AP509
Storage systems to control scald on apples & pears

Barry Tugwell & Louise Chvyl
SARDI

HAL

Know-how for Horticulture™
AP509
This report is published by the Horticultural Research and Development Corporation to pass on information concerning horticultural research and development undertaken for the apple and pear industry.

The research contained in this report was funded by the Horticultural Research and Development Corporation with the financial support of the apple and pear industry.

All expressions of opinion are not to be regarded as expressing the opinion of the Horticultural Research and Development Corporation or any authority of the Australian Government.

The Corporation and the Australian Government accept no responsibility for any of the opinions or the accuracy of the information contained in this report and readers should rely upon their own enquiries in making decisions concerning their own interests.

Cover price: $20.00
HRDC ISBN 1 86423 857 7
Published and distributed by:
Horticultural Research & Development Corporation
Level 6
7 Merriwa Street
Gordon NSW 2072
Telephone: (02) 9418 2200
Fax: (02) 9418 1352
E-Mail: hrdc@hrdc.gov.au

© Copyright 1999
H.R.D.C. FINAL REPORT

PROJECT NO. AP 509

STORAGE SYSTEMS TO CONTROL SCALD ON APPLES AND PEARS

Barry Tugwell
and Louise Chvyl

January 1999
STORAGE SYSTEMS TO CONTROL SCALD ON APPLES AND PEARS

Principal Investigator:-

Barry Tugwell
Chief Scientist, Horticulture
South Australian Research & Development Institute
Plant Research Centre
Hartley Grove
URRBRAE SA 5064

Postal address:-
GPO Box 397, ADELAIDE SA 5001
Tel: 8303 9417
Fax: 8303 9424
e-mail: tugwell.barry@pi.sa.gov.au
INDUSTRY SUMMARY

Storage trials were carried out in 1995, 1996 and 1997 to evaluate low oxygen storage atmospheres and an alcohol vapour treatment for controlling scald on susceptible varieties of apples and pears. A petroleum based oil formulated for the surface disinfestation of citrus was also tested for effectiveness in controlling scald.

In 1995 a low oxygen storage atmosphere of less than 1% oxygen was compared with a nitrogen flushed atmosphere of 1.5% oxygen for controlling scald.

In 1996 apple and pear varieties were treated with alcohol in plastic bags, stored in a controlled atmosphere of 2% oxygen and assessed for scald control and quality.

In 1997 bulk bins of Granny Smith, Red Delicious apples and Packham pears were treated with alcohol, stored in a controlled atmosphere of 2% oxygen and assessed for scald control and quality.

HARVEST MATURITY

Storage trials confirmed the ideal harvest maturity for Pink Lady apples intended for long term storage to be the last week of April extending into the first week of May. Sundowner apples should be harvested 2 weeks later than Pink Lady, harvesting should commence at the end of the first week of May and conclude by the end of the third week in May.

LOW OXYGEN STORAGE

The apple varieties Pink Lady, Sundowner, Red Delicious, Fuji, Golden Delicious, Granny Smith and Packham pears stored well in <1% oxygen with carbon dioxide maintained at <1%. All varieties remained firmer in storage and scald susceptible varieties showed a lower incidence of scald when compared with fruit stored in a nitrogen flushed atmosphere of 2% oxygen and less than 1% carbon dioxide.

Low oxygen storage however did not consistently eliminate scald on early harvests of Red Delicious and Granny Smith apples.

A brown stain on Fuji apples was not affected by either storage system.

ALCOHOL TREATMENT

Alcohol treatment controlled scald on early harvested Pink Lady apples and reduced scald by 50% on other scald susceptible varieties of apples and pears. However changes in skin colour on Red Delicious, core flush of Granny Smith apples and tainting of Jonathans were observed.

Research by Kevin Scott at the University of NSW established that alcohol treatment completely controlled scald on Granny Smith apples when stored for 16 weeks. Scald control was also achieved with Red Delicious apples however a change in the red colour of the skin occurred.
Preliminary tests with several other alcohols has established that they also reduce superficial scald and one of these controlled scald without inducing a colour change on Red Delicious apples.

