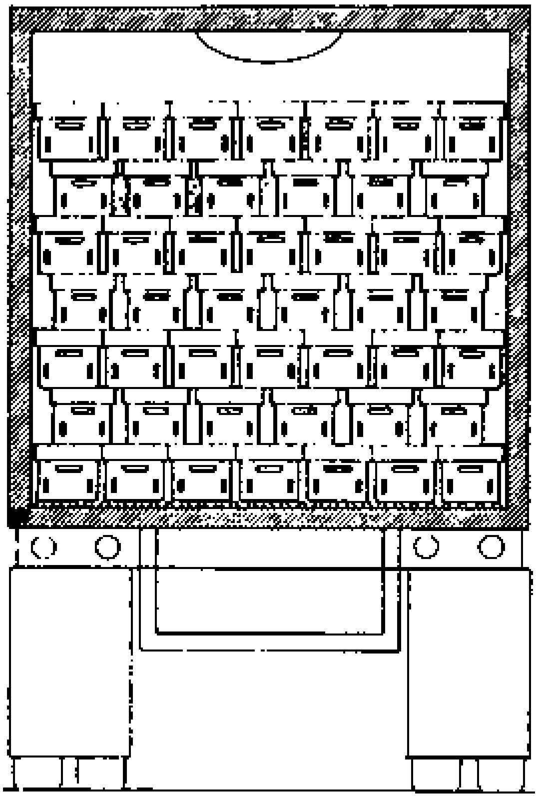


Plate 7. Source: Ashby, B. H. et al. 1987. Protecting Perishable Foods During Transport by Truck. Washington , D.C. : USDA, Office of Transportation, Agricultural Handbook No. 669.

24.4 Bracing the load

There should always be a void between the last stack of produce and the back of the transport vehicle. The load should be braced to prevent shifting against the rear door during transit. If the load shifts, it can block air circulation, and fallen cartons can present great danger to workers who open the door at a destination market. A simple wooden brace can be constructed and installed to prevent damage during transport (Plate 8) (Kitinoja and Kader, 2002).

24.5 Shipping instructions

Clear instructions on how to ship the pallets and grower identification is essential (Plate 9).

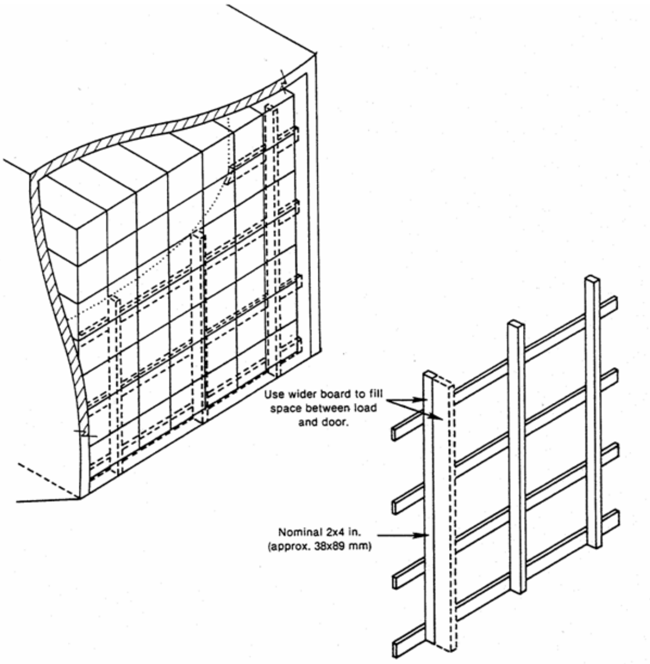


Plate 8. Source: Nicholas, C.J. 1985. Export Handbook for U.S. Agricultural Products. USDA, Office of Transportation, Agricultural Handbook No. 593

Plate 9. Clear instructions on shipping pallets and identification is essential.

QUALITY ASSURANCE AND FOOD SAFETY

25.1 Introduction

In Australia, processes have been designed to reduce risks and manage the factors affecting product quality and food safety along the horticultural supply chain. The majority of Australian growers and processors already have food safety schemes on their farms and/or in their processing facilities. Food Standards Australia New Zealand (FSANZ) estimates approximately 75 per cent of Australian growers are covered by quality assurance scheme. Most growers and pack-houses in Australia are accredited to 3rd party audited internationally-recognised quality assurance systems such as:

- SQF 2000,
- HACCP
- Globalgap

or nationally-recognised systems such as

- Freshcare™
- WQA (Woolworths Quality Assurance)

In this Chapter, we present only a brief overview of QA systems and food safety protocols. We would recommend that all growers of persimmon receive extensive training in QA from an accredited provider.

25.2 Definition of Quality assurance

Quality Assurance (QA) is a term used to describe all the practices that give a business and its customers confidence that the product produced will consistently meet specified food safety and quality standards. Growers of all horticultural produce are now obligated to have a QA system in place. Most QA programs incorporate HACCP processes. For new growers training in QA is available. A brief description of most commonly used QA programs used by persimmon growers is presented below.

25.3 HACCP

What is HACCP?

- H=Hazard,
- A=Analysis
- C=Critical
- C=Control
- P=Point

A HACCP system is based on a food safety risk assessment that identifies and controls food safety hazards (microbiological, chemical and physical).

HACCP Certification is conducted against the accepted Hazard Analysis and Critical Control Point (HACCP) principles and guidelines as outlined by the Codex Alimentarius, CAC/RCP 1-1969, rev. 4-2003. All QA programs incorporate HACCP protocols.

HACCP is all about risk management. It is about a systematic technique or process designed to:

- Identify Hazards
- Determine the critical control points (CCP)
- Establish critical limits for each (CCP)
- Establish a system to monitor control of the (CCP's)
- Establish the corrective actions to be taken
- Establish verification procedures and then
- Establish documentation

One of the main reasons for implementing a documented food safety system is to demonstrate to your customers your willingness to supply safe, quality food all the time. Major supermarkets are now going all the way with Quality Assurance, and using it as a tool to advertise. Another reason is litigation, should a grower or anyone involved in your food supply, which turns out to have been contaminated by a process performed by you or whilst in your care, the grower is liable for prosecution. A documented HACCP food safety system will give you access to markets previously unattainable.

