Stem-end rot

The fungi causing stem-end rot live within the branches of trees without causing symptoms. The disease colonises the flowers and reach the stem-end of the fruit several weeks after flowering. The fungus generally does not move into the fruit until after harvest. As trees age, the level of inoculum increases and the disease can be more severe.

The field program used for anthracnose control is thought to reduce the incidence of stem-end rot.

Pruning to force new growth and remove old wood, as well as avoiding the harvest of immature fruit, will also assist in controlling this disease.

Postharvest disease control strategies are discussed in section, *Packhouse practices.*

Sooty blotch

Sooty blotch colonises the branches of trees generally through late summer and autumn when rainfall occurs. Fruit that set in spring become infected through either heavy dews or rainfall. A typical early symptom is a teardrop stain down the side of the fruit as spores are carried by water. With persistent rain the disease rapidly colonises the whole fruit rendering it unsaleable. Control is best achieved by keeping summer-grown shoots free of the disease through regular applications of copper-based fungicides. Copper fungicides should also be applied during fruit growth to provide protection against the disease.

HARVESTING

Harvesting at the right maturity is essential for good flavour

When to harvest – maturity standards

Fruit maturity is the main factor determining flavour of the ripe mango fruit. This is even more critical for Calypso™ because of its mild flavour, so that harvesting immature fruit will result in bland flavour because of low concentrations of sugars and other flavour components in the ripe fruit. Therefore, best practice in determining maturity is critical to the ongoing success of the Calypso™ variety.

Unlike ‘Kensington Pride’, there is little change in the external appearance of Calypso™ fruit over the last 2-4 weeks of fruit growth. Therefore, characteristics such as fruit shape, skin colour and skin texture are unreliable indicators of when to harvest. In some seasons fruit shape may allow reasonable selection of the more mature fruit under controlled conditions, but trials have confirmed

that this does not translate into satisfactory harvesting of the more mature fruit under the higher demands of commercial harvesting. This inability to selectively harvest for maturity provides particular challenges in seasons with mixed flowering (unless two distinct flowering events occur at least three weeks apart; see the section on *Variation in maturity*), and further reinforces the need for accurate maturity testing.

Maturity and the harvest window

Using several maturity indicators improves the accuracy of determining when to start harvesting

Ripe fruit flavour can be improved by later harvesting, but this increases the risk of fruit ripening on the tree and fruit drop. A commercially practical compromise is required between maximising flavour and ensuring there is sufficient time to harvest the fruit before significant economic loss from fruit ripening and fruit drop. We call this the harvest window. Ideally we need two maturity indicators; one that guarantees an acceptable ripe fruit flavour, and one that indicates the length of the harvest window. The percent dry matter is a good indicator of the former. We have little understanding of a suitable indicator for the latter, but we think that a flesh colour of seven* will give sufficient time (harvest window) to harvest all fruit before significant fruit drop and quality loss.

*See section *Flesh colour maturity test* on page 26

Recommended maturity standards

The following indicators have been found to ensure that Calypso™ fruit will ripen to an acceptable flavour over a number of seasons and production areas:

- Dry matter of at least 14%
- An average flesh colour of seven using the Calypso™ Picking Guide
- Brix of 7
- Heat units of 1640 (see below).

Maturity determination is more accurate if several indicators are used. We suggest that percent dry matter, flesh colour, and heat units be used, since Brix is less reliable. The variation between seasons is generally greater than the variation between regions, so identical maturity standards are used across all production regions.

Dry matter is the most important maturity indicator, combined with flesh colour and heat units

Of the three indicators, percent dry matter is most closely related to flavour. The fruit accumulates more starch as it matures, which increases the dry matter. The starch is converted to sugars during ripening, so that fruit with less starch (for example less mature fruit) will usually have less sugars and reduced flavour when ripe. Flesh colour is not directly related to flavour, but usually has a good relationship with percent dry matter and is an easier indicator to measure.

In most seasons a fruit with 14% dry matter will usually have a flesh colour of seven. However, in several seasons in the Northern Territory, fruit with a flesh colour of seven have had dry matters of 16% and above. In these instances we recommend that fruit never be harvested below 14% dry matter, or below flesh colour six to ensure adequate flesh colour in the ripe fruit. The decision matrix in Table 4 should be used.

Table 4. Decision matrix of when to harvest based on percent dry matter and flesh colour. In most instances fruit should not be harvested before reaching 14% dry matter and flesh colour of 7. When the 14%/7 relationship does not hold, then fruit are harvested when they reach the green sections of the table.

B74 NIR Maturity OK to harvest

Dry matter	Flesh colour
14	7

When there is a misalignment in the DM and FC relationship, use the following matrix.

Higher dry matter

DM	FC	DM	FC	DM	FC	DM	FC
14	5.5	15	5.5	16	5.5	17	5.5
14	6	15	6	16	6	17	6
14	6.5	15	6.5	16	6.5	17	6.5
14	7	15	7	16	7	17	7
14	7.5	15	7.5	16	7.5	17	7.5
14	8	15	8	16	8	17	8
14	8.5	15	8.5	16	8.5	17	8.5
14	9	15	9	16	9	17	9

Higher flesh colour

FC	DM	FC	DM	FC	DM	FC	DM
7	13	7.5	13	8	13	9	13
7	13.5	7.5	14	8	13.5	9	13.5
7	14	7.5	15	8	14	9	14
7	15	7.5	16	8	15	9	15
7	16	7.5	17	8	16	9	16

Additional considerations

- Specific markets may require slightly different standards. For example, certain export markets may demand better flavour and require fruit to be at flesh colour of eight at harvest. Any variations from the above standards will be confirmed in the Calypso™ mango specifications sent to growers before the start of each season.

- In seasons with very mixed flowering and therefore mixed maturity on the tree, some relaxation in the standards may be permitted to allow a certain percentage of fruit below the minimum. If this is not done, harvest will need to be delayed to

ensure all fruit are at the minimum maturity, and this may cause the more mature fruit to ripen on the tree. Under these conditions the harvest window would be too short.

Maturity zones, maturity mapping and harvest schedule

Accurate estimation of maturity across the farm (maturity mapping) is important to allow an effective harvesting schedule for the farm. This should ensure that the most mature fruit is harvested first (so they do not ripen on the tree before they can be harvested) and the less mature fruit harvested later.

Often, fruit from groups of trees within the same management block may mature more quickly than those on other trees in the same block. Therefore, it is better to develop a harvesting schedule based on maturity zones rather than management blocks, and the maturity mapping undertaken based on these zones.

To predict both the start of harvest and develop a harvesting schedule for the whole farm, the following procedures are recommended:

- Map the flowering pattern across the farm on a day or adjacent days when most of the farm is at full flowering. Identify no more than 3-4 zones based on flowering stage.
- Record the date of full flowering for each maturity zone.
- Place dataloggers in each maturity zone to record accumulated heat units (see the section on *Accumulated heat units*).
- Within each maturity zone, record the date of full flowering if two flowering events occur at least three weeks apart. It is likely that fruit developing from these separate flowering events will be obviously different at the start of harvest, allowing relatively accurate select harvesting of the more mature fruit. Flowering events less than three weeks apart are less likely to appear different at harvest, and are not suitable for select harvesting.
- Tag about 100 very early flowering panicles to provide mature fruit for calibrating the near infrared spectroscopy (NIR) hand gun (see below) well before the start of commercial harvest.
- About four weeks before expected harvest for each maturity zone, conduct maturity tests every week and record the results. Repeating over several years will give a reliable guide to how each block performs in relation to maturity, and allow more accurate prediction. Table 5 estimates the average change in percent dry matter, flesh colour and heat units per week from 4-6 weeks before minimum maturity. These figures can be used to help predict the start of harvest for each maturity zone. They can be fine-tuned for each farm if accurate maturity testing and record-keeping is done.

Table 5. The average increase in percent dry matter, flesh colour and heat units per week of Calypso™ mango during the last 4-6 weeks before minimum maturity.

