MANGO QUALITY ASSESSMENT MANUAL

A guide to assessing the postharvest quality of Australian mangoes

Andrew Macnish and Hung Duong

Second Edition

DELIVERING FOR QUEENSLAND
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AUSTRALIAN MANGOES®

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This publication has been compiled by Dr Andrew Macnish and Dr Hung Duong of the Department of Primary Industries.

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The Department of Primary Industries proudly acknowledges Aboriginal people and Torres Strait Islander people as the Traditional Custodians of the Country. We recognise their continuing connection to land, sea, waters and sky. We pay our respect to them, their cultures and to their Elders past and present and commit to ongoing reconciliation.

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CONTENTS

INTRODUCTION

Quality assessment is essential for determining what the customer is receiving, the practices in the supply chain where quality is compromised, and what improvements are required at each point in the chain to meet customer requirements. Improvements in quality cannot be made unless quality is assessed.

Depending on requirements, fruit quality may be measured at any stage of ripeness or at any point in the supply chain (e.g. hard green, sprung, prior to dispatch from a commercial ripener or 'at eating' ripe).

This manual provides a standard method for detailed assessment of external and internal quality of mangoes, for use by both commercial and scientific personnel.

It is an assessment and diagnostic tool to improve communication about mango quality between members of the supply chain—from the farm through to retail shelf. It provides a common language to describe and assess mango quality. It describes quality characteristics, and defects and disorders (collectively called 'defects' from now on) that are present before harvest (called 'field defects'), and that appear during harvest and as fruit ripen during distribution to consumers (called 'harvest and postharvest defects').

The defects have been categorised into two groups: common and less common defects. Descriptions and possible causes are presented for all defects. Photographs illustrating three severity levels are presented for the common defects, while one typical photograph is presented for the less common defects.

External defects that are usually graded out at the time of packing are also illustrated. Severity rating scales are presented for each defect. The tolerable severity level for each quality grade will be determined by the customer (packhouse, agent, retailer or consumer) depending on their needs.

This manual is generic in focus. Many of the quality characteristics and defects described are found in most cultivars such as Kensington Pride, R2E2, B74 (Calypso®), Honey Gold, Keitt, Lady Jane and Lady Grace.

Many defects have been reported in mango fruit. In this manual, descriptive names have been used (e.g. pink spot) rather than naming the defect by what is assumed to have caused it (e.g. mango scale). Attaching a causal name to a defect can lead to confusion—several conditions can cause the same defect. This method is also used to describe rots, where the location and appearance of the rot is used as the name (e.g. stem end rot versus body rots), rather than the disease itself (e.g. anthracnose). This is the best alternative for describing rots when facilities and labour are not available to identify pathogens.

Well understood and accepted names have been retained to avoid confusion.

This manual has been developed on the basis that quality is determined by what is seen at the time of assessment. Thus, fruit acceptability is decided by what is visible at the assessment time, not whether fruit will still be edible, for example, 2 days later.

The manual was originally developed by Rowland Holmes, Peter Hofman and Leigh Barker in 2009. In this second edition, we include updated information and photographs of existing and emerging quality defects of mango fruit.

FACTORS AFFECTING QUALITY ASSESSMENT

Several factors need to be considered when assessing quality. These are:

Sampling

The number of fruit needed to carry out a meaningful assessment of fruit quality depends on several factors:

- Level of accuracy required—Is a general indication of overall fruit quality required, or is the severity of given defects required with a high level of statistical significance?
- Stage at which fruit are assessed—If fruit are assessed after short storage periods, defects that develop with length of time in storage will be less evident, and more replicates will be needed to demonstrate any differences. If fruit are stored for long periods, defects are likely to be more common and fewer fruit may be required.
- Resources available—Larger numbers of fruit will require more labour, time, laboratory space and funds to assess. In general, we suggest that indicative quality can be estimated from one tray of fruit, while for more detailed work at least three replicate trays of fruit should be used, and these should be handled separately as replicates.

Ripening Environment

Fruit should be ripened under similar conditions. This will allow comparison with fruit from other treatments that may be assessed at a different time or in a different location. Key factors that may influence ripening rate and quality (such as skin colour and rots) are temperature, ethylene concentration and exposure times, and carbon dioxide concentrations.

The ripening environment should have good temperature control, air circulation and ventilation. Monitoring of air and fruit temperatures should also be carried out.

Ripeness at Assessment

Some quality defects (such as rots) develop rapidly as the fruit ripen, so results will differ if fruit are assessed at differing ripeness stages. Also, it is important that the stage of softness at which assessments are made is clearly documented to allow comparisons between different assessment points and between different projects.

In soft-eating mangoes such as Kensington Pride, fruit softness is the best indicator of ripeness stage. Other indicators such as skin colour can be influenced by production and ripening practices and can be less reliable. However, with firm-eating mangoes such as Calypso® and R2E2, changes in flesh firmness from harvest to ripe are more difficult to describe and may be a less reliable indicator of when the fruit is ready to eat.

Assessment over several seasons of laboratory-ripened fruit and fruit sampled from commercial ripeners just before dispatch has shown that mangoes usually have acceptable flavour 1–2 days after losing all green colour.

On this basis, we suggest that the stage of ripeness at which quality is assessed be described both in terms of days after loss of all green skin colour, and softness.

ASSESSING FRUIT QUALITY

Classifying Mango Defects

Field defects

The rating scales for field defects are based on the generally accepted commercial grade descriptors in Australia. The severity criteria for each grade often differ between defects and are usually based on a combination of the surface area affected, the colour of the affected area, and the effect on fruit soundness.

Harvest and postharvest defects

Different rating scales have been suggested for two basic groups of defects:

- solid—These defects cover fairly distinct areas of the skin and are reasonably obvious. Generally, only small areas of the fruit need to be affected before the fruit becomes unsaleable. Examples include rots and field blemish.
- scattered—These defects are spread out and sometimes scattered around the fruit. These are generally less obvious, and larger areas of the fruit need to be affected before the fruit becomes unsaleable. Examples include lenticel spotting and dendritic spot.

Rating Scales

An assessment rating scale (0–5) is used to rate the severity of harvest and post harvest mango defects. Refer to Appendix 3: Rating scales.

Where possible, industry quality grade standards (refer to Appendix 4) have been included alongside the rating scales for ease of comparison. This is provided as a guide only, noting that fruit quality specifications may change to account for seasonal impacts and vary with customer requirements. The level of defect for each grade standard should be communicated to the relevant members of the chain before and during the mango season, depending on customer and market requirements.

Rating Description

	Description	
Rating	'Solid' defects	'Scattered' defects*
1	Nil	Nil
2	Less than 1 cm2	Less than 5% (20 cent coin)
3	1–3 cm2 (approx. 3%, 5 cent coin)	Less than 10%
4	3–12 cm2 (approx. 10%)	10–25%
5	12 cm2 (approx. 10%) to 25%	25–50%
6	More than 25%	More than 50%

** The scattered rating refers to the percentage of the overall area of skin covered by the defect relative to the whole surface of the fruit.*

Quality Assessment

This manual attempts to describe a comprehensive range of characteristics and defects that might be seen during assessment of mango fruit quality. These are summarised in the 'List of characteristics and defects' (p. 5).

The quality assessment steps could include:

1. Develop a rating sheet for all relevant quality parameters and defects needed to achieve the desired outcomes. Refer to Appendix 1: Mango packed production inspection record and Appendix 2: Mango reject analysis record. Alternatively, customisable phone apps (e.g. Google AppSheet) are also available for recording and reporting fruit quality parameters.
2. Take relevant photographs with suitable descriptive and legible labels.
3. Rate each sample for shape, size and weight.
4. Determine fruit softness by gently squeezing the fruit in the palm of the hand using the rating scale in the 'Fruit softness' section (p. 12). The assessor can calibrate their rating by regularly testing fruit with a fruit firmness measuring device such as a penetrometer or durometer.
5. Rate the skin colour. When fruit reach 100% yellow skin colour, record the days after full colour. Fruit skin colour can also be determined objectively using devices such as the handheld Konica Minolta Chroma Meter or Nix colour sensor.
6. Assess the external appearance for the common defects.
7. Either rate or note as present any less common defects.
8. Remove both cheeks by cutting longitudinally close to the seed.
9. Rate for the common internal defects and either rate or note as present any less common defects. Cut each cheek into approximately 1 cm slices if further inspection is needed.
10. Record the overall acceptability of fruit quality at the time of assessment. This is determined by taking into account all defects present.

Saleable life index (SLI)

It may be important in some studies to indicate whether a treatment or a consignment provides what retailers want when they buy a tray of mangoes. Studies have shown that they want coloured fruit, at least 60% yellow, and a tray that will last 7 days before the fruit starts to break down with rots. Those 7 days are needed to deliver the fruit from the market to the shop and then sell the fruit to consumers.

As soon as more than one fruit in the tray shows any sign of rots the retailer starts to worry. Trays with rots represent fruit that may have to be discounted or discarded, resulting in lower returns.