25.4 Freshcare™

Freshcare™ is an industry owned, not-for-profit on-farm assurance program, established and maintained to service the Australian fresh produce industry. Freshcare™ is currently the largest Australian on-farm assurance program for fresh produce; proudly providing on-farm food safety and quality and environmental certification services to over 5 000 members nationally.

The foundations of the Freshcare™ Program are the user-friendly Codes of Practice and detailed training support materials. The Freshcare Codes describe the practices required on farm to provide an assurance that fresh produce is safe to eat, has been prepared to customer specifications and legislative requirements; and has been grown with care for the environment. More details can be found at the Freshcare™ website: www.freshcare.com.au/

The Freshcare™ Code of Practice Food Safety identifies good agricultural practices required to:

- identify and assess the risk of food safety hazards occurring during land preparation, growing, harvesting and packing of fresh produce
- prevent or minimise the risk of food safety hazards occurring

- prepare produce to customer specifications
- identify, trace and withdraw/recall produce
- manage staff and documentation
- review compliance

25.5 QA systems for Australian Supermarkets

All major retailers have in place systems where produce will only be purchased from suppliers who can guarantee food safety standards under a food safety quality management system based on Hazard Analysis and Critical Control Point (HACCP). As most fruit is currently supplied to retailers through produce wholesalers (agents and merchants in the major metropolitan produce markets), these wholesalers will have to meet the HACCP requirements. In turn, growers supplying them will be required to meet certain food safety standards and become approved suppliers. It is likely that, in time, other quality issues and price look up numbers (PLUs) will also be required as conditions of approved supplier status.

Growers supplying supermarkets such as Woolworths or Coles must have implemented an acceptable QA program to meet the standards set by these supermarket chains. For example, Woolworth's standards are set out in Woolworths Quality Assurance Manual (WQA version 7). WQA version 7 incorporates HACCP processes. Growers supplying Woolworths will be audited every 6 months. More details can be found at their website*:* www.wowlink.com.au

25.6 SQF - SQF1000 and SQF2000

The SQF (Safe Quality Food) Program is a leading global food safety and quality certification program developed in 1994 and now owned by the Food Marketing Institute (FMI).

The program is designed as a food safety program based on the systematic application of Codex HACCP principles and guidelines but includes quality to assure customers that a management system is in place to deliver Safe Quality Food that meets both their own and regulatory requirements.

The program has two standards based on the type of food supplier:

- SQF1000 - Primary Producers
- SQF2000 - Food Manufacturing and Distribution

These Standards are recognised by the Global Food Safety Initiative (GFSI) and provide a link between primary producers, manufacturers, distributers and agents. They are also recognised by retailers and food service providers around the world who require HACCP food safety and quality management systems of their suppliers.

25.7 GlobalGAP (formerly EurepGap)

For growers exporting to Europe and other countries, the internationally recognized QA system is GlobalGap. GlobalGap is a common standard for farm management practice created in the late 1990s by several European supermarket chains and their major suppliers.

GAP is an acronym for Good Agricultural Practices. The aim was to bring conformity to different retailers' supplier standards, which had been creating problems for farmers. It is now the world's most widely implemented farm certification scheme. Most European customers for agricultural products now demand evidence of GlobalGAP certification as a prerequisite for doing business.

Like most QA systems, the GlobalGAP standard was developed using the Hazard Analysis and Critical Control Points (HACCP) guidelines published by the United Nations Food and Agriculture Organization, and is governed according to the ISO Guide 65 for certifications schemes. Unlike other farm certification schemes, it has definitive rules for growers to follow, and each production unit is assessed by independent third party auditors. These auditors work for commercial certification companies who are licensed by the GlobalGAP secretariat to conduct audits and award certificates where merited.

25.8 Codex Alimentarius regulations

The Codex alimentarius is the internationally recognized standard on food safety. Its protocols are the basis of all QA food safety programs. The Codex Alimentarius Commission (*www.codexalimentarius.net/)* was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organizations.

25.9 What is food safety hazard?

A food safety hazard is any chemical, biological, or physical substance or property that can cause fresh fruit and vegetables to become an unacceptable health risk to consumers.

In Australia, food safety standards are set by FSANZ (*www.foodstandards.gov.au*.) These Standards include requirements for food businesses to meet minimum standards in relation to food safety practices, food premises and equipment.

Food safety hazards can be acute or chronic:

- Acute is where an immediate health response occurs as a result of contamination
- Chronic is where the accumulation of a contaminant results in a delayed health response

Food safety is extremely important because by applying food safety processes and procedures it will:

- To protect consumer health
- consumers expect that food is safe to eat

To gain market access:

- retailers are requiring suppliers to implement food safety systems right back to the farm
- governments are introducing regulations to minimise the risk of food safety hazards occurring in both in local and international trade

Food-borne disease outbreaks associated with fruit and vegetables are a relatively small percentage of all food-borne disease outbreaks, but the number of cases is increasing.

Food safety is a growing issue world-wide with a series of food poisoning and disease outbreaks and fatalities occurring on all continents in recent years associated with fruit and vegetables.

25.10 Types of food safety

There are three types of food safety hazards:

- Chemical
- Biological

- Physical

25.11 Chemical hazards

Harmful chemicals at high levels have been associated with chronic illness and death. For example, in one Asian country, the Ministry of Health reported that in the four year period from 1999 to 2002, nearly 20 000 citizens were poisoned by vegetables products with 250 subsequently dying. Studies have found pesticide residue levels and other chemical contaminants including nitrates and heavy metals to be well above maximum residue limits (MRL).

Chemical contaminants in fresh fruit and vegetables may be naturally occurring or may be added during production and post-harvest handling (Table 1).

TABLE 1.
Types of hazards and causes of contamination.