Region	Year	% Dry matter	Flesh colour	Heat units
NT	2006-7	0.87	1.3	115
	2005-6	0.70	1.4	143
	Average	**0.79**	**1.4**	**129**
NQ	2006-7	0.47	0.6	119
	2005-6	0.50	1.4	109
	2004-5	0.31	1.3	110
	Average	**0.43**	**1.1**	**113**
SEQ	2006-7	0.69	1.0	134
	2005-6	0.44	0.8	107
	2004-5	0.39	0.9	102
	2003-4	0.34	1.7	104
	2002-3	0.36		
	Average	**0.44**	**1.1**	**112**

Estimating maturity

The two essential steps in determining maturity are collecting the fruit sample and measuring the maturity of these fruit. The percent dry matter of Calypso™ fruit on the same tree can vary by up to 3%, so it is important to use the correct fruit sampling procedures. The accuracy of the test will depend on whether the sampled fruit is representative of the fruit to be harvested.

Both steps must be done accurately for reliable results. The same principles apply to using the NIRS handgun. The handgun should be considered simply as an alternative way of estimating dry matter and flesh colour, which therefore requires both accurate sampling and accurate application of the maturity test.

Collecting the fruit sample

Because of the often large variation in maturity between fruit, it is important that the fruit sampled for maturity testing are representative of the fruit you are going to harvest. If not, it is likely that you will be harvesting immature fruit. The recommended procedures for percent dry matter, flesh colour and Brix are:

- Decide on what fruit you intend to harvest. For example, do you intend to harvest only the larger fruit first, or fruit from the trees that flowered earliest, or all of the fruit from a specific block.
- Harvest at least 10 fruit (preferably 20) representing the type of fruit you intend to harvest. Make sure that the fruit sampled covers all of the variability in the fruit to be harvested. For example, if all fruit in the maturity zone is to be harvested, then

Recording blocks or trees that flower early can help reduce mature fruit drop and provide more consistant quality

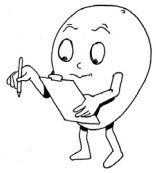
sample fruit from inside and outside the canopy, from all tree aspects (north, south, east and west), and from across the block. This step is very important.

- Place the fruit in a plastic bag to reduce moisture loss and assess for maturity within six hours of harvest.

NIRS sampling procedures are outlined in the *Near infrared hand gun* (Nirvana) section.

Percent dry matter maturity test

When measuring dry matter, one option is to combine the 10 to 20 fruit into one sample, then do the test. However, this will not give any indication of the range in maturity between individual fruit. It is possible for the average percent dry matter to be at the minimum required, but half of the fruit can be under the minimum and the other half can be over. In this case, half the fruit will have unacceptable flavour.



You can buy a good dehydrator from Myer for about $160.00

Recommended procedures

- For each fruit, cut a cheek from the fruit and take a section from each cheek as shown in Plate 12a.
- Remove the skin, then dice or grate the sample without losing any juice. Make sure you use the same part of the cheek for sampling for all dry matter tests, since percent dry matter varies through the fruit.
- Label and weigh a dry container. We use small plastic containers similar to those used for sauces with Chinese take-away.
- After dicing mix the sample to make sure there is no free juice, then place a subsample into the container and weigh the container and sample. Ensure this happens immediately after dicing, since any delay will give a false reading. Use about 30 gm if possible so that electronic scales accurate to 0.1 gm can be used. Smaller weights will require more accurate, more expensive scales.
- Dry the sample in a domestic food dehydrator set at 60 to 65°C for two days.
- Weigh the container with the sample. Place in the dehydrator for another day, then re-weigh. The fruit sample is dry if there is no significant loss of weight with additional drying.
- Determine the percentage dry matter using the following equation:

$$\frac{\text{Final weight of the dried sample - weight of empty container} \times 100}{\text{Initial weight of the fresh sample - weight of the empty container}}$$

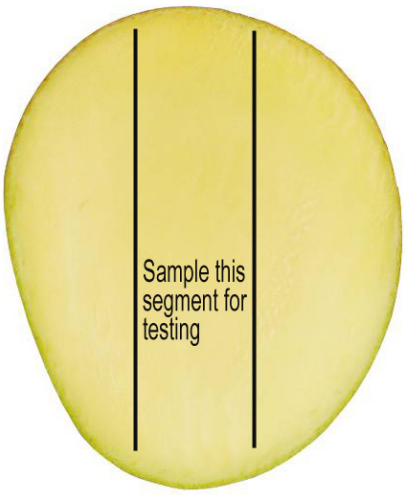


Plate 12a. The portion of the cheek used to determine the dry matter %

Flesh colour maturity test

- Cut a cheek from each fruit close to the seed. Use a very sharp, thin bladed knife otherwise the flesh will shatter and will appear much paler. If necessary, cut an additional slice from the fruit to expose a clean-cut surface.
- Place the Calypso™ Picking Guide over the fruit, with the curved surface of the Guide in line with the outside of the fruit (Plate 12b).
- Compare the colour of the flesh with the colour of each page of the Guide. Make sure the colour comparison is done in the shade and not in full sun or under artificial light. This is important because colour perception varies with the quality of the light.
- Record the flesh colour using the numbers on the Guide. Refer to the annual release of the Calypso™ specifications sent to growers before the start of each season for any variation to the standard.

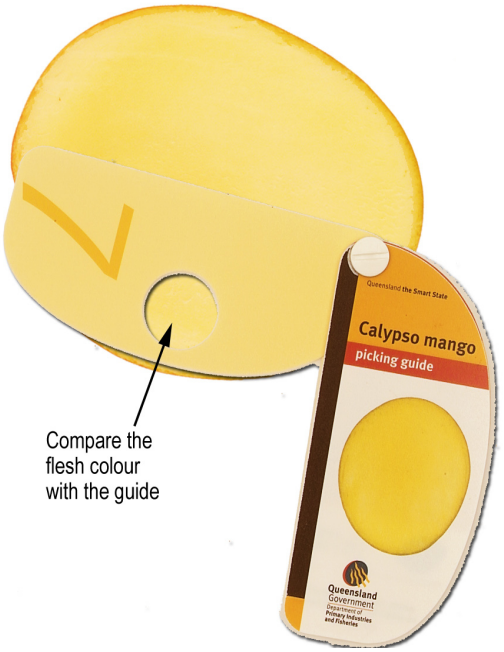


Plate 12b. Using the Calypso™ picking guide to measure the flesh colour of the fruit at harvest

Brix maturity test

- Squeeze juice from the flesh from the remaining sample of sliced/ blended sections of fruit from the dry matter test using a garlic press.
- If the juice is still too cloudy, filter through several layers of cheesecloth or a handkerchief.
- Read the Brix for each fruit using a temperature compensating hand-held refractometer.

Heat accumulation units

The accumulation of 'degree days' from flowering to fruit harvest shows a strong correlation with commercial fruit maturity. The technology is based on the principle that the growth and maturity of fruit depends on the accumulation of a required amount of heat energy. This can be measured in degree days from the point of peak-flowering (first fruit set) through to when the fruit are commercially mature.

Measuring heat accumulation provides a flexible tool for maturity estimation that is independent of seasonal influences. Thus by knowing what value is required and monitoring the accumulation of degree days each season, it is possible to predict with accuracy the approximate starting date for harvest. When heat accumulation

units are used in combination with other maturity measurements, identifying when to start harvest is easy and accurate.

As temperatures vary between seasons and locations, it is important for each grower to determine the rate of heat accumulation on a seasonal basis in their own orchard. There are several ways of doing this, but one of the easiest approaches is to use a temperature logging device with relevant software that allows the easy calculation of degree days. In our research we have used heat accumulation above 10°C, and logged the temperature hourly each day. We recommend similar procedures be followed by Calypso™ growers.

Temperature logging and software

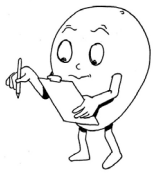
To collect temperature data for accumulated heat unit analysis, a computer is required. A laptop computer can be taken to the field to download the data directly from the logger or alternatively the logger can be taken indoors to a desktop computer for downloading. The following equipment is available from Hastings Data Loggers Pty Ltd (website: www.hdl.com.au) and can be ordered by phoning 1800 243 282.