To measure how well consignments satisfy retailer needs, the saleable life index (SLI) was developed. The SLI is the time from when the average skin colour in a sample of fruit reaches colour stage 4 (50–70% yellow) to when 10% of the fruit show signs of rot development. The SLI can be used to compare the performance of any consignment to any market or at any point in the supply chain.

The SLI concept is explored in more detail in Appendix 5: Saleable life index (SLI).

Shelf Life Assessment

Whilst assessing mango quality, it may also be useful to measure the shelf life of individual fruit. This could help to quantify fruit performance from different harvest batches or consignments to meet consumer expectations following commercial or simulated supply chain handling. Mango shelf life can be defined as the length of time that fruit can be maintained on the retail shelf at 20˚C before becoming unmarketable. End of shelf life criteria have been developed for Australian mango varieties and are based on fruit softening, rot development and visual quality. Further details are presented in Appendix 6.

LIST OF CHARACTERISTICS AND DEFECTS

The quality attributes of mangoes have been divided into characteristics, field defects, harvest and postharvest defects (external and internal) and quarantine defects. For the field, harvest and postharvest defects we have used the following divisions:

- **common**—defects that are seen during most mango seasons
- **less common**—defects that occur only occasionally. In most cases they do not reduce soundness, but affect external or internal appeal. These can cause downgrading of fruit to class 2 (or processing if severe) during sorting in the packhouse.
  Depending on the purpose of the assessments, it may not be necessary to assess fruit for all the characteristics and defects presented in this manual.

Characteristics

- blush at harvest
- skin colour
- fruit firmness
- fruit size.

Common Field Defects

- blemish
- pink spot
- sunburn
- russet
- field lenticel spotting.

Less Common Field Defects

- mango scab
- bacterial black spot
- skin staining
- sooty blotch
- sooty mould
- shoulder blackening
- dimples
- foreign matter (chemical deposit, animal deposit)
- soft nose
- confined light skin
- stem end cavity
- chimera
- misshapen.

Common Harvest And Postharvest Defects

- body rots
- soft stem end rot
- firm stem end rot
- pepper spot
- dendritic spot
- sapburn
- skin browning (smear, etch, spotting, scald)
- physical damage (abrasion, stem punctures, creases, scratches, wounds, rub marks)
- lenticel spotting.

Less Common Harvest And Postharvest Defects

- blotchy green skin
- under skin browning
- leather skin
- resin canal discolouration
- skin greying
- lenticel discolouration
- flat areas (compression damage).

Internal Disorders

- stem end cavity
- jelly seed
- soft nose
- flesh browning
- flesh cavities
- flesh cavity with white patches
- white patches (ricey spots and streaks).

Quarantine Issues

- fruit fly
- mango seed weevil
- live scales on fruit.

CHARACTERISTICS

- Blush at harvest
- Skin colour
- Fruit firmness
- Fruit size

Blush At Harvest

30–50%

50 – 70%

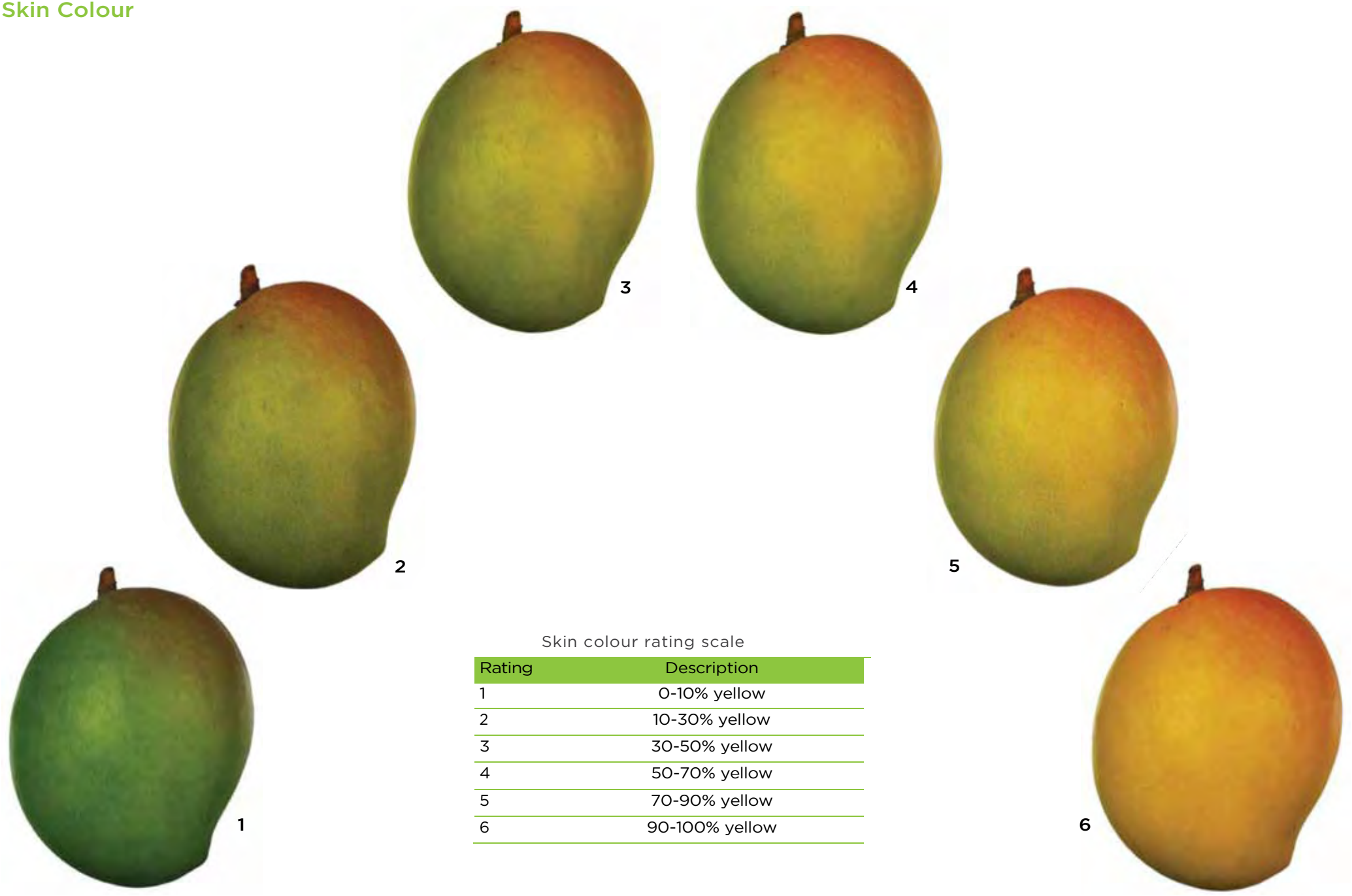
10-30%

70-90%

0-10%

100%

Skin Colour



Skin colour rating scale

Rating	Description
1	0-10% yellow
2	10-30% yellow
3	30-50% yellow
4	50-70% yellow
5	70-90% yellow
6	90-100% yellow

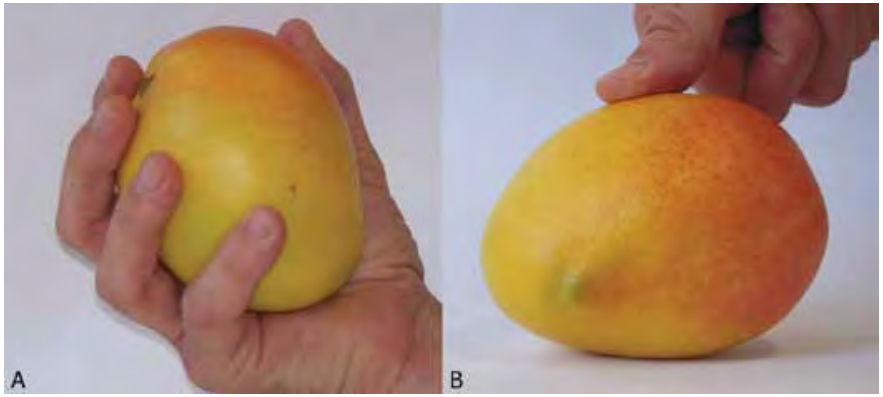
Fruit Firmness

Description

The firmness of mango fruit is often a good indicator of the ripening stage. In general, quality assessors rely on hand feel to estimate fruit firmness. The rating scale below was developed to describe fruit firmness. However, it is a subjective assessment process and can be difficult to ensure consistency of measurement between different operators.