Hazards	Causes of contamination (examples)
Pesticide residues in produce exceeding maximum residue limits (MRLs)	Pesticide not approved for target crop Incorrect mixing Withholding period not observed Equipment faulty or not calibrated Pesticide in soil from previous use Dumping or accidental spillage of pesticide into soil or water source
Non pesticide contamination – lubricants, cleaners and sanitisers, paint, refrigerants, vermin control chemicals, fertilisers, adhesives, plastics	Inappropriate chemicals used for cleaning and sanitation Oil leaks, grease, paint on equipment in contact with produce Residues in picking containers used to store chemicals, fertilisers, oil, fuel Spillage of chemicals (lubricants, cleaners, vermin control chemicals) near produce and packing materials
Heavy metal residues (cadmium, lead, mercury) in produce exceeding maximum levels (MLs)	Continued use of fertilisers with high levels of heavy metals High levels of heavy metals in soil naturally or from previous use or leakage from industrial sites
Natural toxins – allergens, mycotoxins, alkaloids, enzyme inhibitors	Unsuitable storage conditions – for example, storage of potatoes in light
Allergenic agents	Traces of a substance that causes a severe reaction in susceptible consumers – for example sulphur dioxide used to prevent rots on grapes

25.12 Biological hazards

Biological hazards are caused by living organisms, in particular microbes. Microorganisms or microbes are small organisms that can only be seen through a microscope. Microorganisms are found everywhere in the environment.

Fruit and vegetables contain a dynamic and diverse mixture of microorganisms. The produce we handle daily may contain as many as 100 million organisms per gram as normal inhabitants that do not affect the health of consumers. There are 3 classes of microorganisms in relation to food safety:

- Beneficial – act on food to produce desirable quality characteristics such as aroma, texture, microbiological stability – for example yeast for making cheese.
- Spoilage – spoil the food by producing undesirable quality characteristics such as unsoundness and bad odour and flavour – for example fruit rots.
- Pathogenic – affect consumer health – illness is either caused the microorganism itself growing inside the human after eating (infection) or by toxins produced by the microorganism (toxicity).

Pathogenic microorganisms are mostly found on the outside of fresh fruit and vegetables but some can get inside the plant tissue. The most common types of pathogenic microorganisms are:

- Bacteria
- Parasites
- Viruses

Bacteria

Bacteria are the most common cause of food-borne illness. The number of bacteria that must be present to cause human illness varies with the organism and the age and condition of the produce. In order to reproduce, bacteria require adequate nutrients and appropriate environmental conditions such as humidity, oxygen and temperature. Bacteria can grow rapidly in a very short time. In 7 hours, one bacterial cell can generate over a million cells.

Pathogenic bacteria that have been linked to contamination of fresh fruit and vegetables are:

- *Salmonella species*
- *Escherichia coli (E. coli)*
- *Shigella species*
- *Campylobacter species*
- *Listeria monocytogenes*
- *Clostridium botulinum*
- *Bacillus cereus*
- *Staphylococcus aureus*
- *Yersinia enterocolitica*

Bacteria such as *Listeria monocytogenes, Clostridium botulinum, Bacillus cereus* can survive in the soil for up to 60 days. Produce contamination can be caused by soil contact with the edible part of the produce either directly or through dirty containers and equipment.

Other bacteria such as *Salmonella species, E. coli, Shigella species, and Campylobacter species* reside in the intestinal tract of animals and humans. They can contaminate fruit and vegetables through the use of animal manures, contaminated water, and humans handling produce.

Parasites

Parasites are organisms that live in another living organism, called the host. They are unable to multiply outside an animal or human host but can cause illness with only a low number of organisms. Fruit and vegetables can act a vector to pass a parasite from one host to another – animal to human or human to human. Cysts, the dormant phase of parasites, can survive and remain infectious for up to seven years in the soil – for example Giardia. Water contaminated with faecal material, infected food handlers and animals in the field or packing shed can be vectors for contamination of produce with parasites. Parasites most commonly associated with contaminated fruit and vegetables are:

- *Cryptosporidium*
- *Cyclospora*
- *Giardia*
- *Helminthes*

Viruses

Viruses are very small and unable to reproduce outside of a living cell and do not grow in or on fruit and vegetables. However, produce can act as a vector to pass viruses from animals to humans or between humans. Low numbers of surviving viruses on produce can cause illness. Viruses that have been passed onto humans through contaminated produce are:

- Hepatitis A
- Norwalk virus and Norwalk-like virus

25.13 Sources of contamination from pathogenic microorganisms

- Soil
- Water
- Animal manure
- Sewage fluids
- Humans
- Animals
- Dust carried by air

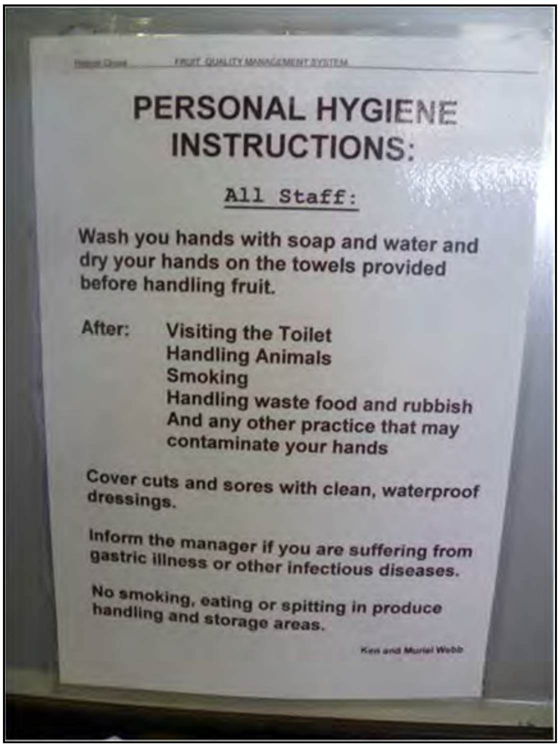


Plate 1. Staff should be instructed on personal hygiene.

25.14 Physical hazards

Physical hazards are foreign objects that can cause illness or injury to consumers. Contamination can occur during production and postharvest handling (Table 2, Plates 2 and 3).