Heat units flesh colour and dry matter can help predict the start of harvest 3 to 4 weeks in advance

Data logger and accessories

There is a choice of two logger units that will do the job:

- Tinytag Ultra 2 – TGU-4017 ($229.00+GST). This logger is the cheaper of the two options and comes with an internal temperature sensor with a logging range of -40 to +85°C. The case is only splash-proof, but providing it is installed in a weatherproof meteorological screen it should perform satisfactorily.
- Tinytag Plus 2 – TGP-4017 ($299+GST). The logger is supplied in a rugged waterproof case. However, it still needs to be installed in a weatherproof meteorological screen to ensure accurate measurement of air temperature. It is fitted with an internal temperature sensor with a logging range of -40 to +85°C.



These loggers can store 12 months of data if recording temperatures every hour

A **Communication cable** is needed to communicate between the logger and the software 'Tinytag Explorer', which should be installed on your computer. These items are supplied as a starter pack (SKCDU-0020; $139+GST) which fits any of the Hastings data logger range.

Weather screen. The Datamate Weather Screen (ACS-5050; $99.00+GST) provides a logging environment similar to a standard Stevenson screen used by meteorological services to measure air temperature. This ensures temperatures logged in this environment

are standard and comparable between sites. The Datamate screen is easily mounted on a steel post driven into the ground so that its top is 1140 mm above soil level. When the logger is enclosed in the screen, it is approximately 1200 mm above ground level which is the standard meteorological height for measuring air temperature.

Configuring the software and estimation of starting time

The calculations to determine the heat accumulation units for Calypso™ mango are based on the following parameters:

- A logging interval of one hour. This needs to be set at the time the logger is activated and is done through the software sold with the Starter Pack.
- Heat accumulation is based on degree days above 10°C. To calculate the accumulated heat units, the recorded temperature data from the logger has to be exported to a spreadsheet. If you are progressively monitoring heat accumulation through the season, then the finish date and time will be that of the last reading on your file.
- Estimation of peak flowering. The starting time chosen for the calculation of heat accumulation units is based on an estimated date of when a Calypso™ maturity zone block has reached full flowering. At this stage at least 50% of the panicles on the tree have reached full flowering (that is, about 50% of the flowers on each panicle have fully opened and the remaining 50% are not yet open (Plate 13), and at least 50% of the trees in the block have reached the full flowering stage. There will be some very small fruitlets visible on the northern aspect of the tree, but usually the flowers at the tips of the panicles would not have opened. It is important to accurately determine this date.

It is important to accurately determine the date of full flowering for each maturity zone

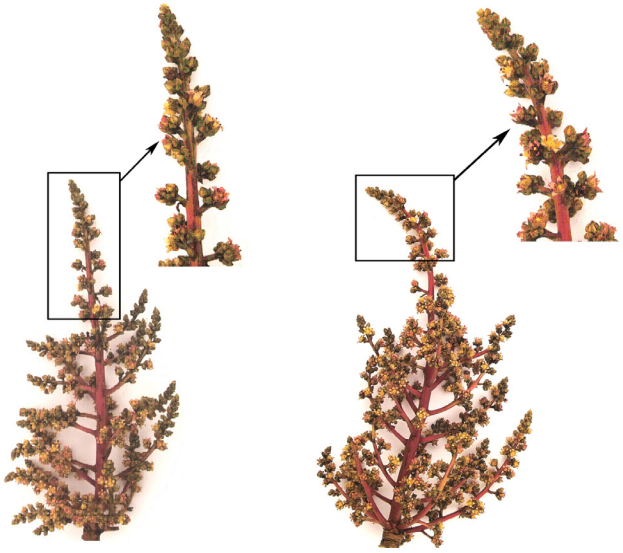


Plate 13. Calypso™ mango panicles at full flowering. At least 50% of the flowers are fully open and the remaining 50% not yet open

Near infrared hand gun ('Nirvana')

NIRS technology provides a non-destructive method of quality control in supply chain management of fresh fruit. For Calypso™, the internal parameters of percent dry matter and flesh colour are used as maturity indices. The handheld Nirvana unit supplied by Integrated Spectronics Pty. Ltd., Sydney (website: www.intspec.com/products/, phone: 02 8850 0262) has been extensively tested

with Calypso™, and is now recommended for commercial use (Plate 14). The two main procedures (calibration of the unit and in-field protocols) are summarised below. For a more detailed description, refer to the Nirvana Instruction Manual for use with Calypso™ (available from One Harvest and Central Queensland University).

Plate 14. Hand held NIRS unit (Nirvana) in use on a Calypso™ mango tree

Calibrating the hand gun

As NIRS is a secondary method, a reference method for the target attributes (in this case percent dry matter and flesh colour) must be developed to calibrate the NIRS instrument. This will ensure that the unit provides accurate and meaningful data on fruit maturity.

There are five key steps to the calibration process:

1. Select fruit of a range of maturities.
2. Take the NIRS readings and save the spectra.
3. Determine flesh colour and percent dry matter.
4. Send the spectral file and the flesh colour and percent dry matter results to horticalnir@gmail.com for processing and model development.
5. Install the new calibration model in the gun.

Fruit can be scanned any time and under any temperature conditions. The details are as follows:

Fruit sampling

- Tag very early flowering panicles to provide mature fruit well before the main harvest period.
- Sample 20 to 100 fruit across a range of maturities about 3-4 weeks before the estimated start of harvest. These fruit should have a colour range of 3-9, with ideally about 10 fruit per colour unit. (ie. 10 fruit at 3, 10 fruit at 5 and so on). If a calibration model already exists for the unit, fewer samples are required (minimum of 20 fruit). If the unit has never been calibrated, a larger number of fruit is required (e.g. start with 100 fruit).
- Do not include heat stressed, sunburnt or mis-shapen fruit.
- Label each fruit with a number, and clearly mark the area of the fruit to be scanned.

NIRS spectra

- Turn Nirvana on by pressing the black button on the left side panel once (Plate 15).
- Select model (product type), e.g. Mango DM.
- Tap once on ‘data’ box in the lower right hand corner of the screen. A new screen will appear. Tap on the option ‘filename’. Type the file name, then tap on the central area of the screen for the keyboard to disappear. Click ‘OK’. Alternatively, to add to an existing file, select an existing filename and click “OK”. This will change the screen to options related to the type of data stored.
- Select ‘Data type’.
- For calibration development, select the 2nd and 4th options (absorbance and interpolated).
- Select ‘Return’ twice.
- Hold the window of the gun against the fruit and press the large blue button. Wait 2-3 seconds for the reading to register. Each scan will be automatically stored.
- Scan both sides of the fruit. Scan the blush side first if present.

Plate 15. Hand held NIR unit (Nirvana), in position on a labelled piece of fruit

Reference measurements

- Slice off the fruit cheek section using a very sharp, thin bladed knife.
- Use the corer provided to cut out the section of the cheek that was scanned by Nirvana (Plate 16).
- Use a potato peeler or sharp knife to remove the skin (approx 1-2 mm depth) from this sample.
- Trim the sample to 1 cm length, cutting off the inside (near seed) tissue.
- Measure the flesh colour of the ‘skin’ side of the sample against

Plate 16. Calypso™ mango fruit sample taken for dry matter assessment

the Calypso™ Colour Guide under natural light (not direct sunlight). Use a colorimeter if available for greater accuracy. Record the flesh colour in the spreadsheet provided.

- Cut the 10 sample into quarters (Plate 17) and determine percent dry matter as above (section *Percent dry matter maturity test*). As the sample is small, use a scale capable of measuring to at least two decimal places.