Firmness rating scale

Rating	Description
0	Hard (no 'give' in the fruit)
1	Rubbery (slight 'give' in the fruit with strong thumb pressure)
2	Sprung (flesh deforms by 2–3 mm with moderate thumb pressure)
3	Firm soft (whole fruit deforms with moderate hand pressure)
4	Soft (whole fruit deforms with slight hand pressure)

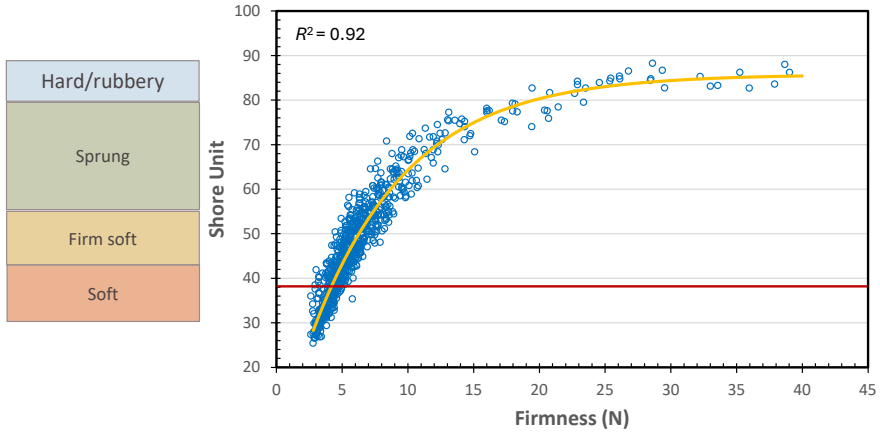


A: Grasping with whole hand (correct). B: Pressing with the thumb (incorrect).

Using objective instruments to determine fruit firmness can help to reduce the operator error. Handheld penetrometers (e.g. Effegi) have been in use for several decades but only work properly to determine fruit firmness by penetrating the flesh once the skin is removed. Handheld durometers are an alternative for non-destructive firmness testing. Durometer readings are expressed as Shore units using a 0 (soft) to 100 (hard) scale. The reading reflects the force applied to the fruit skin to depress the underlying flesh. Examples include the Bareiss digital HPE II Fff and the Turoni 53215 TT durometer.

Researchers can use more accurate and expensive laboratory units to measure fruit firmness. These are typically bench-mounted units that measure the force required to push a plunger 1–2 mm into the fruit. Examples include texture analysers (e.g. Shimadzu EZ Tester) that express readings in Newtons (N). Whilst promoted as non-destructive test devices, measurement using an EZ Tester or durometer may cause a slight indentation and softening of the fruit, particularly in the softer stages. It is recommended to mark the site of any readings using these devices and avoid re-measuring in the same spots.

A minimum of two readings per cheek at the equatorial region of each fruit should be completed. The performance of durometers has been compared with a laboratory instrument (an EZ Tester) by measuring firmness on the same fruit as they ripen.



Comparison of Honey Gold mango fruit firmness assessed with an EZ Tester vs Turoni 53215 TT durometer.

Firmness Rating	EZ Tester (Newtons)	Durometer (Shore Units)
0 Hard	>30.0	>82
1 Rubbery	22.1-30.0	77-82
2 Sprung	7.1-22.0	51-76
3 Firm Soft	5.0-7.0	43-50
4 Soft	<5.0	≤42

Fruit Size

Average fruit size, weight, count (number of fruit per tray) and Australian retailer PLU number for common Australian mango varieties.

Variety	Size	Fruit weight (g)*	Count (per 7kg tray)	Australian Retailer Assigned PLU No.
Kensington Pride	Extra Large	more than 625	10 and less	5298
Kensington Pride	Large	455–625	12–14	5738
Kensington Pride	Medium	355–455	16–18	5739
Kensington Pride	Small	less than 355	20 and more	5740
Calypso®	Large	455–625	12–14	6105
Calypso®	Medium	355–455	16–18	6104
Calypso®	Small	less than 355	20 and more	6103
Honey Gold	Large	455–625	12–14	6124
Honey Gold	Medium	355–455	16–18	6123
Honey Gold	Small	less than 355	20 and more	6122
Keitt	Extra Large	more than 625	12 and less	5933
Keitt	Large	455–625	12–16	5404
Keitt	Medium	355–455	18–20	5405
Keitt	Small	less than 355	22–25	5406
R2E2	Extra Large	more then 845	9 and less	5741
R2E2	Large	640–845	10–12	5742
R2E2	Medium	Less than 640	13 and more	6028

** Fruit weights are based on 6.8kg net weight per tray for Kensington, Calypso®, Honey Gold and Keitt and 8kg net weight per tray for R2E2.*

FIELD DEFECTS

COMMON FIELD DEFECTS

- Blemish
- Pink spot
- Sunburn
- Russet
- Field lenticel spotting

LESS COMMON FIELD DEFECTS

- Mango scab
- Bacterial black spot
- Skin staining
- Sooty blotch
- Sooty mould
- Shoulder blackening
- Dimples
- Foreign matter (chemical deposit, animal deposit)
- Soft nose
- Confined light skin
- Stem end cavity
- Chimera
- Misshapen

COMMON FIELD DEFECTS

Blemish

Description

- Discoloured or black areas of healed scar tissue on the skin
- The damage is superficial and does not penetrate into the flesh
- The damage includes ground marks, tree rub, cleavage scars, healed wounds, hail damage, pest damage, brown-coloured ‘dimples’ and mango seed weevil eggs.

Possible causes

- Skin rub, pest chewing, sapburn while on tree, hail damage.

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm^2	✓	
2	Less than 3cm^2 (approx. 3%, 5 cent coin)	✓	
3	Less than 12cm^2	×	✓
4	Less than 25% but sound	×	×
5	More than 25%	×	×

1

2

3

Blemish Types

Healed wounds

Pest damage

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm^2	✓	
2	Less than 3cm^2 (approx. 3%, 5 cent coin)	✓	
3	Less than 12cm^2	×	✓
4	Less than 25% but sound	×	×
5	More than 25%	×	×

Pest damage

Tree rub

Cleavage scar

Hail damage

Pink Spot

Description

- Scale infestation on the fruit causes a conspicuous pink spot
- The pink spot remains after the scale has been removed and detracts from the appearance.

Possible causes

- Mango scale *(Aulacaspis tubercularis)*.

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm^2	✓	
2	Less than 3cm^2 (approx. 3%, 5 cent coin)	×	✓
3	Less than 12cm^2	×	×
4	Less than 25% but sound	×	×
5	More than 25%	×	×

**The rating refers to the percentage of the overall area of skin affected by pink spots*

1

3

5

Sunburn

Description

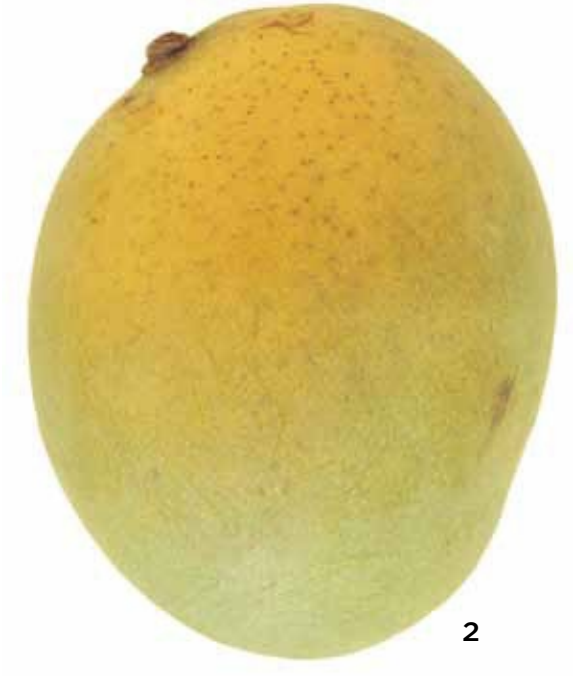
- Slight sunburn shows as bleached or yellow patches, usually on the exposed shoulders of the fruit
- In severe cases the affected skin is leathery, red-brown to black and slightly depressed; fruit can also be misshapen.

Possible causes

- Overexposure of fruit to high levels of the sun during growth and development damages the skin, especially if associated with high skin temperatures
- Fruit exposed to the sun, particularly on the western side of the tree are most susceptible
- More common if fruit is suddenly exposed to sunlight when branches are broken, if harvested fruit is left in direct sun or trees are under water stress
- Fruit on water-stressed trees will sunburn more easily.