Types of physical hazards include:

- Glass
- Wood
- Metal
- Plastic
- Soil and stones
- Personal items – jewellery, hair clips
- Other – paint flakes, insulation, sticks, weed seeds, toxic weeds

Plate 2. Dirty cups can be a source of contamination.

TABLE 2.
Physical contamination hazards.

Hazards	Causes of contamination (examples)
Foreign objects from the environment – soil, stones, sticks, weed seeds	Harvesting of ground crops during wet weather Dirty harvesting and packing equipment, picking containers, packaging materials Stacking of dirty containers on top of produce
Foreign objects from equipment, containers, buildings and structures – glass, wood, metal, plastic, paint flakes	Broken lights above packing equipment and areas where produce is exposed Damaged picking containers, harvesting and packing equipment, pallets Inadequate cleaning after repairs and maintenance
Foreign objects from human handling of produce – jewellery, hair clips, personal items	Careless or untrained staff Inappropriate clothing

25.15 Cleaning and sanitising programs

Cleaning should encompass:

- transport equipment used in the field or packing house and between the field and packing house
- containers or bins used for transfer or storage of fruit at any stage of the operations
- the packing shed, including floors, walls, drains, door and window screens
- cool rooms and storage rooms
- air conditioning units
- staff facilities (toilets, lunch rooms, etc)

- packing lines including bin tippers, conveyors, tanks and water flumes, dryers, grading belts/cups/chutes
- storage areas

Sanitising follows the cleaning process. Sanitisers are designed to significantly reduce the numbers of remaining viable microorganisms and so render the surface safe. They will not kill all

microorganisms. General classes of sanitisers that can be used on surfaces and equipment include:

- chlorine agents
- iodine compounds
- quaternary ammonium chloride compounds
- peroxy compounds
- acid anionics
- carboxylic acids

Plate 3. Swabbing wash brushes for microbial contamination. Guidelines for the Management of Microbial Food Safety in Fruit Packing Houses Bulletin 4567.

25.16 Australian Certification Schemes

In Australia, a scheme has been set up to deal with fruit movement between states. The Interstate Certification Assurance Scheme (ICA) is a national scheme of plant health certification that is accepted by all states and the Northern Territory. The national ICA scheme provides a harmonised approach to the audit and accreditation of business throughout Australia and the mutual recognition of Plant health Assurance Certificates accompany consignments of produce moving intra and interstate (DPI, 2004).

ICA is based on operational procedures developed by DPI in conjunction with industry and interstate quarantine authorities. Operational procedures describe the management system, processes and process control that must be implemented and maintained by a business to become accredited to certify a specific quarantine requirement has been met (DPI, 2004).

Key points

Food safety is becoming increasingly important to consumers

All growers will need to implement QA programs based on HACCP protocols to market their fruit

QA system/standards will vary within and between countries – growers must use the appropriate system to gain market access

EXPORTING

26.1 Export markets

There are both domestic and export markets for non-astringent persimmons. The domestic market is small and sensitive to oversupply. The economics of growing persimmons is most strongly determined by what percentage of production meets export standards. Postharvest losses along the export supply chain are an issue; with some fruit going soft and collapsing while all the other fruit stays in good condition.

The major export markets are:

- Singapore
- Hong Kong
- Thailand
- Malaysia

These markets take around 70% of total Australian exports. Most other Asian countries, the Middle East and Pacific islands represent small markets with varying potential for development. Over the past decade, exports of Australian persimmons have increased steadily from virtually nil to more than 100 000 trays (400 tonnes). This represents about 20 per cent of national production. The Australian marketing season extends from late February to early June. From late April onwards, competition from New Zealand, which has an industry five times bigger than Australia's, can be expected.

Different export countries prefer fruit of different sizes. For example, Thailand prefers large fruit with counts of 12-16 whereas Singapore prefers smaller fruit with counts between 18-25 and bulks.

All exports are currently airfreighted. However, new post-harvest technologies using combined MA bags and 1-MCP will make sea-freight a reliable alternative. Quarantine barriers prevent Australian access to markets such as Japan, China, Korea and Taiwan. Therefore, new disinfestation protocols to access these markets need to be developed and implemented.

26.2 Australian Persimmon Export Company

The Australian Persimmon Export Company (APEC) is entirely grower owned and controlled. Members come from five Australian states (Queensland, New South Wales, Victoria, South Australia and Western Australia). APEC is the major Australian persimmon exporter, handling well over half of Australia's total persimmon exports, and about two-thirds of the Australia's exports to Singapore.

APEC has set its own grade standards which are enforced by the company. APEC has also developed its own quality management program, and two dedicated brands:

- Sweet Gold
- Golden Star.

APEC's marketing focus is on Asian countries, particularly Singapore, Malaysia, Hong Kong and Thailand. Grower members of APEC personally visit these markets every year to build relationships with our agents and consumers, ensuring good supply chain relationships.

Plate 1. APEC export brand names.

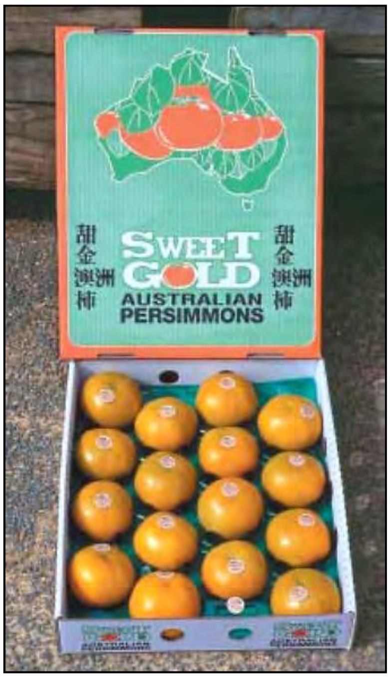


Plate 2. High quality 'Fuyu' persimmons packed in a single layer tray for export.

26.3 Air-freight vs. sea-freight

Currently all persimmons exported from Australia are air-freighted in AV containers. In contrast, most NZ persimmons are sea-freighted (Plates 3 and 4). With the new developments in post-harvest technologies using 1-MCP and MA bags it is now feasible to sea-freight persimmon fruit from Australia. Depending on destination, the duration of cool storage required for sea-freighting to Asia as compared with air-freighting is about 40% longer (Table 1).