A petroleum based oil was effective in controlling scald but when used without a fungicide caused excessive mould wastage of treated fruit.

The varieties Sundowner and Golden Delicious remained scald free when removed from storage in November.

Pink Lady apples from the first harvest in mid April 1996 developed scald when removed from storage in September.

**BULK TREATMENT WITH ALCOHOL**
Alcohol treatment of bulk bins of fruit in a C.A. room followed by storage for 6 months in 2% oxygen controlled scald on Granny Smith and Red Delicious apples and Packham Pears.

Scald on Packham Pears was controlled for up to 8 months however Granny Smith apples showed scalding after 7 months storage and developed severe core flush after 8 months storage. Red Delicious apples developed a skin discolouration after 7 months storage.
TECHNICAL SUMMARY AND RECOMMENDATIONS

For best retention of quality, scald susceptible apples and pears should be dipped after harvest in Diphenylamine (DPA) and stored in a controlled atmosphere (CA) of between 1.5% and 2.0% oxygen with carbon dioxide maintained at less than the oxygen concentration.

Pink Lady apples harvested in mid April for export or storage are susceptible to scald if stored beyond September. Treatment with a scald inhibitor and fungicide is recommended. Golden Delicious apples have a low risk of scalding but treatment with a scald inhibitor and fungicide is recommended for fruit from warmer growing regions.

Sundowner apples did not develop scald during storage however treatment with a fungicide is recommended to control postharvest rots.

Storage in less than 1% oxygen or an atmosphere continuously flushed with nitrogen cannot be recommended as an alternative to DPA for consistent control of scald.

Alcohol and oil are promising alternatives to DPA for scald control however further research is required to establish treatment rates and overcome negative effects on fruit quality.
DIRECTIONS FOR FUTURE RESEARCH

Low oxygen storage, treatment of fruit with alcohol or oil and harvesting fruit at ideal maturity can reduce the incidence and severity of scald but no single treatment is as effective as post harvest treatment with the antioxidant Diphenylamine.

Further research is required to develop application methods to maximise scald control with alcohol and oils, evaluate other alcohols that may not cause changes to red pigmentation on Delicious apples and identify a denaturant that can be safely used to allow excise free alcohol to be used.
STORAGE SYSTEMS TO CONTROL SCALD ON APPLES AND PEARS

Barry Tugwell and Louise Chvyl
South Australian Research and Development Institute
Hartley Grove, Urrbrae, S.A. 5064

INTRODUCTION
Increasing consumer demand for chemical residue free fruit may in the future prevent the use of antioxidant chemicals to control scald. Susceptibility of apples to scald reduces with maturity and accurate timing of harvest combined with new storage technology may be sufficient to control scald without using chemical antioxidants. In addition some new varieties may be less scald susceptible than existing commercial varieties.

Research from 1976 to 1989 (Tugwell, 1989) established and demonstrated practical systems for design and operation of CA stores to maintain specialised low oxygen atmospheres. Research in Victoria (Little, 1988) has shown that low oxygen storage atmospheres can reduce scald and overseas research (Dilley, 1989) has shown that nitrogen purging of CA stores can reduce or eliminate the need for chemical control of scald. More recent overseas research established that low oxygen levels controlled scald of Granny Smith apples (Patterson, 1993).

Fast cooling combined with rapid establishment of low oxygen CA atmospheres will reduce scald on susceptible varieties and the introduction of nitrogen separation equipment to continuously flush out ethylene and other volatiles from CA rooms has reduced scald on some varieties of apples and pears.

By determining the scald susceptibility of current and new varieties over a range of maturities, harvest dates can be set. When combined with new storage strategies, it should be possible to reduce scald to tolerable levels and eliminate the need to apply chemical antioxidants.

Storage trials funded under project AP123 showed some quality benefits from storage in Nitrogen flushed atmospheres but no significant reduction in scald.

During the 1994 season, commercial control of scald on Granny Smith apples harvested in late April was achieved with an atmosphere of 0.7% oxygen.

Low oxygen storage was further evaluated in 1995 on Granny Smith and other varieties of apples and pears.

The timing of harvest is vital in ensuring that fruit has sufficient colour, size, texture and flavour to satisfy the consumer without compromising the internal condition necessary for long term storage.