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Yellow bleaching on not more than 5% of the surface	✓	
2	Yellow bleaching on not more than 10% of the surface; no dark or sunken blotches	✓	
3	Yellow bleaching on not more than 25% of the surface; discoloured blotches to 3 cm^2 not sunken	✓	
4	Yellow bleaching on not more than 50% of the surface; dark 12 cm^2 not sunken	×	✓
5	More than 50%	×	×



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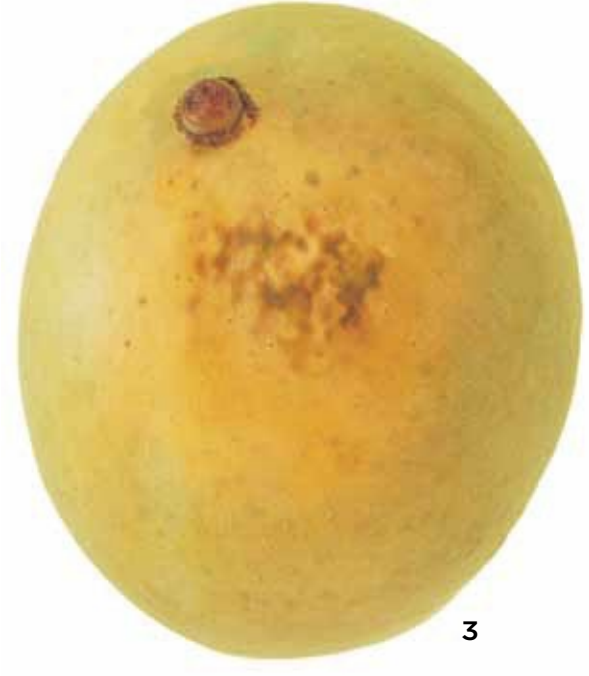

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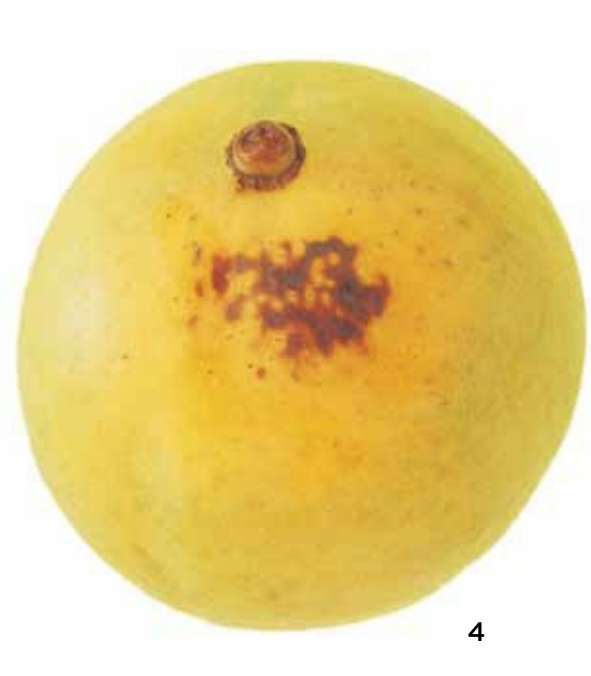

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Russet

Description

- Light-coloured blemish
- Symptoms appear as silver lines or blotches on the skin of the fruit
- In severe cases, large raised blotches/lines develop with associated brown scar tissue.

Possible causes

- Actual cause is still unknown. May be related to leaf rub, thrips and powdery mildew.

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Dense thick lines on not more than 5% of the surface, scattered thin lines not a defect	✓	
2	Dense thick lines on not more than 10% of the surface	✓	
3	Dense thick lines on not more than 25% of the surface, not raised	×	✓
4	Dense thick lines on not more than 50% of the surface, not raised	×	✓
5	Dense thick lines on more than 50% of the surface	×	×

**The rating refers to the percentage of the overall area of skin affected by russet*


1


2


4

Field Lenticel Spotting

Description

- The corky tissue in the lenticels (breathing pores) on the skin swells and becomes pronounced, resulting in small round or star-shaped spots scattered over the skin
- Can sometimes get green, red/brown haloes around the lenticels.

Possible causes

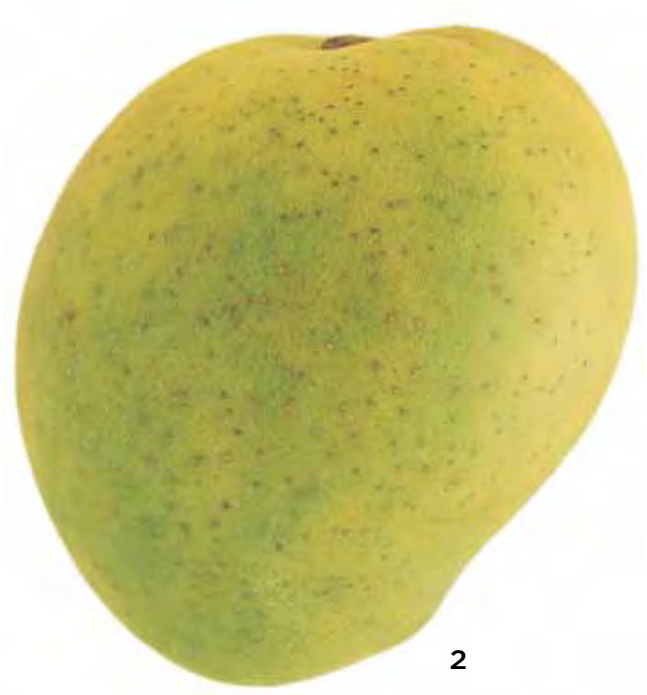
- Certain growing conditions including water stress during fruit development can damage lenticels
- Worse in low temperature, high humidity, rainy conditions when fruit stays wet
- Sometimes worse on larger fruit, particularly when there is rapid fruit growth during late maturity.

Rating scale

Rating	Description	Class 1	Class 2
0	Nil	✓	
1	Dense, pronounced spots on not more than 5% of the surface; not star-shaped or cracked	✓	
2	Dense, pronounced spots on not more than 10% of the surface or pronounced spots on not more than 25%; not star-shaped or cracked	✓	
3	Dense, pronounced spots on not more than 25% of the surface or scattered, pronounced spots on not more than 50%; not star-shaped or cracked	✓	
4	Dense, pronounced spots on not more than 50% of the surface or scattered, pronounced spots on more than 50%; not cracked	×	✓
5	Dense, pronounced spots on more than 50% of the fruit; not cracked	×	×

**The rating refers to the percentage of the overall area of skin affected by lenticel spotting. Dense = spots no more than 2 mm apart.*

1



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LESS COMMON FIELD DEFECTS

Mango Scab

Description

- Grey to greyish-brown lesions on the surface of fruit, with dark irregular margins
- Lesions are usually raised and enlarge as fruit grows, developing a cracked and corky appearance
- Causes a variety of symptoms that can be confused with spray damage, thrips damage or scaring from anthracnose infection during fruit development.

Cause

- Caused by the fungus *Elsinoë mangiferae* (sometimes referred to as *Denticularia mangiferae* in Australia)
- Only young tissue is susceptible to infection and fruit is no longer susceptible after it reaches about half size.

Mango scab

Bacterial Black Spot

Description

- Appears initially around the lenticels as small, irregular, water-soaked specks on which a bead of bacterial ooze may develop, resembling fruit fly stings
- Raised black spots with greasy margins develop later. Cracks can also develop from which sap laden with bacteria may ooze
- Anthracnose and secondary rots commonly develop in bacterial black spot lesions as the fruit matures, causing deep, extensive decay
- Bacteria from fruit lesions may infect the fruit in a tear-stain pattern. Lesions can also occur on fruit and flower stalks
- The symptoms are visible on fruit at harvest.

Cause

- The bacterium *Xanthomonas campestris pv. mangiferaeindicae.*

Bacterial black spot

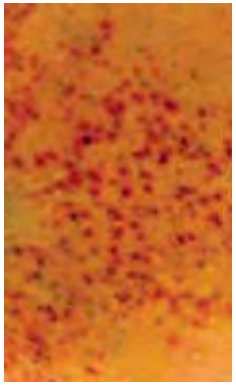
Skin Staining

Description

- Red to black staining on the fruit surface
- Usually starts around the stem end and progresses in a streaky pattern toward the nose of the fruit
- Observed after prolonged rain
- Often the point at which rots develop as fruit ripen.

Cause

- Associated with water flowing over the fruit, possibly from damaged plant material above the fruit
- Possibly fungal disease spores from dead plant material above the fruit causing restricted damage to the skin.



Skin staining

Sooty Blotch

Description

- Blotchy dark grey to black staining of the skin
- Often concentrated on the top half of the fruit
- Usually worse with prolonged wet weather
- Staining cannot be removed by brushing
- Does not cause disease lesions after harvest.

Cause

- Various saprophytic fungi.

Sooty blotch

Sooty Mould

Description

- Dark/black patchy, superficial covering that can be rubbed away to reveal undamaged tissue underneath
- Although these fungi do not cause disease lesions, their dark saprophytic growth makes the fruit surface unsightly, reducing fruit quality
- Staining from sooty mould can be removed by water/brushing after harvest, while sooty blotch and skin staining cannot.

Possible causes

- Saprophytic fungi growing on the sugar exudate of sucking insects including mango scale, pink wax scale, mango planthopper and mango leafhopper.

Sooty mould

Shoulder Blackening

Description

- Grey to black superficial patches on the stem end of the fruit
- In most cases, the defect is concentrated around the stem end, but in more severe cases spreads down from the shoulder of the fruit
- The defect is superficial only and does not affect the flesh
- Appears to be more common in younger orchards
- Generally obvious on harvested fruit, but sometimes is only noticeable on ripening fruit.

Possible causes

- Causes are unknown
- May be associated with younger trees.

Shoulder blackening

Dimples

Description

- Small, circular indentations in the fruit, generally less than 3–5 mm diameter
- No obvious signs of broken or discoloured skin
- No effect on flesh quality.

Possible causes

- Dimpling bugs feeding during early fruit growth
- Associated with abnormal skin formation.

Dimples

Foreign Matter (chemical deposit, animal deposit)

Description

- Visible residues of pesticides, soil or other matter on the skin of the fruit, particularly around the stem
- Foreign matter is unsightly and reduces fruit appearance
- Can have food safety implications.