The advantages of sea-freight are that it is considerably cheaper and secondly fruit can be cold disinfested whilst in transit.

TABLE 1.
Activities of supply chain participants and estimated duration.

Activity	Export to Hong Kong (days per activity)	
	Airfreight	Sea-freight
Harvesting	1	1
Pre-conditioning	2	2
Application of 1-MCP	1	1
Transport to exporter	1	1
AQIS inspection	1	1
Air freight	1	-
Sea freight	-	14
Customs	2	2
Importer	2	2
Quarantine inspection	1	1
Distributor	3	3
Wholesaler	1	1
Retailers	4	4
Consumer	4	4
TOTAL	25 days	37 days

Plate 3. Trial sea-freight container of persimmons being treated with 1-MCP (SmartFresh).

Plate 4. Sea-freight container of NZ persimmons being loaded for export. Note: ventilation spaces around the stacks of trays.

26.4 International Quality Standards

Growers exporting fruit must implement a quality assurance program recognised by the importing country. This may be: HACCP, SQF 2000 or GlobalGap (see Chapter 25). Export standards include minimal chemical residues, lack of food contamination organisms, freedom from foreign matter as well as quality parameters such as good shelf life, colour, and flavour. In addition, importers are moving towards demanding individual produce labels containing PLUs (Price look up numbers).

26.5 Export issues

Several shipments of Australian persimmon to Singapore and Thailand have been rejected in recent years. Major problems identified have been:

- Soft fruit disorder
- Presence of fruit fly
- Presence of mealybugs

All export fruit must be thoroughly checked for pests and diseases. Before the fruit leaves the pack-house it should be inspected by experienced personnel (see Plates 5 and 6).

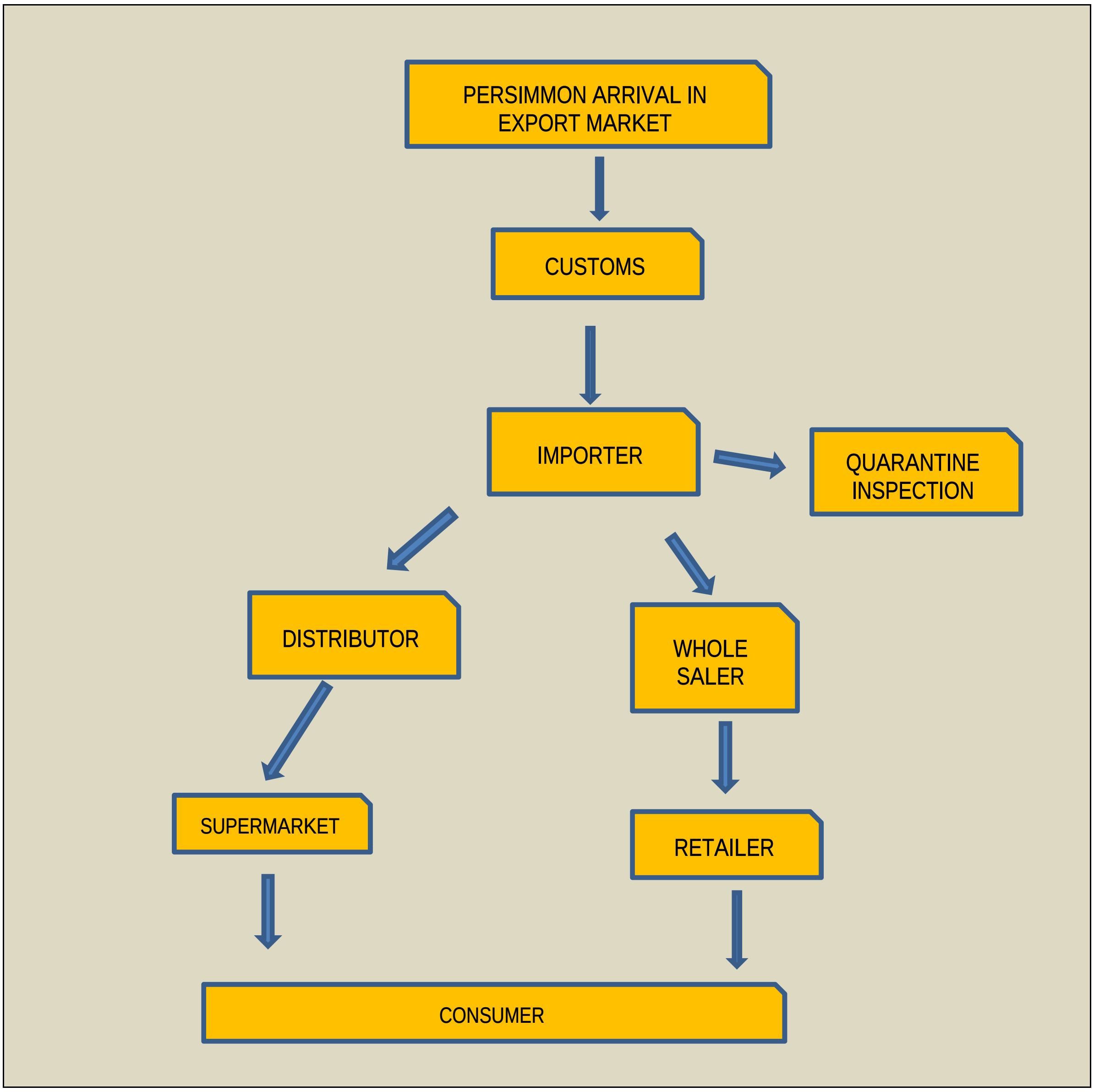


Figure 1. Supply chain map of persimmon exported to Asian destination.

Plate 5. Great attention is paid to ensuring export fruit to Thailand have no insects beneath the calyx or on the fruit.

Plate 6. Checking for all pests on the packing line.