Project AP123 established harvest criteria for W.A. grown Pink Lady and Sundowner apples. During 1994 it was established that S.A. grown fruit from young trees matured earlier than W.A. fruit and had a brighter red colour at maturity.
Storage performance of fruit grown under cooler conditions in the southern area of Australia was assessed during the 1995 season.

In December 1995, Kevin Scott from the University of N.S.W. presented results of his research which showed that alcohol or oils applied after harvest controlled scald on Granny Smith and Red Delicious apples. During the 1996 storage season the effect of alcohol treatment combined with low oxygen storage on scald and quality of apple and pear varieties was determined. In 1997 the alcohol treatment was applied to bulk lines of fruit which were then stored in a low oxygen CA atmosphere.

**METHOD**

In 1995 three harvests were made at fortnightly intervals from mature trees carrying a heavy crop of averaged size fruit of the varieties Granny Smith, Red Delicious (Hi Early), Red Fuji, Sundowner, Golden Delicious and Packham pears.

Fruit maturity factors (starch index, sugar, firmness and colour) were measured. On each harvest date the fruit were rapidly cooled to 0°C and stored in specialised CA atmospheres for examination after 6, 8 and 10 months storage.

Half of the fruit was stored in a CA atmosphere of less than 0.7% carbon dioxide maintained by product generation and lime to absorb carbon dioxide. The second room was continuously purged with nitrogen from a P.S.A. air separator to maintain 1.5% oxygen and 1.5% carbon dioxide.

On removal from storage the fruit was assessed for internal quality, scald and storage disorders. The data was analysed to determine effects of harvest maturity and storage method on fruit maturity and scald.

In 1996 Granny Smith, Red Delicious (Hi Early), Red Fuji, Pink Lady and Sundowner apples and Packham pears were harvested at fortnightly intervals, treated with the equivalent of 0.2g of alcohol per fruit and sealed in plastic bags. Prior to storage in an atmosphere of 2% oxygen and less than 1% carbon dioxide, the bags were opened to allow equilibration with the CA atmosphere.

Equivalent harvests of fruit not treated with alcohol were stored in a separate CA room. On removal from storage fruit was evaluated for scald, skin blemishes, internal quality and off flavours.

In 1997 bulk bins of Granny Smith, Red Delicious apples and Packham pears were treated with 1 litre of alcohol per bin (the equivalent of 0.3g of alcohol per fruit) in a CA room, stored in 2% oxygen and assessed for scald and storage disorders after 6, 7 and 8 months storage.

Kevin Scott, consultant in postharvest horticulture, evaluated alcohol and other alternative treatments for overcoming colour changes in Red Delicious apples following treatment.
RESULTS

EVALUATION OF STORAGE ATMOSPHERES FOR SCALD CONTROL
Storage in low oxygen atmospheres of less than 1% oxygen was more effective in controlling scald than continuous flushing with nitrogen to maintain oxygen at 2%. Complete control of scald was not achieved for scald susceptible varieties stored for more than 6 months.

GRANNY SMITH

Effect of Low Oxygen Storage and Nitrogen Flushing on Scald of Granny Smith Apples after 7 months storage

![Graph showing % Scald over different harvest dates](image)

After 5 months C.A. storage Granny Smith apples harvested during early April had developed severe superficial scald. Low oxygen storage reduced the severity and incidence of scald at all harvests however after 8 months storage more than 50% of the fruit had developed scald. Nitrogen flushing was not effective in controlling scald with most fruit from all harvests scalding after 5 months storage.
RED DELICIOUS

Neither low oxygen storage or nitrogen flushing were effective in controlling scald on Red Delicious apples after 6 months C.A. storage.

Scald on Red Delicious Apples

Effect of low oxygen storage on firmness of Red Delicious apples after 8 months storage

Low oxygen storage however increased the firmness of fruit at all harvest maturities. Fruit harvested on the 23rd March and stored in less than 1% oxygen for 8 months was 1 kg firmer than fruit stored in a nitrogen flushed atmosphere.
**FUJI**

Very little scald developed on Fuji apples of all maturities but a brown staining which developed on fruit harvested in mid April was not affected by either storage system.