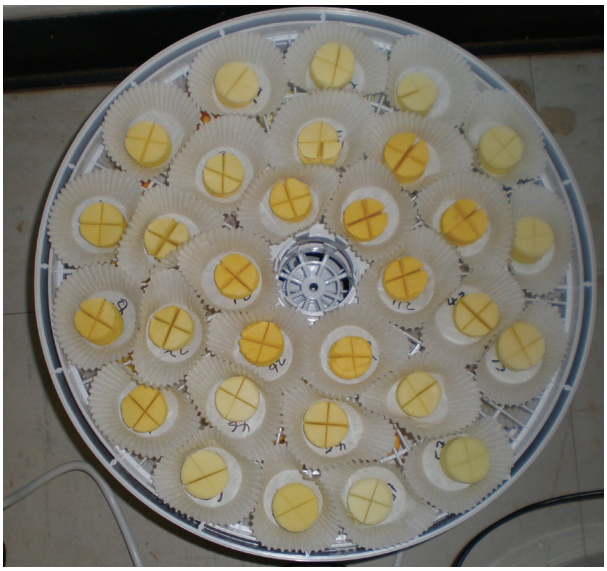


Plate 17. Calypso™ mango fruit samples on a rack ready for drying in a food dehydrator

Downloading data from Nirvana to a computer

Check that you have the 'ActiveSync' software on your computer. If not, it can be easily downloaded from the internet free of charge (e.g.: http://www.microsoft.com/windowsmobile/en-us/help/synchronize/device-synch.mspx)

On Nirvana

- Click on 'Data', then on 'Close file'.
- Connect Nirvana to the computer using a standard USB cable.
- Turn Nirvana on and wait 30 seconds.

On the PC

- ActiveSync will automatically appear on your computer screen. Minimise this screen by clicking the '–' symbol on the screen.
- Go to 'link to mobile device'.
- Double click on 'FlashDisk', then on 'iQcalibri.exe', then on 'Data'.
- Copy or cut the calibration files from the data folder to your computer.

Two files are required to be sent to horticalnir@ gmail.com:

- The calibration files from the Nirvana.
- The flesh colour and percent dry matter results (Excel file).

Downloading the calibration model file back to the NIR gun

The scan data and the reference (flesh colour, DM) results will be used to create or update a calibration model. This model will be returned as a file attached to an email. Save this file from the email to your PC.

On Nirvana

- Connect Nirvana to the computer using a standard USB cable.
- Turn Nirvana on and wait 30 seconds.

On the PC

- ActiveSync will automatically appear on your computer screen. Minimise this screen by clicking the '–' Symbol on the screen.
- Go to 'link to mobile device'.
- Double click on 'FlashDisk'.
- Double click on 'iQcalibri.exe'.
- Copy calibration model from your PC into the folder, 'Models' on Nirvana.
- Nirvana is now ready to use with the new model.

Estimating maturity in Calypso™ orchards

The Nirvana provides an efficient means of determining the harvest schedule, which indicates when maturity zones have reached minimum maturity, and the sequence (and dates) when zones will be harvested.

Assess all maturity zones on the farm about four weeks before the expected start of harvesting. Tag about 100 trees on a diagonal across the zone (this number should be adequate as long as the maturity across the zone is relatively uniform as indicated by flowering times). Assess 10 fruit per tree, either randomly around the tree, or from a specific position within the tree (e.g. the upper, northern aspect of the outer canopy) if these fruit are to be harvested first. Data from each tree within the same harvest zone will be averaged, and compared to that of other zones.

In the near future, Nirvana will include a GPS unit with software allowing a 'mapping' function to relate tree position in the zone to percent dry matter or flesh colour. Systematic sampling can then be used. In this case, select trees within the zone based on a systematic grid (e.g. every fifth tree in row, and every third row). Aim to sample from approximately 100 trees within

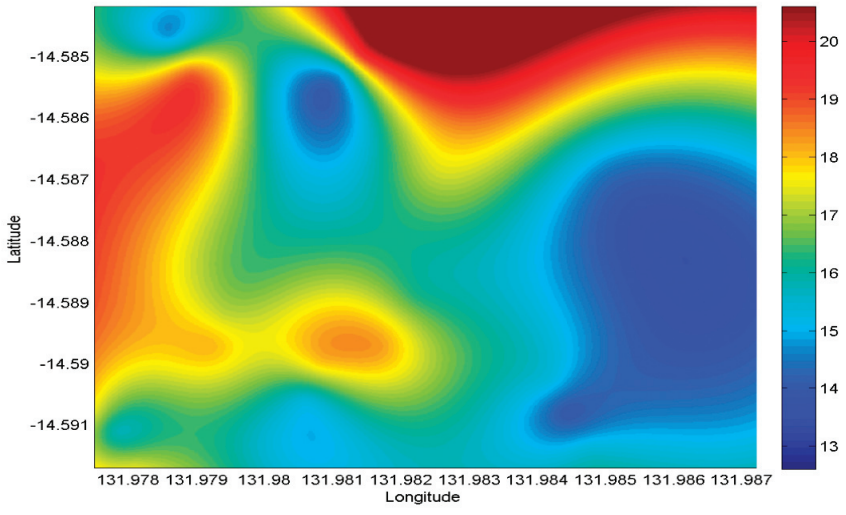


Plate 18. Using NIRS technology to map maturity zones based on fruit percent dry matter (scale on the right) within orchards in Katherine (NT) in 2009.

the zone, and 10 fruit per tree. The individual tree data can be used to develop a maturity map for each zone or for the whole farm (e.g. Plate 18). This can be used to further refine understanding of maturity patterns across the farm and improve maturity zone use.

The Nirvana can be used for several other related purposes. The increase in maturity during fruit growth can be recorded by tagging 10 fruit of a given flowering event with a ribbon and following percent dry matter and flesh colour change every week for 4-6 weeks before expected harvest. This can help predict when the minimum maturity might be reached (Figure 1). The rate of increase will vary with several factors such as the location of the farm, temperature, and soil water status.

Maturity can vary around the tree, generally in relation to sunlight interception. This information may be used to guide picking decisions if selective harvesting of the more mature fruit is required. This can often be more effective than requesting pickers to harvest based on fruit appearance. To determine canopy position effects, measure the percent dry matter and flesh colour of 10 fruit from each of the four aspects of the canopy (north, south, east and west) and from inside and outside the canopy if desired. As an alternative, sun-exposed and shaded fruit can be tested, since sun exposure is the major determinant of variation in maturity (apart from flowering date). Calculate average percent dry matter and flesh colour for each canopy position.

The Nirvana can also be useful to check picker performance when instructed to selectively harvest the more mature fruit. To do this, assess the average percent dry matter and flesh colour of 50 fruit in the field bin, and 50 fruit remaining on the same trees from which the fruit were harvested. The average percent dry matter and flesh colour of the fruit remaining on the tree should be at least two units lower than the harvested fruit. A similar process can be used to check fruit on delivery to the packhouse. Check 20 fruit per bin using Nirvana for compliance to the percent dry matter and flesh colour specifications adopted by that farm for harvest.

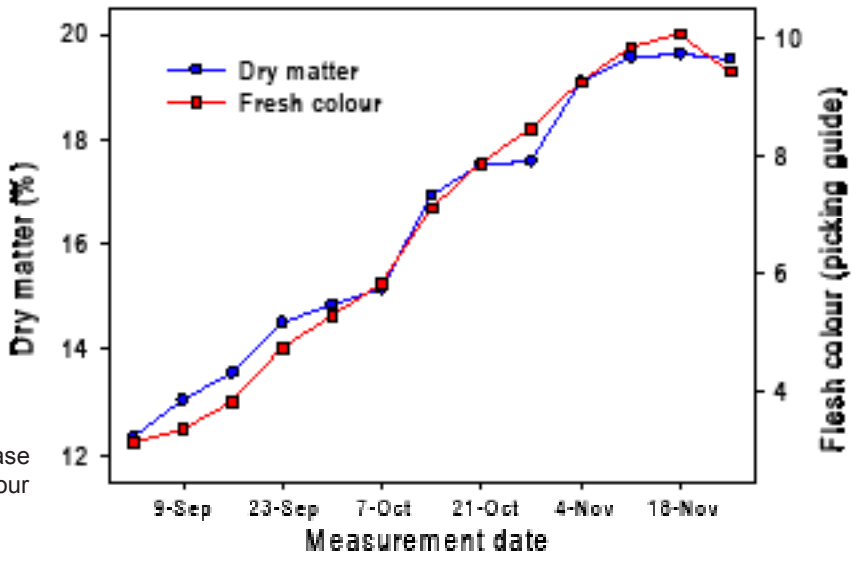


Figure 1. Estimate of typical increase in percent dry matter and flesh colour in Calypso™ mango during fruit growth using NIRS technology.