26.6 Phytosanitary measures

International trade in horticultural food products has grown substantially in recent years. Concurrent with, but not unrelated to, this growth has been increasing concerns by food consumers about the safety (and, quality, more generally) of the food that they eat. This increase in consumers' concerns about the health risks from food has stemmed, in large part, from well-publicised food scares from outbreaks of food poisoning caused by *E. Coli, Listeria* and *Salmonella*, from suspicions about the presence of pesticide and veterinary residues, and from newly-identified potential dangers such as acrylamide.

It is now generally accepted that the WTO Agreement on the Application of Sanitary and Phytosanitary Barriers (the SPS Agreement) has been beneficial overall to the international trading community in preventing SPS barriers from being used for protectionism (i.e., protecting domestic producers from import competition) rather than protection of consumers of imported food.

Sanitary and Pytosanitary (SPS) measures are applied to protect human, animal and plant life or health from risks arising from the introduction and spread of pests and diseases and from risks arising from additives, toxins and contaminants in foods and feedstuffs.

SPS measures are subject to rules set under the WTO. In particular, the use of SPS measures is governed by the provisions of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement). In the Agreement, governments are encouraged to use the international standards for food safety which have been developed by the Codex Alimentarius Commission.

26.7 AQIS services and phytosanitary certificates

Fruit for export to overseas markets with phytosanitary requirements must be inspected by the Australian Quarantine and Inspection Service (AQIS) before leaving Australia . Provided the fruit meets importing country regulations, they issue Phytosanitary Certificates declaring that the fruit is free of pests and diseases. AQIS also provides advice and assistance to existing and potential exporters of agricultural and fisheries produce on the following:

- Import conditions of destination countries for all agricultural, fisheries and forestry products. A number of conditions are available online - see export requirements
- Australian export legislation requirements
- Export documentation, including export permits, health and phytosanitary certificates
- AQIS quality assurance arrangements
- Premises registration requirements
- Inspection procedures
- Fees and charges

The Department of Foreign Affairs and Trade website (*www.daff.gov.au*) contains information relating to AQIS. It also maintains a database on importing country requirement called the Manual on Importing Country Requirements (MICoR) (Table 2). This manual contains information about the conditions to export plants and plant products, including fruit, vegetables, seeds, grains, cut flowers and timber from Australia. It is a simple and convenient reference tool detailing the requirements for Import Permits, Phytosanitary Certificates, Additional Declarations and/or treatments, any other relevant export information and documentation, such as protocols.

TABLE 2.
Extract from AQIS MICoR database

Thailand (TH)

Fruit - Fresh
Diospyros kaki Persimmon

NPPO details: Plant Protection Research & Development Office, Department of Agriculture
Relevant web addresses:
Documentation

Document Type	Required?
Import Permit	No
Phytosanitary Certificate	Yes
Additional Declaration/Endorsement	No

General
Consignments are to be free from pests, soil, weed seeds and extraneous material.

Treatment

Reference

26.8 Exports – Approved Treatments

The importation of persimmons originating from production areas in the Australia which are not free of fruit flies must be treated prior to arrival in the importing country. Disinfestation treatments must be performed either in Australia prior to loading or in-transit prior to arrival in the importing country. Any treatment performed in Australia must be stated in the Treatment section of the AQIS Phytosanitary Certificate. Treatments performed in-transit will be stated as “Subject to in-transit cold disinfestation’ in the Additional Declaration section of the Phytosanitary Certificate. (See Chapter 27 on Disinfestation)

26.9 Checklist for Overseas shipment

Considerations include:

- Timeliness and availability of service
- Sufficient available space
- Sufficient suitable containers/equipment
- Shortest total transit time
- Destination infrastructure acceptable
- Acceptable freight cost – include ALL charges
- Identify the transaction and its requirements – know your shipment!
- Overseas shipping requirements, availability, bookings
- Distances to container packing depot, port, etc
- Transport and container packing requirements
- Special requirements (eg: ethylene/odour/taste production/sensitivity, in-transit sterilization,
- AQIS, etc
- Contact of Sale requirements
- Banking requirements (Letter of Credit)
- Documentation requirements
- Timing

26.10 Container preparation

Checks to be carried out include:

- Container physically sound
- Container has been pre-tripped and calibrated by qualified refrigeration personnel within approved period (30 days)
- Container is clean and free from odours, pests & contaminants
- Drain-holes clear
- Temperature recorder operational, with chart in place and details entered (container no, vessel, produce type, set temperature
- Set temperature is as required (Plate 7)
- Vent setting is as required

Both exporters and carriers should pre-alert the container packing depot of the estimated time of arrival trucks, especially if they to arrive outside normal operating hours (e.g. 2.00 am).

TABLE 3.
Reefer container-maximum time off without power.

Product temperature	Maximum time off power Maximum ambient temperature (°C)			
	10°C	20°C	30°C	40°C
0°C	40 hours	20 hours	14 hours	8 hours
5°C	60 hours	25 hours	16 hours	10 hours
10°C	70 hours	40 hours	20 hours	12 hours