Fuji apples stored in a low oxygen atmosphere were firmer than fruit stored in a nitrogen flushed atmosphere after 7 months storage.

**PINK LADY**

Pink Lady apples harvested prior to the 20th of April scalded after 5 months storage however low oxygen storage considerably reduced the incidence and severity of scald after 7 months storage.
Effect of low oxygen storage and maturity on scald on Pink Lady Apples after 7 months storage

PACKHAM PEARS

Packham pears harvested from the 16th February 1995 to the 16th March 1995 stored well in both low oxygen storage and a nitrogen flushed atmosphere for 8 months until November 1995.

No scald developed on pears stored in either atmosphere after 6 months storage however a trace of scald developed on C.A. stored fruit after 8 months storage.
SUNDOWNER

Sundowner apples stored well in both storage atmospheres over a range of harvest maturities from 20th April 1995 to 18th May 1995. Fruit retained a firmness of 9.0 kg after 6 months storage and remained scald free when removed from storage.

GOLDEN DELICIOUS

Golden Delicious apples rapidly softened in storage dropping 2 kg in firmness from 8.0 kg at harvest to 5.6 kg after 7 months storage.

Storage in a low oxygen atmosphere resulted in fruit 0.5 kg firmer than that stored in a nitrogen flushed atmosphere.

Scald developed on fruit harvested early during the first week of March stored in a nitrogen flushed atmosphere but was not observed on fruit stored in a low oxygen atmosphere.
Effect of Harvest Maturity on Storage Rots of Golden Delicious Apples

Over mature Golden Delicious apples were very susceptible to the development of storage rots. 80% of fruit harvested on the 5th of April 1995 developed storage rots after 5 months storage.
EVALUATION OF ALCOHOL TREATMENT FOR CONTROL OF SCALD

GRANNY SMITH APPLES

Effect of Alcohol Treatment on Scald Incidence on Granny Smith Apples
Harvested on 16/4/96

Alcohol treatment applied to Granny Smith apples sealed in a plastic liner followed by C.A. storage reduced scald by 50% for up to 5 months storage. The treatment was not effective in controlling scald on fruit stored for 7 or 9 months.

RED DELICIOUS APPLES

Alcohol treatment reduced scald on fruit harvested in mid March and stored for 6 months however brown staining and skin discoloration spoilt the appearance of fruit when removed from storage.
Pink Lady apples harvested on the 16th April 1996 developed superficial scald after 5 months storage in a C.A. atmosphere of 2% O₂. Scald increased from 20% on removal from storage in September to 78% in February (9 months storage).

Delaying harvest until the 1st of May 1996 completely controlled scald.

Alcohol treatment in plastic liners completely controlled scald on fruit harvested on the 16th of April 1996.
PACKHAM PEARS

Effect of Alcohol Treatment on Scald Incidence on Packham Pears
Harvested on 29/2/96

Packham pears harvested on 29th February 1996 developed superficial scald after 7 months storage. Alcohol treatment controlled scald for up to 7 months storage however after 9 or 11 months storage scald was reduced by only 50%.

FUJI APPLES

Effect of Alcohol treatment on scald incidence on Fuji apples harvested on 10/4/96

Fuji apples harvested in late March scalded severely after 5 months storage. Fruit harvested during the last week of April did not develop scald until after 9 months storage. Treatment with alcohol controlled scald after up to 5 months storage however after 7 months or 9 months storage scald was only reduced by 50%.
EVALUATION OF A PETROLEUM OIL FOR SCALD CONTROL

GRANNY SMITH APPLES
Granny Smith apples dipped in a petroleum based post harvest dipping oil appeared to be free of scald after 5 months storage however a high incidence of storage rots made it difficult to assess the fruit for scald.

The dip solution did not include a post harvest fungicide which is necessary to prevent a high incidence of wastage following post harvest dipping.
Alcohol treatment controlled scald for up to 6 months of storage however after 7 and 8 months of storage the incidence of scald increased to 10%. After 8 months of storage all fruit treated with alcohol had developed core flush.