Variation in maturity

The percent dry matter of Calypso™ and 'Kensington Pride' fruit can vary by up to 3% between individual fruit on one tree. There can also be considerable variation in dry matter (up to 1.8%) between fruit on the same bunch, despite the flowers on these panicles generally flowering within about one week. Also, smaller fruit are not always less mature than larger fruit. Variation in maturity is influenced by at least three factors:

- Inherent physiological variation between each fruit, even between fruit from the same flowering event. We know little about why this variation occurs, or how to minimise this during harvesting.
- The degree of sun exposure of the fruit can affect the percent dry matter. In subtropical climates, the northern or western aspect of the tree receives more sun, often flowers earlier and the fruit mature more quickly. Generally shaded fruit (for example in the inside of the canopy) are less mature.
- Fruit developing from different flowering times within each tree or between trees. Little can be done to cope with this variation. In seasons with very uneven flowering such as during mild winters, the variation in maturity at harvest can be even greater.

There is little change in external appearance of Calypso™ fruit over the last 2-4 weeks of fruit maturation, so selective harvesting can be unreliable. Several approaches can be used to minimise the impact of variable maturity:

Determine maturity zones

Using the maturity zone concept outlined in the section *Maturity zones, maturity mapping and harvest schedule*.

Variation between trees

In some seasons, specific trees will flower early, but fairly uniformly within each tree. Fruit from these trees can be commercially mature two weeks before the remainder of the block. Tagging these early flowering trees at flowering can provide early harvest fruit, and prevent fruit drop because of fruit ripening on these tree before the majority of the block is ready for harvest. Simple procedures such as spraying the trunk with a colour dye may be sufficient to identify these trees at maturity. Different colours may be required in different seasons to avoid confusion.

Recording blocks or trees that flower early can help reduce mature fruit drop and provide more consistent quality

Variation within the tree

Within individual trees, distinct flowering events occurring 3-4 weeks apart may provide obvious differences in fruit shape and size at maturity to allow selective harvesting of fruit from the earliest flowering event. If this happens, it may be worth recording/tagging trees or maturity zones that have large and distinct separation between flowering events, particularly if, say over 40% of the northern canopy flowered earlier than the rest of the canopy. However, little can be done with extended, even flowering over 3-4 weeks because fruit appearance will not sufficiently distinguish maturity under the pressure of commercial picking. Under these conditions, harvesting should start when the latest flowering fruit have reached minimum maturity. Also, a slight relaxation in the maturity standards may be considered to allow a small percentage of fruit below the maturity standard.

Very mature fruit

Leaving fruit on the tree longer will improve flavour but increase the risk of lenticel spotting, skin marking, fruit starting to ripen on the tree, and fruit drop. Little research has been done on a maximum maturity standard to indicate when these risks become unacceptable. However, circumstantial evidence suggests that fruit should be harvested before they reach about 18-19% dry matter (maybe higher in the Northern Territory in high percent dry matter seasons).

In relation to fruit starting to ripen on the tree, preliminary evidence suggests that at the start of the season these fruit have physiological disorders such as stem end cavity and jelly seed, and should not be marketed. Fruit starting to ripen on the tree at later harvests should not be marketed at this stage because of concerns over flavour and damage during commercial picking and packing. The potential to market these fruit will be investigated in future projects.

Harvesting during rain

Fruit harvested during or soon after rain are more likely to be damaged during harvest and have more lenticel spotting, brushing damage and scald from hot dips. It is best to delay harvest for 1-2 days if more than 20 mm falls within 12 hours (refer to the Hazard Analysis report for more details) or adjust hot dip practices (see section *Cleaning, disease treatment, grading and packing*).

At this stage, we recommend that fruit be harvested before they reach 18% dry matter.

The main risk with late harvest is increased susceptibility to lenticel spotting, which has been observed in several commercial consignments in some preliminary research. In these late harvests, there is a greater risk of fruit ripening on the tree. Fruit with any sign of softening or yellow skin colour on the tree should not be placed in the commercial consignment because of increased variability in ripening and the risk of off flavours.

How to harvest

Mechanical damage

Mechanical damage (as illustrated in Plate 19), can occur at all stages from harvest to retail shelf, but harvesting procedures are a significant cause of damage. Damage may not be obvious during sorting, but usually becomes more obvious as the fruit ripen and age, particularly under the low humidity on the retail shelf. The more sensitive skin of Calypso™ fruit make it more susceptible to mechanical damage compared with 'Kensington Pride'. Therefore, additional care is required with handling of Calypso™.

Significant damage can occur with secateurs. Tree height should be controlled to minimise the need for secateurs, or secateur design improved to minimise sharp edges.

Give special attention to harvest aid design and operation. Protect all sharp edges on the harvest aid. Place fruit carefully on the harvest aid rather than throwing from several metres away. If throwing is tolerated, use a small vertical tarpaulin (Plate 20) to reduce the momentum of the fruit before it hits the horizontal tarpaulin. Nonetheless, adjust harvest aid speed to minimise the need for pickers to throw fruit onto the machine. Clean all tarpaulin surfaces daily and keep them continually wet with harvest aid solution to prevent abrasion from dust and deposits on the tarpaulin.

Minimise drop heights into the field bins from the harvest aid.

Damage could also occur in the packhouse before packing (see *Packhouse practices*).

Wounds

Abrasions

De-sapping and detergents

Issues

Similar issues apply with Calypso™ as with 'Kensington Pride' in relation to harvesting, de-sapping and the use of detergents, but more care is required with Calypso™ because of its more sensitive skin. Refer to the *Agrilink Mango Information Kit* for a more complete discussion on this issue. Following are a number of observations relating specifically to Calypso™:

- The stem of Calypso™ breaks more easily from the fruit than with 'Kensington Pride'. Long stems can break when harvesting Calypso™ into crates and cause sap damage to adjacent fruit. These fruit should be sorted the day after harvest when sap damage is obvious.

Scratches

Plate 19. Types of physical damage on Calypso™ fruit

- Calypso™ fruit are very susceptible to lenticel spotting (Plate 21). Lenticel spotting is made worse by harvest and packhouse practices. Even exposure to water can increase lenticel spotting.
- Detergents can have differing effects on lenticel spotting. The commercially available 'mango detergents' and some other commonly used detergents have been evaluated, but inconsistent results have been noticed over the years. It appears that there are seasonal/orchard effects on detergent suitability, but Mango Wash® has consistently performed well.
- Ensure that the fruit are in contact with Mango Wash® for at least 60 seconds, and preferably 90 seconds. Increased exposure can increase lenticel spotting, but insufficient exposure can cause sapburn and skin browning.
- Excessive ooze sap on the fruit (insufficient contact with Mango Wash®) or ooze sap staying on the fruit for too long (more than 6-12 hours delay between picking and packing) can also increase lenticel spotting.
- There have been few consistent benefits with a water rinse at the end of the harvest aid in trials on several farms, possibly due to farm/season effects. We suggest that trials be conducted on each farm to justify the need for a water rinse. It is likely that other factors such as not replacing Mango Wash® frequently enough and excessive delays between picking and packing are more important in lenticel spotting then presence or absence of a water rinse.
- Very mature fruit appear to be more sensitive to lenticel spotting. Also, fruit that have started to ripen on the tree can develop severe damage when placed over the packing line.

Plate 20. Harvest aid with a vertical tarpaulin to reduce the momentum of thrown fruit

Recommended procedures

Follow the general recommendations in the *Agrilink Mango Information Kit*, but with the following considerations:

- Minimise the length of time the fruit are wet.
- Minimise the use of detergents without increasing the risk of sapburn or skin browning.
- Mango Wash® performs well in harvest aids, although results have been variable with fruit from young trees grown on red soils. Do not use LOC or Cold Power.