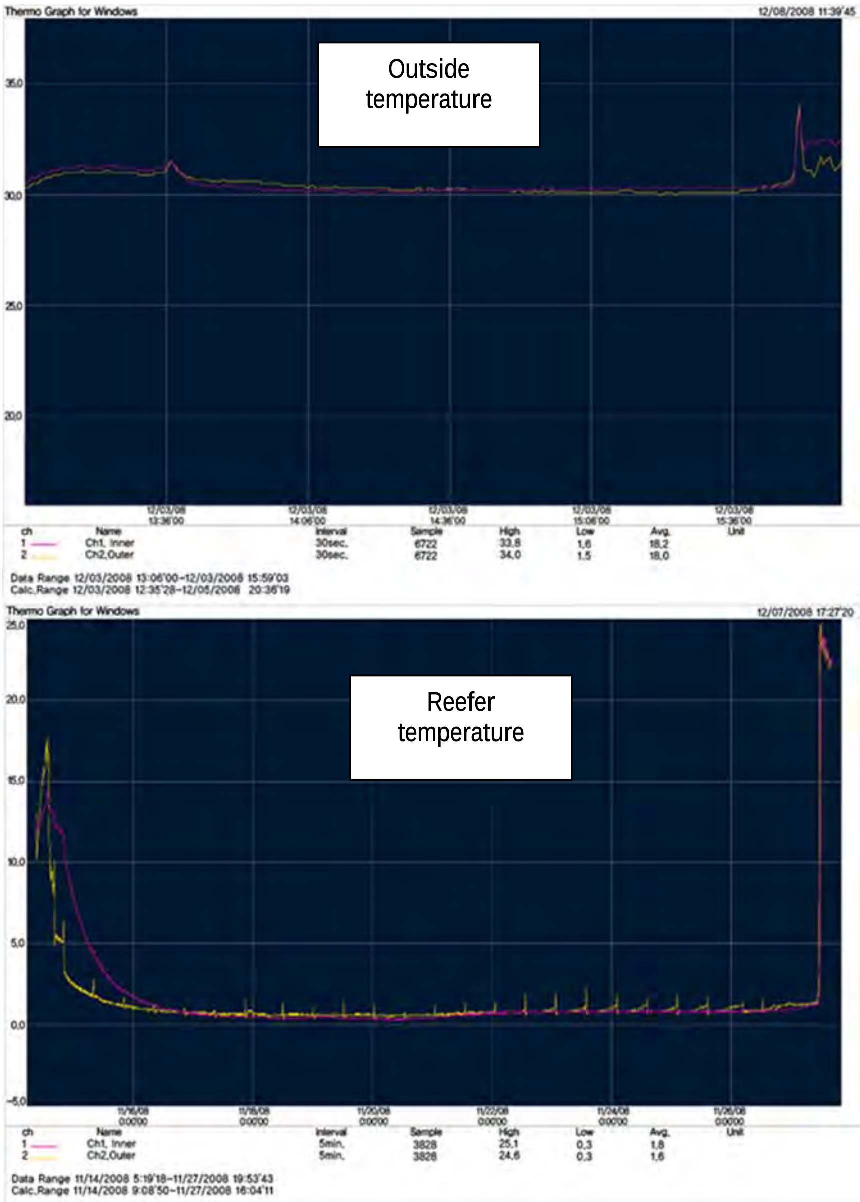


Plate 7. Rapid cooling and maintaining the correct temperature in the reefer container is important.

Key points

Australia is well positioned to increase exports

Australia has a competitive advantage in terms of fruit quality (high sugar concentrations and flavour) - a premium export grade could be developed

Only fruit from inland regions and southern states which have a low incidence of soft fruit disorder may be suitable for export

Exporters must meet QA and quality standards of importers

Export fruit must be inspected by AQIS and issued with phytosanitary certificates before leaving Australia

New technologies such as 1-MCP will permit use of less expensive sea-freight and allow cold disinfestation in transit

Exporting requires excellent logistical organisation to prevent value chain losses and to maximise returns

DISINFESTATION

27.1 Interstate certification assurance (ICA)

There are legal requirements on the movement of sweet persimmon fruit from one Australian state to another, and even on the movement of fruit and plants from one region to another within the state. Interstate Certification Assurance (ICA) is a system of plant health certification based on quality management principles. ICA provides an alternative to traditional plant health certification involving government inspectors. The ICA Scheme is a national scheme administered by all states and territories. The scheme enables a business to be accredited by a state or territory plant quarantine authority to issue plant health assurance certificates for its produce.

To be accredited, a business must be able to demonstrate it has effective in-house procedures in place that ensure produce consigned to intra or interstate markets meets specified plant quarantine requirements. The plant quarantine authority regularly audits compliance by the business. The ICA Scheme seeks to provide a harmonised approach to the audit and accreditation of businesses throughout Australia and the mutual recognition of plant health assurance certificates accompanying consignments of produce moving intrastate or interstate.

As an example, fruit which is a host for Queensland fruit fly cannot be sent to other states which are free of this fruit fly, unless such fruit has been treated either in the orchard and/or after harvest. For the latest information on these regulations contact your state animal and plant health service.

A farm business which has in place ICA accreditation can issue their own Plant Health Assurance Certificates (PHACs) for exporting produce to other States. These PHACs issued by ICA accredited businesses have the same legal force/value as Plant Health Certificates (PHCs) issued by State government Inspectors.

27.2 ICA post-harvest disinfestation protocols

The only ICA's available for sending fruit to fruit fly free zones in South Australia, Tasmania and Western Australia is ICA 55- Irradiation treatment (see irradiation section) and ICA04- Fumigation with

methyl bromide. Please note the effect of postharvest use of methyl bromide on persimmon is unknown and possible changes in fruit quality and shelf life may occur. We recommend if the use of methyl bromide is required that small trials are carried out prior to commercial use.
If growers would like to send fruit to these regions/states and do not have access to irradiation facilities please contact Biosecurity Queensland and an ICA can possibly be negotiated.

27.3 Cold treatment disinfestation

Cold treatment is a commercially viable method of disinfestation of persimmon that is easy to apply and does not leave chemical residues. Cold treatments of 14-16 days at 1°C are currently used for the disinfestation of citrus against Queensland fruit fly and Mediterranean fruit fly, for the Japanese market.

Produce certified under this Operational Procedure must be subjected to cold treatment in an approved facility in accordance with one of the following treatment schedules.

- All States except Tasmania
  Temperature Minimum Number of Days
  - 0.0° C ± 0.5°C 14
  - 1.0° C ± 0.5°C 16
  - 1.5°C ± 0.5°C 18
  - 2.5°C ± 0.5°C 22
- Tasmania
  Temperature Minimum Number of Days
  - -0.5° C ± 0.5°C 14

27.4 Disinfestation for export markets

Persimmons are hosts to fruit flies, which are considered to be high-risk quarantine pests by quarantine authorities worldwide. Currently most of the major export markets in south-east Asia (Hong Kong, Singapore, Thailand) do not require quarantine treatment, however, this quarantine status is under review and the requirement for a disinfestation treatment could be introduced. The export of persimmons from Australia to countries with quarantine barriers against fruit flies such as Japan or Taiwan is only possible following an approved quarantine disinfestation treatment.