Possible causes

- Excessive chemical spray applications
- Fruit coming in contact with soil during harvesting
- Animal deposits.

Foreign matter

Soft Nose

Description

- The beak or nose end of the fruit changes colour prematurely and begins to soften
- In other cases, colour change occurs on the body of the fruit as the fruit ripen on the tree
- Flesh near the nose becomes over-soft and dark, yellow and watery (see 'Internal disorders' section).

Possible causes

- Inadequate nutrition (low calcium/high nitrogen) or excessive vegetative growth during fruit development
- Fruit from early flowers mature more quickly than the main crop and ripen on the tree.

Soft nose

Premature ripening

Confined Light Skin

Description

- Well-defined area of the skin that is lighter in colour than the surrounding skin
- Can affect both the blushed and non-blushed areas
- Usually covers at least 25% of the skin
- Affected area can have slightly rougher feel
- Always on only one area of the fruit.

Possible causes

- Sunburn on very young fruit. The fruit 'recovers' but the affected area does not develop full skin colour.

Confined light skin

Stem End Cavity

Description

- Occurs at the stem end
- Visible external symptoms appear only in severe cases when the cavity extends to the under-surface of the skin
- Grey-brown sunken area on the skin of the fruit near the stem attachment
- If no visible external symptoms in hard mature fruit, press around the stem with the thumb. If the tissue gives easily to pressure, then cavities are usually present.

Possible causes

- May be linked to a physiological and nutritional imbalance during fruit development
- Possibly associated with low calcium/high nitrogen
- Harvesting over-mature fruit.

Stem end cavity

Chimera

Description

- Stripped areas or blotches of lighter or darker green colour on the skin.

Possible causes

- Genetic defect with the cause unknown.

Chimera

Misshapen

Description

- Deformed fruit which do not develop evenly on both sides.

Possible causes

- May be linked to a physiological and nutritional imbalance during fruit development.

Unacceptable

Acceptable

HARVEST AND POSTHARVEST DEFECTS

COMMON HARVEST AND POSTHARVEST DEFECTS

- Body rots
- Soft stem end rot
- Firm stem end rot
- Pepper spot
- Dendritic spot
- Sapburn
- Skin browning (smear, etch, spotting, scald)
- Physical damage (abrasion, stem punctures, creases, scratches, wounds, rub marks)
- Lenticel spotting

LESS COMMON HARVEST AND POSTHARVEST DEFECTS

- Blotchy green skin
- Under skin browning
- Leather skin
- Resin canal discolouration
- Skin greying
- Lenticel discolouration
- Flat areas (compression damage)

COMMON HARVEST AND POSTHARVEST DEFECTS

Body Rots

Description

- Anthracnose is the predominant body rot of mango
- The symptoms of Anthracnose are a dark brown to black rot, usually rounded and slightly sunken, appearing on the body of the fruit
- The rot is initially superficial but may penetrate up to around 10-20 mm beneath the skin as the lesion expands during ripening
- Salmon-pink spore masses may be present when the rot is advanced
- Alternaria rot is another body rot of mango, but in Australia is usually only a problem during prolonged storage
- Symptoms of Alternaria rot are small brown spots with diffuse margins which expand into extensive dark brown lesions on the body or stem end of fruit.

Cause

- Anthracnose can be caused by a number of *Colletotrichum* species, but the main causal agent is *Colletotrichum asianum*
- Alternaria rot is caused by *Alternaria alternata.*

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Less than 1cm^2	×	×
2	1-3cm^2 (approx. 3%, 5 cent coin)	×	×
3	3-12cm^2 (approx. 10%)	×	×
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

1

3

Soft Stem End Rot

Description

- Fast-growing, watery soft rot starting around the stem and penetrating deep into the flesh
- Grey to light brown rot with diffuse margins becoming darker as the rot advances
- Severe flesh breakdown is associated with the rot in later stages
- Steel-grey fungal hyphae may develop around the fruit pedicel or through skin ruptures in advanced stages, and a brown watery fluid may exude from these areas.

Cause

- The main casual agents of 'soft' stem end rots include *Neofusicoccum parvum* (previously *Dothiorella dominicana*) and *Lasiodiplodia theobromae.*

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Less than 1cm^2	×	×
2	1-3cm^2 (approx. 3%, 5 cent coin)	×	×
3	3-12cm^2 (approx. 10%)	×	×
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

2

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4

Firm Stem End Rot

Description

- A black, relatively firm rot, slightly sunken, starting around the stem end of the fruit
- The rot does not usually penetrate more than 10-20 mm into the flesh
- Salmon-pink spore masses may be present when the rot is advanced.

Cause

- The main fungal disease associated with 'firm' stem end rot is anthracnose, which is predominantly caused by *Colletotrichum asianum*, although a number of other *Colletotrichum* species can also be involved.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Less than 1cm^2	×	×
2	1-3cm^2 (approx. 3%, 5 cent coin)	×	×
3	3-12cm^2 (approx. 10%)	×	×
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

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4

Pepper Spot

Description

- Also known as pre-harvest fruit anthracnose or tear-stain anthracnose
- Small black spots that are initially concentrated at the stem-end of green fruit and may be misdiagnosed as lenticel spotting
- Lesions can also be randomly scattered on the body of fruit
- In ripe fruit, the lesions will develop into larger, more diffuse areas.

Cause

- Fungal disease invading through the fruit skin during warm, wet conditions
- *Colletotrichum asianum* is the main fungal pathogen associated with pepper spot, although a number of other *Colletotrichum* species may be involved.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Not more than 10 spots per fruit	×	×
2	Not more than 15 spots or an area not more than 3 cm^2	×	×
3	Not more than 10% of the surface area	×	×
4	Not more than 25% of the surface area	×	×
5	More than 25% of the surface area	×	×

2

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4

Dendritic Spot

Description

- Small black spots with irregular edges in a branched or dendritic pattern
- Superficial lesions with distinct margins
- The rot is slow-growing and does not penetrate deep into the flesh
- Appears on ripe fruit
- In ripe/very ripe fruit, the lesions may develop into larger, more diffuse lesions.

Cause

- Very little is known about this disease
- The main fungal pathogens associated with dendritic spot are *Neofusicoccum parvum* (previously *Dothiorella dominicana*) and *Lasiodiplodia theobromae.*

Rating scale

Rating	Rating %	Class 1	Class 2
O	Nil	✓	✓
1	Not more than 10 spots per fruit	×	×
2	Not more than 15 spots or an area not more than 3 cm^2	×	×
3	Not more than 10% of the surface area	×	×
4	Not more than 25% of the surface area	×	×
5	More than 25% of the surface area	×	×

**The rating refers to the percentage of the overall area skin affected*

2

3

4

Sapburn

Description

- Dark brown spots or blotches
- Can appear as runs or streaks down the cheek or scattered around the stem or the shoulder of the fruit
- In severe cases, can result in sunken areas of the affected skin
- Flesh generally not affected.

Possible causes

- Spurt sap (the sap that 'spurts' out from the broken stem and continues to flow for up to 30 seconds) contacting skin when stem is broken close to the fruit
- The oil in this first fraction of sap causes damage to the skin
- The capacity of the sap to cause damage can vary from season to season, irrigation/rainfall patterns etc.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm^2	✓	
2	1-3cm^2 (approx. 3%, 5 cent coin)	✓	
3	3-12cm^2 (approx. 10%)	×	✓
4	12cm^2 (approx. 10%) to 25%	×	✓
5	More than 25%	×	×

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Skin Browning

Description

- Light to dark brown flecking, spots, blotches, smears or rings
- Usually only becomes obvious after at least 2–3 days after harvest
- Usually becomes more severe as fruit ripens and becomes over-ripe.

Possible causes

- Prolonged contact with sap of low oil content or detergent containing excess sap contamination
- Detergent used during harvesting not topped up or replaced often enough
- Fruit staying wet for a long time (4–6 hours)
- Ethylene treatment of hot fruit
- Exposure to high temperatures for too long (e.g. during hot fungicide treatment).

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm^2	✓	
2	1-3cm^2 (approx. 3%, 5 cent coin)	✓	
3	3-12cm^2 (approx. 10%)	×	✓
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

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3

Identifying Types of Skin Browning

Smear

Description

- Dark brown areas with a uniform appearance and distinct margins
- Looks similar to mild sapburn
- Usually irregular in shape but can be streaks or rings.

Possible causes

- Caused by the sap with high oil content, which exudes 5–60 seconds after stem removal.

Smear

Etch

Description

- Light to dark brown flecking pattern, which is easily seen with a hand lens
- Damage varies from distinct areas to the whole fruit surface
- Usually associated with lenticels
- Can result in confined areas of etch and lenticel damage at the contact points between fruit.

Possible causes

- Prolonged exposure to moisture including ooze sap, detergents and surfactants
- Can be particularly obvious at contact points between fruit if left in the bin for too long before packing.

Etch

Spotting

Description

- Numerous, uniform light brown spots
- 1–3 mm in diameter
- Typically associated with lenticels.

Possible causes

- Fruit with high skin temperatures (more than 24˚C) being treated with ethylene.
- May be associated with exposure to elevated carbon dioxide concentrations during transport.