Plate 21. Lenticel spotting on Calypso™ fruit. Detergents, excess brushing and aging can increase lenticel spotting

- Use a flow through system (do not re-circulate the water) on the harvest aid if possible to reduce the risk of sap build-up in the water. If a recirculating system is used, ensure the Mango Wash® is replaced about every two tons per 2000 L of Mango Wash®, or more often if the solution loses its slippery, soapy feel.

See the Appendix for a detailed checklist regarding sap burn and skin browning.

From field to shed

Fruit damage can occur during transport in bulk bins. The damage can be caused by fruit rubbing against other fruit and with the side and base of the bin (Plate 22). Damage is likely to be worse if fruit are wet from rain or condensation. The following is recommended:

- Minimise the distance from the field to the packhouse, and not more than 200 km to the packhouse.
- Pack fruit within 12 hours of harvest. See the Hazard Analysis report in the Appendix for more specific recommendations.
- Use vehicles with soft suspension at all times.
- Reduce speed when travelling over rough roads.
- Avoid breaks in the cold chain if refrigerated transport is used. Minimise condensation on the fruit.
- Regularly wash field bins to reduce fruit abrasion from dust and grit.

Packhouse practices

Cleaning, disease treatment, grading and packing

Compromises are often required in handling practices in the packhouse and during distribution to the retail shops. Following are a range of issues which impact on quality and illustrate some of these compromises. Firm rules cannot be made because recommended practices will vary depending on the history of the fruit, the intended market for the fruit and other considerations. Refer to the Hazard Analysis report in the Appendix for more detailed recommendations.

Plate 22. Damage to Calypso™ fruit during long-distance transport in bulk bins

Issues

Packing quickly after harvest increases storage life

- Generally, any delay between harvest and cooling shortens the storage life. Therefore, pack fruit as soon as possible after harvest (preferably the same day) if transport to domestic markets is longer than about three days, or if fruit are to be exported.
- Holding fruit overnight in the field bins can damage the fruit from the button (the remaining stem) pressing on adjacent fruit, or from fruit to fruit contact if there is water or sap at the contact point. This can downgrade fruit from premium to first grade. Lenticel spotting can also increase because of ooze sap and other residues remaining on the fruit for too long.
- Based on observations with 'Kensington Pride', delaying packing by 24 hours can reduce skin damage from hot fungicide treatment, heat disinfestation treatment, or brushing, particularly if the fruit had been harvested within 2-3 days of rain.
- Detergent sprays over the brushes can increase lenticel spotting, and excessive brushing (more than one minute) will increase the risk of lenticel spotting and other skin damage.
- Good postharvest disease treatment is essential. Calypso™ appears to be fairly tolerant of anthracnose, but stem-end rot can be a major issue. Anthracnose is controlled by cold Sportak® sprays, but stem-end rot is only controlled by hot fungicide treatment. Spin Flo® has recently been de-registered for mangoes, and alternative products are under review.
- Hot fungicide treatment of fruit harvested within three days of rain can increase the risk of heat damage. Ideally, delay harvesting for 2-3 days following wet weather to allow the fruit to 'harden'. If this is not possible, leave the fruit to 'harden' for 24 hrs before packing. However, delaying packing too long after harvest may increase lenticel spotting if significant ooze sap remains on the fruit. Under these conditions, it may be better to reduce the temperature of the hot water to 50°C, or remove the hot water treatment completely. This will increase the risk of fruit rots particularly in old orchards and orchards grown under high rainfall conditions during fruit growth.
- Hot spray systems can increase hot fungicide treatment efficiency. Maintain similar conditions of fruit skin temperature and duration as those delivered with hot dips. Set the hot fungicide reservoir temperature higher than 52°C to compensate for heat loss from the spray between the nozzle and the fruit surface.

- Mechanical damage has been observed on fruit on the retail shelf (see How to harvest). Packhouse practices may contribute to mechanical damage, particularly when fruit are transferred from field bins onto the packing line, and from impacts along the packing line.
- Damage illustrated in Plate 23 has been observed in loose-packed fruit with plastic inserts, probably caused by vibration during road transport. Pack trays tightly, and consider using compressed paper inserts.
- Bruising has been noted on the stem-end of ripe fruit in the retail store as a result of holding ripe fruit on crinkled plastic inserts (Plate 23).

Precooling

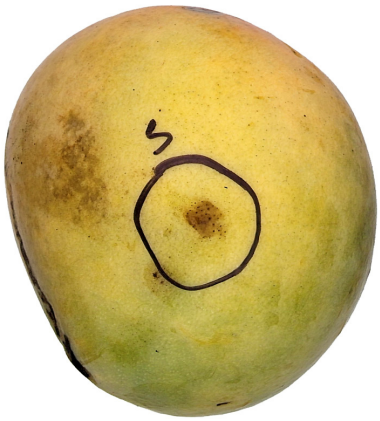
It is important to precool fruit to the required temperature before ripening, storage or transport. Ineffective precooling can result in reduced shelf life and uneven ripening within the pallet. Forced-air cooling is the preferred cooling method as it provides fast and even cooling through the pallet, while room cooling is slow and uneven.

Design the forced air system to reduce fruit temperatures to 7/8 of the final temperature (12°C) within 6-12 hrs of the start of precooling. Cooling any quicker than six hours requires considerable air flow, and may be uneconomical. Fruit can be removed one-two hours earlier and placed in a holding room to reach the targeted fruit temperature if the quantities for precooling are higher than the forced air cooling capacity.

The following practices are important for tunnel cooling to ensure that the cold air is forced through the packages, rather than leaking past gaps between pallets or cartons:

- Pull the tarpaulin tight over the top of the pallets to eliminate air gaps.
- For open top packages, the tarpaulin must cover across the top of the two rows of pallets.
- For pallets with different heights, position the pallets so the heights along the two rows are similar to minimise the air gaps under the tarpaulin.
- Stack the cartons on the pallet to ensure the air flows through the sides of the cartons that have the most ventilation.
- Position the pallets so that the runners of the pallet prevent any leakage underneath into the tunnel.

Damage from stem



Heat damage

Damage from plastic liners

Plate 23. Skin marking from the remaining stem pressing on adjacent fruit when the fruit are left in the field bins for 24 hours before packing, heat damage from hot fungicide treatment of fruit harvested just after rain, and marking on ripe fruit from plastic liners

- If different types of packages are stacked on pallets, position the pallets with the packages having the least ventilation at the front nearest the fan.
- Ensure the tunnel and the gap on the outside of the pallets where the air enters is wide enough to ensure that air flow through the pallets along the row is not restricted.

Precooling is important to increase shelf life and even ripening

Take care when precooling fruit after heat treatment, as skin damage can occur. Delay precooling for at least six hours when precooling to below 20°C after heat treatment.

Maintain fruit temperatures after precooling (maintaining the cold chain) to maximise storage life, minimise condensation on the fruit and cartons, and save the energy costs of re-cooling.

Recommended procedures

- Pack fruit on the same day of harvest if the fruit are to be exported.
- For the domestic market, delay packing by 24 hours if fruit are harvested within three days of rain. If this is not possible, reduce the hot dip temperature to 50ºC, or remove the hot fungicide treatment completely and use only cold Sportak® spray until at least the third day after rain. Inform the One Harvest harvesting manager to ensure this fruit is marketed quickly to minimise the risk of stem-end rot, particularly if fruit are from older orchards.
- Do not use a detergent spray over brushes because of increased risk of lenticel spotting.
- Do not brush fruit for more than one minute. Minimise the number of brushes in the line for polishing the fruit. Experiment by covering a number of brushes, and increase the number of brushes used until the waxy bloom and other residues have just been removed.
- Examine all parts of the packing line for potential mechanical damage to the fruit. This includes the method for placing fruit onto the packing line from the field bins, excessively high drops or sharp edges, and dirty equipment.
- Compressed paper inserts are preferred. Pack fruit tight to minimise vibration, particularly if using plastic inserts and for long distance transport.
- After heat treatment delay precooling for at least six hours when cooling to below 20ºC.
- Stop the forced air once the desired fruit temperature is reached. Excessive airflow can increase weight loss and accentuate skin damage.