Alcohol treatment controlled scald for 6 months
DELICIOUS

Effect of Alcohol Treatment in a C.A. room on Scald of Red Delicious

Alcohol treatment controlled scald for up to 6 months storage however the development of skin discolouration after 7 months storage negated the benefits of scald control.

PACKHAM Pears

Effect of Alcohol Treatment in a C.A. room on scald of Packham Pears

Alcohol treatment controlled scald for up to 7 months storage when 16% of C.A. stored fruit had developed scald. After 8 months storage the pears had reached the end of their storage life with 80% of the fruit developing storage rots.
RESULTS OF RESEARCH BY K.J. SCOTT
OF THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, THE
UNIVERSITY OF NEW SOUTH WALES TO EVALUATE ALCOHOL TREATMENT
FOR SCALD CONTROL.

There has been concern both in Australia and overseas that the use of diphenylamine to control superficial scald may no longer be permitted. There have been unconfirmed reports that some countries have acted already to prevent the use of diphenylamine on apples for scald control. There is no approved alternative to the use of diphenylamine. Studies have been carried out for several years at the University of New South Wales to develop alternative (preferably natural treatments) for the control of superficial scald.

Early studies showed that exposure of Granny Smith apples to ethanol (the ordinary alcohol in alcoholic drinks) gave excellent control of scald. Similar control was also obtained by applying undiluted vegetable oil directly to the skin of the fruit by hand.

There is a high excise tax (administered by Customs) on food grade alcohol which is over 30 times the wholesale price. When this was realised, the HRDC project concentrated on developing a vegetable oil treatment. Application of oil direct to the skin by hand before storage was obviously unsuitable and emulsified oil treatment that could be applied using the equipment now used for DPA application were studied.

The ethanol vapour treatment appeared to have many advantages, it seems simple to apply and without the tax the cost would be less than DPA. The avoidance of dipping should greatly reduce the need for fungicides and probably no fungicide would be needed. Ethanol has some fungicidal properties and this attribute should be a bonus. By using the facilities at the University of New South Wales, K.J. Scott investigated the excise tax both in Australia and the U.S.A. and found that it was possible to obtain tax free alcohol for scald control provided the alcohol was made undrinkable. This aspect required further study to find an additive that did not effect the fruit. Such an additive has been found and has been successfully tested on Granny Smith. Funds were provided from a HRDC project AP509 to re-start the programme on the use of ethanol vapour.

These studies have shown that complete control of superficial scald can be obtained without injury or obvious off flavour on Granny Smith. However there was an unexpected result with Red Delicious. While scald was controlled, higher levels of pure ethanol induced an unacceptable change in the red colour. The flesh did not appear to be affected. Work aimed at preventing the objectionable colour change has begun. There are several aspects being considered. Firstly all Red Delicious are now all virtually stored in C.A. This reduces scald so that the use of reduced amounts of ethanol may be adequate for scald control without inducing the colour change. Secondly, a postgraduate student has examined the specificity of ethanol for controlling scald and has found that several higher alcohols are also effective, some more effective than ethanol. In a preliminary test low levels of one of these alcohols has controlled scald without inducing the colour change. These other alcohols occur in food, some in fruits and there is no problem with excise tax.

It is not possible to recommend the use of ethanol on apples at present until ethanol and other alcohols are approved by health authorities. This is required for ethanol even though it is widely consumed in many countries. Before recommendations can be made for fruit to be treated and then sold, health approval will need to be obtained both for the alcohols themselves and the denaturant rendering ethanol undrinkable. This will require analysis of residues after fruit are treated and again when sold. There does not appear to be any great
difficulty in obtaining health clearance but it will take time and the analytical costs need to be met.

The denaturant is not considered toxic. When used at very low concentrations it renders ethanol undrinkable. When the denatured ethanol evaporates in the C.A. room, the denaturant will not evaporate at the low temperature and thus should not contaminate the atmosphere or the fruit. The amount required is so low that even if the denaturant evaporated and was absorbed by the fruit, it would be difficult to detect its presence in the fruit even with modern chemical techniques.