Spotting

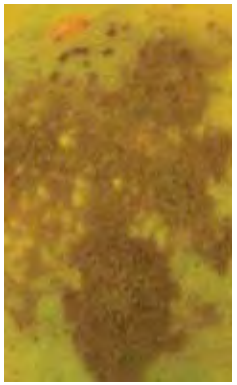
Scald

Description

- Large areas of brown to grey discolouration, usually around the mid-region of the fruit
- A halo of undamaged tissues surrounds the lenticels
- Irregular sunken areas can occur when damage is severe.

Possible causes

- Caused by fruit being exposed to high temperatures (more than 52˚C) for too long (more than five minutes, and less for higher temperatures)
- Exposure to low (less than 10˚C) temperatures postharvest.



Scald

Physical Damage

Description

- Includes abrasion, punctures, crease marks and cuts
- Fine, brown scratches, indentations or cuts in the skin.

Possible causes

- Damage from secateurs
- Impact on the sharp edges of harvest aids, picking crates or bulk bins and packing line equipment
- Impact on the tree branches and other fruit, including the ‘stem button’ on the fruit
- Dust and dirt on tarpaulins of harvest aids, field bins etc.
- Excessive vibration during transport when the fruit are loose-packed in plastic liners.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	
1	Less than 1cm², 2cm in length	✓	
2	1-3cm² (approx. 3%, 5 cent coin), 5m in length	✓	
3	3-12cm² (approx. 10%), greater than 5cm length	×	✓
4	12cm² (approx. 10%) to 25%	×	×
5	More than 25%	×	×

1

2

3

Identifying Types of Physical Damage

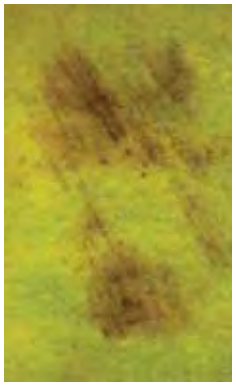
Abrasion

Description

- Small light brown streaks or scratches often in conjunction with skin browning
- Usually very superficial.

Possible causes

- Rough handling
- Abrasive surfaces on dirty equipment and worn brushes
- Grit and dust on harvest aid tarpaulins and on packing equipment
- Risk of damage increases following wet weather at harvest.



Abrasion

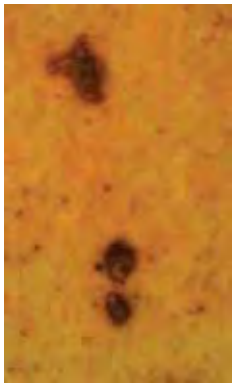
Stem Punctures

Description

- Small, brown marks on the fruit
- Usually near-circular
- Often sunken.

Possible causes

- Fruit being hit by the stem button of another fruit
- Throwing fruit onto the harvest aid, excessive drops into the field bin or on the packing line
- May be worse after prolonged rain before harvest because of more sensitive skin.



Stem puncture

Creases

Description

- Random, irregular, depressed brown lines, indentations or marks on fruit
- Usually sunken and more severe in over-ripe fruit.

Possible causes

- Impact on the sharp edges of harvest aids, picking crates or bulk bins and packing line equipment
- Loose-packing of fruit in crumpled plastic liners and excessive vibration during transport causing damage to the skin
- Also caused by ripe fruit being held too long in crumpled plastic liners after packing.

Creases

Scratches

Description

- Fine brown scratches on the skin, not indented.

Possible causes

- Damage from secateurs during picking
- Throwing fruit onto the harvest aid, excessive drops into field bins or on the packing line
- Rough handling including pulling fruit through the tree canopy during picking.

Scratches

Wounds

Description

- Injury (cuts or punctures) on the fruit with open skin.

Possible causes

- Damage from secateurs during picking
- Impact on the sharp edges of harvest aids, picking crates or bulk bins and packing line equipment
- Throwing fruit onto the harvest aid, excessive drops into field bins or on the packing line.

Wounds

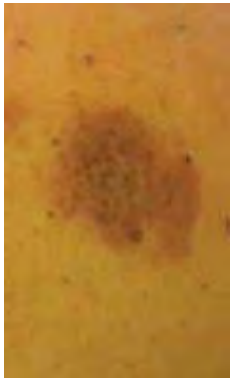
Rub Marks

Description

- Small, brown oval shaped blotches and lines at contacts points between fruit, cartons and inserts.

Possible causes

- Loose packing and rough roads
- Fruit vibrating and rubbing against other fruit, cartons and plastic insert during transport.



Rub marks

Lenticel Spotting

Description

- The corky tissue in the lenticels on the skin swell and become pronounced, resulting in small round or star-shaped spots scattered over the skin surface
- Often becomes more obvious as the fruit change from green to yellow during ripening
- Often gets worse if fruit are not consumed quickly once ripe.

Possible causes

- Certain growing conditions, and sometimes larger fruit
- Detergent or ooze sap staying wet on the fruit for too long or diluted sap in the harvest aid
- Excessive heat treatment, brushing, holding ripe fruit for too long
- Other postharvest treatments (e.g. irradiation).

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	
1	Dense, pronounced spots on not more than 5% of the surface	✓	
2	Dense, pronounced spots on not more than 10% of the surface or scattered, pronounced spots on not more than 25% of the surface	✓	
3	Dense, pronounced spots on not more than 25% or scattered, pronounced spots on not more than 50% of the surface	✓	
4	Dense, pronounced spots on not more than 50% or scattered, pronounced spots on more than 50% of the surface	×	✓
5	Dense, pronounced spots on more than 50% of the surface	×	×

**The rating refers to the percentage of the overall area skin affected by lenticel spotting. Dense = spots no more than 2 mm apart*

1

2

3

LESS COMMON HARVEST AND POSTHARVEST DEFECTS

Blotchy Green Skin

Description

- Patches or blotches of green skin on yellow, ripe fruit.

Possible causes

- Ripening, storage or transport at high temperatures usually above 24˚C or ripening below 18˚C
- High CO_2 levels, usually above 1% during ripening, storage or transport
- Immature fruit failing to ripen
- Excessive nitrogen fertiliser during growing.

Under Skin Browning

Description

- Previously referred to as ‘Disorder X’
- Diffuse discoloured ‘bruise-like’ brown areas under the skin
- In some cases, the unaffected waxy layer on the skin gives the affected brown area an opaque appearance
- The affected area is not sunken
- Does not affect the flesh
- Usually not visible at harvest
- Observed in all major Australian mango varieties. Honey Gold and Lady Jane are the most sensitive. Calypso® and Kensington Pride are less susceptible.

Possible causes

- Exposure of fruit to 12-13˚C in combination with vibration and skin abrasion during transport
- Fruit produced in hotter regions such as the Northern Territory are relatively more susceptible
- Fruit harvested in the afternoon are more sensitive than those picked during the early morning or at night in association with compositional changes in fruit sap
- Is a phytotoxic response to leakage of fruit sap from latex vessels under the fruit epidermis leading to discolouration of surrounding cells.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Less than 1cm^2	✓	✓
2	1-3cm^2 (approx. 3%, 5 cent coin)	✓	✓
3	3-12cm^2 (approx. 10%)	×	✓
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

Leather Skin

Description

- Similar symptoms to under skin browning but potentially more severe
- Brown ‘scald-like’ discoloured areas beneath the skin
- The affected area is sunken and deeper than under skin browning symptoms
- Does not affect the flesh
- Physical impact damage sites may be visible within brown areas
- Reported in R2E2 fruit but likely can occur in all major Australian mango varieties.

Possible causes

- Harvesting over-mature fruit during hot weather in combination with severe handling impact (e.g. fruit dropped onto hard surface) that ruptures the cuticle and underlying latex vessels in the flesh
- Fruit harvested during higher ambient temperatures in the afternoon appear to be most sensitive.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Less than 1cm^2	✓	✓
2	1-3cm^2 (approx. 3%, 5 cent coin)	✓	✓
3	3-12cm^2 (approx. 10%)	×	✓
4	12cm^2 (approx. 10%) to 25%	×	×
5	More than 25%	×	×

Resin Canal Discolouration

Description

- Also called ‘Resin canal’
- Brown-black latex vessels or resin canals in the flesh
- Dark outlines of canals are sometimes visible through the skin
- Typically observed in ripe to over-ripe fruit
- Predominantly found in fruit produced in the Northern Territory but can occur in Queensland fruit
- Most commonly observed in Kensington Pride fruit but has occasionally been reported in other Australian and Asian mango varieties.

Possible causes

- Symptom development may be associated with contamination of fruit by bacteria found in non-sanitised mango wash and dump water solutions
- Harvesting immature fruit
- May be worse for fruit harvested soon after a rainfall event.

Rating scale

Rating	Rating %	Class 1	Class 2
0	0-15% surface area	×	×
1	15-30% surface area	×	×
2	30-45% surface area	×	×
3	45-70% surface area	×	×
4	70-85% surface area	×	×
5	85-100% surface area	×	×

Skin Greying

Description

- Light grey discolouration of the skin
- Usually patchy and scattered
- Affected areas not sunken
- Does not affect the flesh
- Damage is not restricted to around the lenticels.