Disinfestation for export

Calypso™ fruit can be vapour heat treated (VHT) using the same protocol as 'Kensington Pride'. The flesh around the seed is heated to 47°C and held for 15 minutes. This heat treatment advances the ripening of fruit by a half to one day.

Ensure fruit are firm when treated. Precool fruit and use refrigerated transport if there is a risk of fruit ripening before treatment. If fruit are cooled, hold fruit at air temperature to warm to at least 20°C for at least six hours before treatment.

After treatment hold fruit at 20°C for at least 12 hours before cooling to transport temperature. Cooling immediately after heat treatment may cause skin damage.

For sea freight, do not delay cooling for longer than 24 hours after heat treatment as fruit may start to ripen before dispatch.

Irradiation of Calypso™ fruit is not recommended at this stage as it accentuates skin and lenticel damage that occurs during harvesting, grading and packing. Further research is planned to develop commercial irradiation protocols for Calypso™.

Transport conditions

Domestic

Results from the Better Mangoes project identified two main transport scenarios. The systems are based on the distance and time from harvest to delivery to the markets or retail distribution centre. System one is required for export, with the added practice that fruit should be precooled as soon as possible after harvest, and transport temperatures should be maintained at 12°C at all times. See the Hazard Analysis report in the Appendix for more suggestions.

Export – airfreight

Fresh produce is transported under non-refrigerated conditions during air freight. To minimise ripening during transit, precool fruit to 12°C before loading air freight containers.

For customers requiring backward fruit, maintain fruit temperatures at 12°C from precooling until loading and minimise exposure to ethylene. This is critical for Calypso™ because of relatively rapid loss of green skin colour.

For customers requiring partly ripened fruit, ripen the fruit to one colour stage below the required stage, cool to 12°C and hold at this temperature for as long as possible before loading on the airplane. The fruit should ripen to the required stage during transport.

Export – seafreight

Precool fruit to 12°C within 24 hours of harvest, and maintain the cold chain at 12°C through to unloading of the container in the export destination. Use controlled atmosphere containers with 2-3% oxygen and 4-5% carbon dioxide for sea freight journeys longer than 14 days. Establish controlled atmosphere conditions within three days of harvest.

Modified atmosphere packaging is not recommended. Surface coatings such as waxes can help reduce lenticel spotting and lenticel damage during irradiation, but further research is required to get the right balance between minimising lenticel damage without interfering with skin colour loss and flavour development during ripening.

Smartfresh[SM] (ethylene inhibitor) is not recommended because of inconsistent or minimal benefits.

Plate 24. Airfreight AV container (top) and seafreight pallet (bottom) with mango fruit

Ripener practices

Ripening conditions

Calypso[TM] should be ripened at 18-20°C using 10 ppm (trickle) or 100 ppm (shot) ethylene for 2-3 days. Lower temperatures can increase fruit rots and lenticel spotting. Fruit ripen more quickly at temperatures above 22°C, but the benefits are small and the fruit may ripen too quickly. Longer ethylene treatment provides little additional benefit. Experience with 'Kensington Pride' suggests that very mature fruit require only 1-2 days of ethylene.

In 'Kensington Pride', fruit temperatures must be below 25°C before the start of ethylene injection, otherwise skin spotting (small circular areas of skin greying) can occur. Similar responses are likely with Calypso[TM].

Ripen Calypso[TM] fruit at 18–20°C with ethylene for 2–3 days

Carbon dioxide concentrations should be maintained below 1%, otherwise fruit can ripen with poor skin colour. This can be achieved by installing a carbon dioxide monitor that opens a vented fan when concentrations reach 1%. A passive venting system can be

Better mangoes recommendations

System 1 — ripen at market

The aim of System 1 is to deliver uniformly backward fruit to the market destination and then use ethylene to ripen fruit ready for retail sale. Temperature is managed through the chain to prevent mixed ripening and to avoid high temperatures above 22°C. This is the preferred system for NT and northern WA growers. The recommended handling conditions are:

- pre-cool fruit to transport temperature within 12 to 15 hours of packing;
- transport at 12 to 16°C for trips of 1 to 2 days and 12°C for longer trips;
- ripen at the market using 10 ppm ethylene for 2 to 3 days at 18 to 20°C;
- continue to hold fruit at 18 to 20°C until ready for sale;
- store at 10 to 12°C to slow ripening for a maximum of 3 days.

System 2 – ripen on farm

The aim of System 2 is to deliver fruit to the market destination ready for retail sale within one to two days. Fruit are ripened evenly using ethylene to colour stage 3 (30 to 50% yellow) before transport and temperature is managed through the chain to avoid high temperatures above 22°C. Ripening on farm is not recommended for transport times longer than 4 days. The recommended handling conditions are:

- Pre-cool to 18 to 20°C within 12 to 15 hours of packing;
- Ripen using 10 ppm ethylene for 2 to 3 days at 18 to 20°C;
- Hold at 18 to 20°C until colour stage 3 (30 to 50% yellow);
- Transport at 12 to 16°C for trips of 1 to 2 days and 12°C for 3 to 4 day trips;
- Hold at market at 18 to 20°C until ready for sale;
- Store at 10 to 12°C to slow ripening for a maximum of 3 days.

installed by placing a venting pipe near the cooling fans and another at the opposite side of the room near the floor. The diameter of the pipe needs to be sufficient to achieve the required air change of the room. Passive venting is not suitable for shot systems because it increases room leakage which affects ethylene concentrations. For these systems, the ripening room doors should be fully opened for at least 15 minutes every 6-8 hours to release the carbon dioxide.

A forced air system is recommended for ripening to maintain fruit temperatures and consistent ethylene concentrations throughout the pallet. However, excessive air movement must be avoided to minimise dehydration of the skin and accentuate lenticel spotting and skin marking. Either use a low airflow forced air fan or cycle the fan for

one hour on and seven hours off. Ripening systems should be tested by placing temperature loggers in the last pallet of a full forced air line to check that fruit temperatures do not exceed 22°C during ripening.

Holding conditions

Sometimes the supply of fruit can exceed retailer requirements and fruit have to be stored until the demand increases. It is best to store unripe fruit at 12°C, which allows storage for about two weeks. However, in some cases partly ripened fruit may have to be held before being sent to the retailer. Sprung Calypso™ fruit can be held at 10-12°C for seven days without significant loss of quality. Minimise storage times to prevent loss of appearance and flavour.

When to dispatch to the retailer

Calypso™ has a mild flavour. The two main factors affecting fruit flavour are:

- The stage of maturity at which the fruit is harvested. If the fruit are harvested immature they will never ripen to a good flavour. The recommendations in the *Harvesting* section are aimed at ensuring that fruit are harvested at the right maturity to maximise ripe fruit flavour.
- The stage of ripeness at which the fruit is consumed. Unripe fruit have lower sugars and higher acidity while over-ripe fruit can have bland flavour due to lower acidity and other flavour components.

To maximise the eating experience, display fruit at the right stage of ripeness on the retail shelf. Give clear, easy consumer guidelines on when to eat fruit. A good consumer guide would be, “Consume on the day the fruit is purchased. If fruit is held for longer periods, place the fruit in the refrigerator for a maximum of three days”.

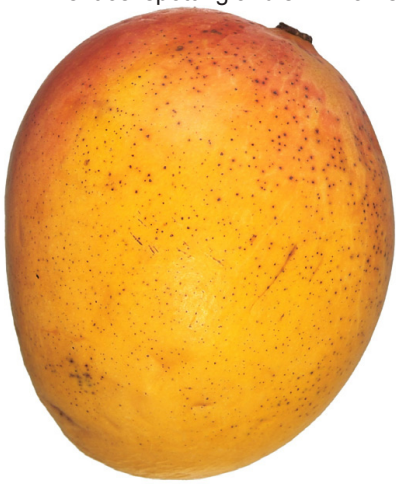
If this is the agreed consumer guide, then dispatch fruit from the ripener at the ripeness stage when it will have acceptable flavour one day later (that is, when the fruit is placed on the retail shelf). This assumes the fruit are sold within 2-3 days. Any longer delay will result in fruit ageing too much, which could increase lenticel spotting, shrivelling and skin marks, and reduce flavour.