Some people may be concerned at using a flammable substance in their C.A. rooms. Although ethanol is flammable, a concentration of over 3% is required at room temperature. The amount required to control scald if applied at one time would not reach the flammable level. In fact, it is proposed to apply the ethanol over several weeks at low temperature and probably after C.A. conditions are established. These factors would further reduce any possibility of ignition.

The above information suggests that providing the red colour change can be overcome, there is a good possibility of developing a new commercial treatment for preventing scald which is based on natural food substances. It is proposed to carry out a study on a commercial scale on Granny Smith apples as soon as funds can be obtained. These studies would probably use mainly juice fruit to reduce costs as fruit could not be sold until health approval was obtained. A further joint programme involving NSW, Victoria and South Australia is proposed and an application for funds from HRDC has been made through Department of Agriculture, Victoria.
REFERENCES


PUBLICATIONS AND REPORTS


- New apple varieties - improvement in postharvest quality - paper presented by Barry Tugwell to the Australian Institute of Food Science and Technology Convention - Adelaide, May, 1993.

- Evaluation of harvest maturity, storage life and storage conditions for new apple varieties by Louise Chvyl and Barry Tugwell - presented to the Australasian Postharvest Conference - Gatton, September, 1993.


- Gas levels critical for effective C.A. storage by Barry Tugwell and Louise Chvyl. Pome Fruit Australia, Jan-Feb 1996.

- Harvest maturity key to successful storage by Barry Tugwell and Louise Chvyl. Pome Fruit Australia, Jan-Feb, 1997.

- Predicting Harvest Dates by Barry Tugwell Pome Fruit Australia, p.9, March 1998.

- Maturity the key to quality for Apples, Pears and Cherries by Barry Tugwell - presentation to Australian Apple and Pear Growers Conference "Integrated Fruit Production" 1998.

Maturity the Key to Quality for Apples, Pears and Cherries

By Barry Tugwell

Consumers expect to obtain a year round supply of attractive, crisp full flavoured apples and pears from storage or sweet juicy fresh cherries when in season.

Maturity is a critical factor in determining quality and consumer acceptability of fruit out of storage. Maturity not only affects fruit appearance but also determines the rate of loss quality especially flavour and firmness.

Early maturing varieties generally have a shorter storage life, soften more rapidly in storage and develop storage disorders that spoil their appearance and texture.

Guidelines for harvesting apples and pears at the correct maturity for storage have been established by storage trials, which in recent years were funded by the Horticultural Research and Development Corporation.

Maturity forecasting has for 25 years provided South Australian growers with reliable harvest dates for the main apple and pear varieties in January giving growers time to arrange harvest labour and complete harvesting before early varieties become over-mature. Forecasts are based on temperature data from bud burst until the end of December, which provides an accurate prediction of seasonal variation in fruit maturity. Ideal harvest dates for Jonathan and delicious apples have varied on a seasonal basis by up to 4 weeks.

Changes in some fruit quality characteristics which may be indicators of fruit maturity have been recorded for each apple and pear variety. Changes in background colour, sugar and starch levels and fruit firmness have been found to confirm maturity but actual values at maturity vary from year to year.

Measurement of fruit colour, sugar levels and firmness are essentially quality factors for which minimum specifications can be agreed with buyers. Depending on seasonal conditions these specifications may be recorded ahead of the ideal maturity for storage.

In order for growers to satisfy "customer specifications" for fruit quality on a year round basis I suggest adoption of the following strategies:

• Plan your harvesting season based on maturity forecasts provided by SARDI in January.
• Do not store "off crop" or "light crop" from young trees it has a short storage life and rapidly loses quality in storage.
• Commence harvesting as the early ripening fruit reaches minimum specifications for size, colour and flavour so as to ensure the majority of the fruit is harvested at ideal maturity.
• Do not store fruit damaged by sunburn, or severely affected by water core (Fuji is an exception to this rule).
• Use the following quality guidelines for each variety to confirm suitability for storage.

Cherries

• Flavour development only occurs on the tree, sugar accumulation stops at harvest so "what you pick is what you get".
• Harvest fruit according to colour development, this is the most consistent and reliable indicator of maturity of red cherries.

• Sugar levels vary from season to season but check to ensure compliance with minimum quality specifications.