Possible causes

- Storage at too low temperatures, usually below 10˚C for more than 7 days but this depends on the variety
- Lower storage temperatures will cause damage more quickly.

Rating scale

Rating	Rating %	Class 1	Class 2
0	Nil	✓	✓
1	Dense, pronounced greying on not more than 5% of the surface	✓	✓
2	Dense, pronounced greying on not more than 10% of the surface	✓	✓
3	Dense, pronounced greying on not more than 25% or scattered, pronounced greying on not more than 50% of the surface	×	×
4	Dense, pronounced greying on not more than 50% or scattered, pronounced greying on more than 50% of the surface	×	×
5	Dense, pronounced greying on more than 50% of the surface	×	×

Lenticel Discolouration

Description

- Small areas (‘haloes’) around the lenticels are discoloured
- Haloes can be either red or grey if on the non-blushed area of the fruit, or dark brown or purple if on the blushed area
- In severe cases the haloes overlap to cause widespread discolouration
- Usually associated with lenticel spots that are obvious at harvest.

Possible causes

- Usually worse after prolonged rain before harvest, and when lenticel spotting is present on fruit at harvest
- Can be worse on fruit from young trees and when the trees have high nitrogen
- Fruit from young trees with high nitrogen—ooze sap left on the fruit for too long after harvest can increase damage, especially if the ooze sap is at the contact points between other fruit or the side of the bin
- Damage from irradiation used for insect disinfestation.

Rating scale

Rating	Rating %	Class 1	Class 2
O	Nil	✓	
1	Dense, pronounced spots on not more than 5% of the surface	✓	
2	Dense, pronounced spots on not more than 10% of the surface, pronounce spots on not more than 25% of the surface	✓	
3	Dense, pronounced spots on not more than 25% or scattered, pronounced spots on not more than 50% of the surface	✓	
4	Dense, pronounced spots on not more than 50% or scattered, pronounced spots on more than 50% of the surface	×	✓
5	Dense, pronounced spots on more than 50% of the surface	×	×

**Dense = spots no more than 2 mm apart*

Flat Areas (compression damage)

Description

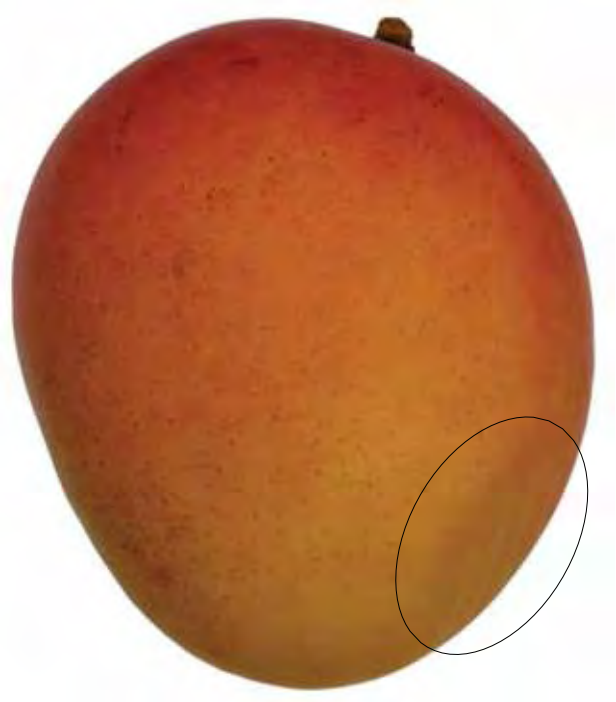
- Flat areas on the fruit, usually on the nose of the fruit
- Usually no skin damage or discolouration.

Possible causes

- Compression from the tray above, when stacked on the pallet.

Rating scale

Rating	Rating %
0	Nil
1	Less than 1cm^2
2	1-3cm^2 (approx. 3%, 5 cent coin)
3	3-12cm^2 (approx. 10%)
4	12cm^2 (approx. 10%) to 25%
5	More than 25%



INTERNAL DISORDERS

- Stem end cavity
- Jelly seed soft nose
- Flesh browning flesh cavities
- Flesh cavity with white patches
- White patches (ricey spots and streaks)

INTERNAL DISORDERS

Stem End Cavity

Description

- Occurs at the stem end
- Initial symptoms show as watery patches in the flesh, often with discoloured strands
- As the disorder develops the flesh collapses, leaving a distinct cavity
- The flesh surrounding the cavity can be grey-brown in colour
- Irregular tissue strands may be found within the cavity
- Visible external symptoms appear only in severe cases when the cavity reaches the under-surface of the skin (see 'Field defects' section).

Possible causes

- May be linked to a physiological and nutritional imbalance during fruit development, possibly associated with low calcium/high nitrogen
- Harvesting over-mature fruit.

Stem end cavity

Jelly Seed

Description

- Similar to soft nose, but the flesh around the seed ripens more rapidly than the rest of the flesh
- No obvious symptoms on the outside of the fruit
- Flesh often has a slightly 'off' odour and flavour.

Possible causes

- Thought to be similar causes as with soft nose.

Jelly seed

Soft Nose

Description

- Flesh toward the nose of the fruit ripens more rapidly than the rest of the flesh
- Flesh near the nose becomes over-soft and dark yellow and watery
- In more severe cases the flesh around the seed becomes over-soft (jelly seed)
- The skin around the nose turns yellow before the rest of the skin (see 'Field defects' section).

Possible causes

- Not clearly established, but may be linked to a nutritional imbalance
- Harvesting over-mature fruit.

Soft nose

Flesh Browning

Description

- Diffuse dark brown discolouration of the flesh
- Can start as small areas with smaller darker spots, usually near the seed
- In severe cases can cover over 50% of the flesh
- Varies considerably between blocks, regions and seasons

Possible causes

- Thought to be associated with long storage times, or a combination of shorter storage times with excessive delays (several days) between harvest and the start of cold storage
- Harvesting advanced maturity fruit (>17% dry matter content).

Flesh browning

Flesh Cavities

Description

- Cavities in the flesh
- Not restricted to any area of the flesh
- Can have a white border around the cavity.

Possible causes

- Fruit dropped onto a hard surface (impact damage)
- Hot water treatment.

Flesh cavities

Flesh Cavity with White Patches

Description

- Dry white starchy honeycomb-like cavities in the flesh near the seed
- Reported in Calypso® fruit
- Incidence and severity vary across production regions and seasons.

Possible causes

- Harvesting immature fruit (<15% dry matter content)
- Occurs in fruit that receive vapour heat treatment
- The incidence is highest in fruit from trees with low to medium crop loads and a relatively high flesh potassium + magnesium/calcium mineral ratio.

Flesh cavity with white patches

White Patches (ricey spots and streaks)

Description

- White areas in the ripe flesh
- Can be either small ‘rice-sized’ spots, small streaks or larger areas
- Usually firmer than the surrounding flesh.

Possible causes

- Ricey spots usually caused by damage during heat treatment for disinfestation
- Streaks and larger areas usually caused by impact damage. May also have cavities in the flesh as a result of the impact.
- May also be associated with fruit spotting bug damage.

QUARANTINE ISSUES

- Fruit fly
- Mango seed weevil
- Live scales on fruit

QUARANTINE ISSUES

Fruit Fly

Description

- The fruit fly leaves an inconspicuous ‘sting’ (oviposition site) on the skin of the fruit when laying eggs under the skin
- Small white larvae emerge from the eggs and consume the fruit flesh, opening the way for decay from fruit rots
- The fruit ripens prematurely and is unfit for marketing.

Possible causes

- Fruit flies of the genus *Bactrocera*, especially the Queensland fruit fly *(Bactrocera tryoni)*
- Adults are wasp-like, red-brown with yellow markings and about 8 mm long. Larvae are white, torpedo-shaped and jump when disturbed.

Fruit fly

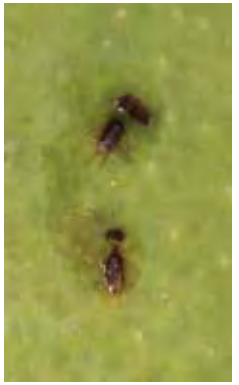
Mango Seed Weevil

Description

- Adult seed weevils lay brown tubular eggs with two small tails on the fruit and then damage the skin to cover the eggs with sap
- Newly hatched larvae tunnel through the fruit to the seed
- Larvae of the mango seed weevil feed on the seed, destroying its viability
- Tunnelling larvae have no effect on the flesh of the fruit.

Possible causes

- Larvae and adults of the mango seed weevil *(Sternochetus mangiferae).*



Mango seed weevil

Live Scales on Fruit

Description

- Scales on fruit causes a conspicuous pink blemish
- The pink spot remains after the scale has been removed and detracts from the appearance.

Possible causes

- Mango scale *(Aulacaspis tubercularis)*
- Adult females are white with a round transparent wax covering. Each female lays about 50 eggs under a protective covering
- After hatching the crawlers move around in search of a feeding site.