To achieve these objectives, dispatch fruit from the ripener when all fruit have just reached full-colour, or perhaps one day later for less mature fruit, and one day earlier for longer transport times between ripener and retail store. The fruit can be dispatched when about 90% yellow if there are concerns that the fruit will not de-green during ripening because of production factors (for example excess nitrogen).

Recommended procedures

- Hold green fruit at 12°C for no more than two weeks if not ripening immediately. Do not hold at 15 to 16°C to slow ripening as the fruit will ripen at this temperature and will have more rots and lenticel spotting.
- When fruit need to be ripened, bring them to the ripening temperature before injecting ethylene. This is particularly relevant when ripening immediately after harvest. Do not introduce ethylene until the fruit temperature is below 25°C.
- Ripen under the right conditions to ensure that ripening proceeds as quickly as possible. Use 18-20°C with 10 ppm ethylene treatment (trickle) for 2-3 days, or for 1-2 days for very mature fruit. Avoid ripening temperatures outside the 18 to 22°C range.
- Ensure adequate air movement around the fruit to maintain even ethylene concentrations and temperatures within the pallet. However, avoid excess air movement to reduce the risk of skin dehydration.
- Maintain carbon dioxide concentrations below 1% by adequate venting of the rooms.
- After ethylene treatment, hold fruit at 18-20°C until all fruit have just reached the full-colour stage. Less mature fruit can be ripened for one day longer, and fruit ripened for one day less for longer transport times between ripener and retail store. Reduce the fruit temperature to that required by the customer before dispatch.
- Store the sprung fruit at 10-12°C for no more than seven days if they need to be held after ripening. Adjust then fruit temperatures to meet customer requirements before dispatch.

Lenticel spotting and skin marks



Shrivelling of the skin (2 views below)

Plate 25. Lenticel spotting and skin marks become more obvious, and fruit become shrivelled if not sold from the retail shelf quickly

Retailers and consumers

Issues

Calypso™ fruit can age quickly in the retail store, resulting in the following:

- The skin shrivels because of moisture loss under the low humidity in the store, and other skin defects such as lenticel spotting and skin marks become more obvious (Plate 25). Fruit rots can also increase.
- The fruit can lose flavour as they become over-ripe. The rate at which this happens depends on store temperatures. Under controlled laboratory conditions, flavour starts to deteriorate after 4-5 days, especially in less mature fruit. Fruit that have been stored longer before ripening will deteriorate more quickly.
- If fruit have been dispatched from the ripener to arrive at the retail store with acceptable flavour, place fruit on the retail shelf within one day of arrival and sell within two days of placing on the shelf. On the day of purchase, the fruit is likely to have good flavour. If the consumer delays eating for several days and leaves fruit on the bench, appearance and flavour at consumption will probably be unacceptable.

Recommended procedures

- Place the fruit on the retail shelf on the day of delivery to the store.
- If there is a carry-over of fruit, hold excess fruit at 10°C for no more than five days, or at 7°C for no more than three days.
- Ensure that trays are clearly marked with the day of delivery and place the first-delivered fruit on the shelf first to ensure “first in-first out”.
- Rotate stock on the shelf to ensure that older fruit are purchased first. Move older fruit into the area of the display that is most likely to be picked over by the consumer. Place younger fruit in the areas of the display that are more difficult to reach.
- Educate the consumer to eat the fruit on the day of purchase. Fruit that are not consumed within 1-2 days should be placed in the chiller drawer of the fridge for no more than three days.

APPENDIX

Source: Mango Care, October 2003. R. Holmes

Did you know?

1. Mango sap

Mango sap, consisting of oils and latex (protein – sugar), is highly toxic ☐

The oil component is responsible for sap-burn and some skin browning ☐

'Spurt sap' has a high oil content and usually last for 5 to 30 seconds ☐

'Ooze sap' has a low oil content that decreases with time and continues for 30 minutes to 2 hours ☐

Ooze sap is a common cause of skin browning when it stays wet on the skin of fruit for any length of time ☐

2. Sap-burn

Sap-burn is often confused with disease breakdown ☐

Symptoms don't appear for 24 to 48 hours making it difficult to grade it out in the packing shed ☐

Spurt sap causes sap-burn when it contacts the fruit skin and stays wet for a short time ☐

Fruit maturity, rain and water stress all influence the amount and toxicity of mango sap ☐

Surfactants, wetting agents and detergents used incorrectly can also increase sap-burn and skin browning ☐

3. De-sapping systems

There are two main harvesting and handling systems that can stop sap-burn occurring ☐

Both systems rely on the use of specific chemical solutions to negate the effect of mango sap ☐

The chemical you need is dependant on the de-sapping system you use ☐

4. De-sapping in the packing shed

This system aims to stop the sap contacting the skin during destemming, thus protecting it ☐

Fruit have to be sprayed or dipped with the chemical solution before removing the stem to protect the fruit ☐

The best chemicals for this system are wetting agents or surfactants ☐

The oil in the sap reacts with chemical forming an emulsion that can then be washed off ☐

If the chemical solution is not washed off, sap-burn can still occur ☐

5. De-sapping in the field

Ooze sap is the main problem, because the spurt sap is released into the air during picking ☐

The most effective chemicals are those that react with the ooze sap neutralising its effects ☐

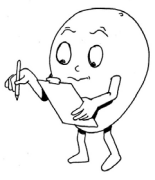
Chemicals such as Mango Wash™, Mango Glow™ or lime are examples of neutralisers ☐

If ooze sap stays wet on fruit, sap-burn and skin browning can still occur ☐

The chemical solution needs to be washed off the fruit before being loaded into field crates or bulk bins ☐

If you ticked more than 20 boxes then you're an expert on sap-burn and should be able to solve any problem you encounter. If you ticked less than 10, you either don't see the problem or need to update your knowledge by going to these references:

Agrilink Mango Information Kit
MangoCare, Issues 18 (Sep 1996), 21 (July 1997) and 22 (Sep 1997)



Check your harvest aid system

In the orchard, check that:

- ☐ Fruit are picked carefully to avoid sap spurting onto fruit on the tree
- ☐ Hands of the pickers are kept free from sap
- ☐ The fruit are completely covered by the chemical solution
- ☐ Fruit are washed by the chemical solution for at least 90 seconds
- ☐ The water dries quickly on fruit in field crates or bulk bins after de-sapping
- ☐ The initial spurt and ooze sap is washed off the fruit
- ☐ Sap doesn't build up in dips, tanks and recirculating sprays
- ☐ No short stems are left on fruit to break off during transport to the packhouse or while on the packing line, leaving sap residues

In the packing shed, check that:

- ☐ Field crates or bulk bins are handled carefully to avoid broken stems during handling and transport
- ☐ Sap and dirt collecting on brushes, rollers, belts, cups and packing bins
- ☐ No short stems are left on fruit to break off while on the packing line and leave sap residues
- ☐ Check your shed de-sapping system

In the orchard, check that:

- ☐ Fruit are picked carefully to avoid broken stems during picking and loading of field crates
- ☐ Hands of the pickers are kept free from sap
- ☐ Field crates or bulk bins are handled carefully to avoid broken stems during transport and handling

In the packing shed, check that:

- ☐ De-sappers are trained to stand fruit up really straight on de-sapping rollers
- ☐ Hands and gloves of the de-sappers are kept free from sap
- ☐ A chemical pre-treatment is used to protect fruit from sap during de-stemming
- ☐ Spurting sap doesn't contact other fruit or surfaces during destemming
- ☐ Ooze sap does not contact fruit after de-stemming
- ☐ Water sprays are low pressure to avoid mist
- ☐ Sap and dirt doesn't collect on rollers, brushes, belts, cups and packing bins
- ☐ No short stems are left on fruit to break off while on the packing line and leave sap residues

Appendix II – Hazard analysis