Pears

• Pressure testing or firmness is the best indicator of maturity.
• If fruit is of adequate size harvest Williams at 7-9kg and
Packhams and Buerre Bosc at 8-10kg.

Nashi- Nijisseiki
- Harvest when the background colour changes from green to green yellow as indicated by background colour charts.
- Check sugar levels at harvest, sugar does not increase during storage.

Royal Gala
- Background colour change from green to green yellow is a reliable indicator with an increase in sugar and some loss in firmness.
- Late harvested fruit rapidly loses flavour in storage.
- Storage beyond July is not recommended due to loss of flavour.

Jonathan
- Change in background colour from green to green yellow is the best indicator of ideal maturity for storage.
- Sugar levels do not change sufficiently to indicate maturity however a minimum specification of 12% is suggested for fresh fruit marketing.

Golden Delicious
- Harvest as for red delicious usually 2 weeks after Jonathan maturity.
- Harvest according to flavour as it changes from "starchy" to slightly sweet.
- Fruit colour is affected by seasonal conditions and is not a reliable indicator of maturity.
- Regularly check fruit firmness as an indicator of quality out of storage. Rapid loss of firmness is a characteristic of this variety.

Red Delicious
- Clearing of starch from the centre of the fruit combined with the development of "delicious" flavour coincides with maturity.
- Sugar levels increase during storage as starch converts to sugar. A minimum level of 10% is suggested for fresh marketing.
- Check firmness out of storage as an indicator of quality and customer acceptability.

Fuji
- Harvest 2 to 3 weeks after delicious when water core appears in about 50% of fruit sampled.
- Background colour from green to green yellow is also a useful indicator.
- Check sugar levels since sugar will not increase during storage. Consumers expect between 12 and 15% sugar in this variety.

Pink Lady
- Harvest during the last week of April when background colour changes from green to green yellow.
- Sugar levels increase during storage.
- Firmness is retained during storage but avoid long term storage of fruit from young trees.

Sundowner
- Harvest 2 weeks after pink lady when background colour changes from green to green yellow.
- Sugar levels increase during storage and firmness is well maintained.

Granny Smith
- Fruit is harvested between 2 and 4 weeks after delicious based on "green" colour.
- Best flavour results from harvesting fruit during the last week in April however market specifications require green coloured fruit to be harvested up to 2 weeks earlier.

Summary
In order to satisfy customer specifications for quality fruit growers should plan harvesting according to forecast maturity dates for each variety, check for changes in maturity indicators and measure and record quality specifications at harvest and on removal from storage.
The recent benchmarking study of the Australian apple and pear industries established that harvest maturity is a key factor in supplying consumers with crisp full-flavoured apples and pears.

In order to harvest fruit at the peak of maturity growers need to commence harvesting at least a week before optimal maturity to complete harvesting for early varieties within a two week harvesting window.

Maturity indices such as sugar and starch levels, fruit firmness, and changes in background colour can confirm maturity but give no advance warning on when to harvest.

South Australian apple and pear growers have for 25 years planned holidays, scheduled maintenance work and arranged harvest labour based on the predicted harvest dates for early varieties of apples and pears which are made available by SARDI during early January each year.

A project has been submitted to the Horticultural Research and Development Corporation to implement the forecasting system in all major Australian apple and pear production areas during the 1999 harvest season and at the same time demonstrate the value and limitations of apple maturity criteria in confirming maturity.

If you, as apple and pear growers believe that predicting seasonal variation in harvest maturity up to two months ahead of time is of value, make sure you talk to your representatives on the HRDC research committee or if you want more information talk to South Australian apple and pear growers about the reliability and value of predicted harvest maturity.

The project “Prediction and Monitoring for the Determination of Optimum Harvest Maturity” has been submitted by Dr Gordon Brown from Tasmania in collaboration with Michael Rettke, Barry Tugwell and Louise Chryl from SARDI who have 70 years combined experience in assessing apple maturity.

In order to harvest fruit at the peak of maturity growers need to commence harvesting at least a week before optimal maturity to complete harvesting for early varieties within a two week harvesting window.

The above information is jointly funded by the Horticultural Research and Development Corporation and the apple and pear industry's R&D levy.