27.5 Exports – Approved Treatments

The most likely treatment to be approved to export persimmon fruit to Japan, Taiwan and other countries with fruit fly exclusion is cold disinfestation. This treatment will be the same as those approved for other temperate fruits such as plums. The export of plums is permitted provided they have been subject to cold treatment in line with the below treatment schedules presented below and in
Table 1.

The importation originating from production areas in the Australia which are not free of fruit flies must be treated prior to arrival in the importing country. Disinfestation treatments must be performed either in Australia prior to loading or in-transit prior to arrival in the importing country. Any treatment performed in Australia must be stated in the Treatment section of the Phytosanitary Certificate. Treatment performed in-transit will be stated as “Subject to in-transit cold disinfestation’ in the Additional Declaration section of the Phytosanitary Certificate.

TABLE 1.
Cold disinfestation treatment for importing Australian plums into Taiwan.

Cold treatment schedule for Queensland fruit fly	
Fruit pulp temperature	Exposure period (consecutive days)
3 degrees Celsius or below	14 days or more

Cold treatment schedules for Mediterranean fruit fly	
Fruit pulp temperature	Exposure period (consecutive days)
1.11 degrees Celsius or below	14 days or more
1.67 degrees Celsius or below	16 days or more
2.22 degrees Celsius or below	18 days or more

27.6 Irradiation

Irradiation treatment of fresh produce is increasingly gaining worldwide acceptance and the presence of commercial facilities able to conduct the treatment adds to the potential for this technology as a suitable alternative. The treatment is so widely accepted that the researchers only needed to assess fruit quality responses at the low range of doses already known to be effective against the quarantine pests of concern.

Researchers at Queensland Department of Agriculture, Fisheries and Forestry compared the response of the two major cultivars 'Jiro' and 'Fuyu' at doses of 250, 400 and 500 Gray (Gy) against untreated fruit. Although all persimmons showed evidence of fruit softening, irradiated fruit softened more than untreated fruit and this effect increased with increasing treatment dose. The final level of softening was dependent on the source of the fruit. Fruit from some orchards softened more than from others. This indicates that the irradiation increased the natural tendency of the fruit to soften and choosing fruit from orchards that were not prone to fruit softening would result in a better quality result.

Overall 'Jiro' fruit showed less softening than 'Fuyu'. In addition 'Jiro' fruit showed no other quality loss symptoms while 'Fuyu' showed a slight amount of skin injury, which was again dependent on the orchard from which fruit was sourced.

Overall this research shows that good quality fruit can be irradiated at 250 Gy, a dose sufficient to control fruit fly, without loss of retail quality.

An ICA protocol (ICA -55) has been written and has been accepted for commercial use.

Key points

Potential export markets such as Japan and Taiwan require persimmon fruit to be disinfested

Non-chemical means of disinfestation are becoming increasingly important

Cold disinfestation in transit is now possible due to use of 1-MCP to prevent chilling injury at storage temperatures of 0°C

Hot water and hot air treatments have been used successfully in other countries such as NZ to disinfest fruit. These techniques should be trialled in Australia

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WEB SITES FOR ADDITIONAL INFORMATION

Site	Web Address	Information
Industry organisations		
Persimmons Australia Inc.	*www.persimmonsaustralia.com.au/*	Information of Australia persimmon industry
Australian Persimmon Export Company	*www.sweetgold.com.au/*	Export organisation
Government authorities		
Hort Innovation	*www.horticulture.com.au*	(HAL) is a national research, development and marketing organisation
Australian Pesticides and Veterinary Medicines Authority	*www.apvma.gov.au/*	Registration of chemical, review of chemicals
Food Standards Australia New Zealand (FSANZ)	*www.foodstandards.gov.au/*	Administers the Australia New Zealand Food Standards Code
Department of Foreign Affairs and Trade	*www.daff.gov.au*	Export procedures
Manual of Importing Country Requirements (MiCor database)	*www.daff.gov.au/micor*	Importing country requirements
Australian Quarantine Inspection Service	*www.daff.gov.au/aqis*	Export phytosanitary certificates
Interstate Certification	*www.dpi.qld.gov.au*	ICA requirement – Qld
Interstate Certification	*www.dpi.nsw.gov.au › Biosecurity › Plant biosecurity*	ICA requirement – NSW
Codex Alimentarius	*www.codexalimentarius.net/*	FAO and WHO food and veterinary standards
QA programs		
Freshcare	*www.freshcare.com.au/*	Australian on–farm assurance program
Safe Quality Food Institute	*www.sqfi.com*	SQF certification
Woolworths Quality Assurance (WQA)	*www.wowlink.com.au*	Woolworths Quality Assurance (WQA)
Global Gap	*www.globalgap.org*	International quality assurance program – Europe
HACCP Australia	*www.haccp.com.au/*	HACPP training programs

Educational resources		
University of California	*postharvest.ucdavis.edu/*	Postharvest quality maintenance guidelines
Agriculture, Fisheries and Forestry, Queensland	*www.dpi.qld.gov.au/*	Information on pests and diseases,
Equipment		
Visy Board Pty Ltd	*www.visy.com.au*	Cartons
Amcor Pty Ltd	*www.amcor.com*	Cartons
	www.amcor.com/businesses/afap/lifespan/	Lifespan MA bags
Label Press Pty Ltd	*www.labelpressaustralia.com.au*	Fruit stickers
KW Automation	*www.kwautomation.com.au/*	Graders, packing equipment
Carter Holt Harvey	*www.chhpackaging.com/*	Packaging
Lindsay Rural	*www.lindsayaustralia.com.au/*	Packaging
Q Pak	*www.qpak.org/*	Inserts/liners

Site	Web Address	Information
Agrofresh	*www.agrofresh.com/smartfresh/persimmon.html*	SmartFresh, 1-mcp
Bioconservacion Australia Pty Ltd	*www.bioconservacion.com.au/*	Supplier of MA bags, ethylene absorbents, scrubbers
Mary Valley Orchards	*www.persimmons.com.au/*	Agents for SGS inserts

Queensland Government