Live scales

APPENDICES

- Appendix 1: Mango packed product inspection record
- Appendix 2: Mango reject analysis record
- Appendix 3: Rating scales
- Appendix 4: Mango grading posters (Class 1 and Class 2)
- Appendix 5: Saleable life index (SLI)
- Appendix 6: Shelf life assessment

APPENDIX 1: MANGO PACKED PRODUCT INSPECTION RECORD

Variety:		**Facility:**		**Customer:**		
Date/Time:		**Batch no.:**		**Pack Type:**		
Skin Colour:		**Firmness:**		**Total no. cartons:**		

Carton number						
Count						
Product ID code						
Net fruit weight (kg)						
Presentation						
Labelling						
QUARANTINE DEFECTS						
Mango seed weevil						
Live scale						
Total quarantine (no./%)						
MAJOR DEFECTS						
Wounds						
Soft nose						
Stem end cavity						
Rots						
Total major (no./%)						
MINOR DEFECTS						
Blemish						
Cleavage scar						
Pest chewing						
Sunburn						
Misshapen						
Immature						
Dark green skin						
Pink Spot						
Sapburn						
Skin browning						
Abrasion						
Stem puncture						
Scratches/cuts						
Pressure mark/crease						
Lenticel spotting						
Not enough blush						
Total minor (no./%)						
Total all defects (no./%)						
Over-grading (no./%)						

Comments:

Assessor:

Variety: _____ **Facility:** _____ **Location:** _____

Date/Time: _____ **Batch no.:** _____ **No. Fruit Assessed:** _____

DEFECTS—PRE-HARVEST	NUMBER OF FRUIT	TOTAL
Wounds		
Soft nose		
Stem end cavity		
Blemish		
Cleavage scar		
Pest chewing		
Pink spot		
Sunburn		
Misshapen		
Immature		
Not enough blush		
Total pre-harvest defects (no./%)		

DEFECTS—POSTHARVEST	NUMBER OF FRUIT	TOTAL
Rots		
Sapburn		
Skin browning		
Abrasion		
Stem puncture		
Scratches/cuts		
Pressure mark/crease		
Lenticel spotting		
Heat damage		
Total post-harvest defects (no./%)		
Total all defects (no./%)		
Over-grading (no./%)		

Comments: _____

_____

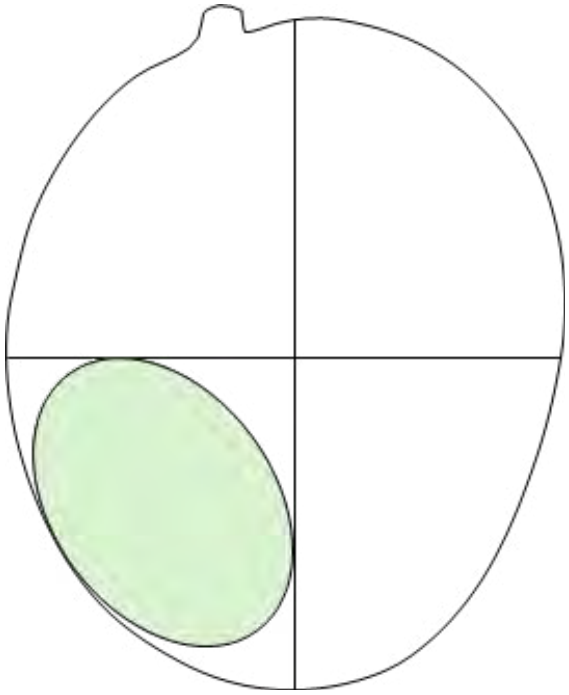
_____

_____

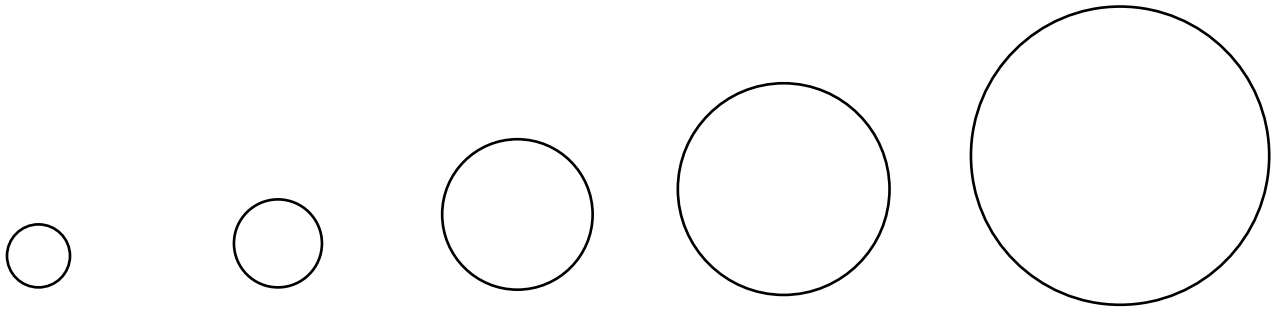
_____

Assessor: _____

APPENDIX 3: RATING SCALES



Area = 10% (or one-tenth) of total surface area



0.5cm²
(pencil diameter)

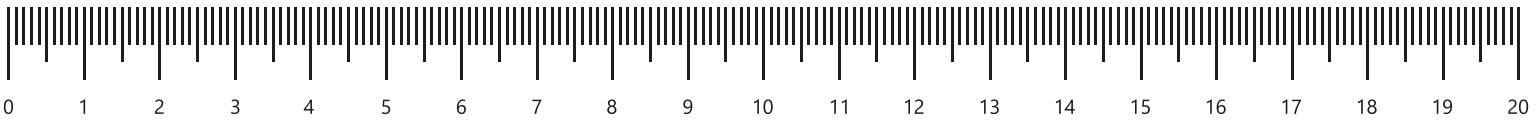
1cm²

3cm²
(5 cent piece)

6cm²
(20 cent piece)

12cm²

Scale for physical damage (cm)



APPENDIX 4: MANGO GRADING POSTERS

MANGO GRADING **1ST CLASS**

Sunburn

Yellow bleaching on no more than 25% of the surface; no browning or dark or sunken blotches.

Blemish

Less than 4cm² in total or 10% (cumulative). Blemish includes healed scarring, cleavage scar and browning skin marks.

Lenticel

Dense pronounced spots on no more than 25% of the surface, or scattered pronounced spots on no more than 50% of the surface; not star-shaped or cracked.

Pink Spot

Less than 6 spots or an area no more than 1cm² (caused by Scale).

Russet

Dense thick lines on no more than 10% of the surface.

Sapburn

Less than 4cm² in total or 10% (cumulative).

Total Defect Area
(to scale)

1cm² = 

4cm² = 

Poster designed and developed by the Queensland Department of Agriculture and Fisheries and the Australian Mango Industry Association with funding from Horticulture Innovation Australia Ltd.
Current as at June 2017.

Scan the QR code to download a copy

These posters were designed and developed by the Queensland Department of Agriculture and Fisheries and the Australian Mango Industry Association in 2016. They provide the grading standards for Class One or First Grade and for Class Two or Second Grade fresh mangoes.

APPENDIX 4: MANGO GRADING POSTERS

MANGO GRADING 2ND CLASS

Sunburn

Yellow bleaching on no more than 50% of the surface; discoloured blotches to 12cm² not sunken.

Blemish

Less than 12cm² in total or 25% (cumulative). Blemish includes healed scarring, cleavage scar and browning skin marks.

Lenticel

Dense pronounced spots on no more than 50% of the surface, or scattered pronounced spots on no more than 50% of the surface; not star-shaped or cracked.

Pink Spot

No more than 15 spots or an area no more than 4cm² (caused by Scale).

Russet

Dense thick lines or blotches on no more than 50% of the surface; not raised.

Sapburn

Less than 12cm² in total or 25% (cumulative).

Total Defect Area (to scale)

Poster designed and developed by the Queensland Department of Agriculture and Fisheries and the Australian Mango Industry Association with funding from Horticulture Innovation Australia Ltd. Current as at June 2017.

Scan the QR code to download a copy

These posters were designed and developed by the Queensland Department of Agriculture and Fisheries and the Australian Mango Industry Association in 2016. They provide the grading standards for Class One or First Grade and for Class Two or Second Grade fresh mangoes.

APPENDIX 5: SALEABLE LIFE INDEX (SLI)

The saleable life index (SLI) is a measure of the time from when mangoes are ready for sale until the first sign of disease breakdown. We describe below how the SLI for Kensington Pride loads at market arrival varied, discuss factors affecting the SLI and show how the SLI is measured.

Ask retailers what they want when buying a tray of mangoes and they will tell you that they want coloured fruit, colour stage 4 (50–70% yellow), and a tray that will last 7 days before the fruit starts to break down with rots. Those 7 days are needed to deliver the fruit from the market to the shop and then sell the fruit to consumers. As soon as more than one fruit in the tray shows any sign of rots, the retailer starts to worry. Trays with rots present represent fruit that may have to be discounted or discarded and lower returns.

To measure how well consignments satisfy retailer needs, the SLI was developed. The SLI is the time from when the average skin colour in a sample of fruit reaches 60% yellow to when 10% of the fruit show signs of rot development (Figure 1). The SLI can be used to compare the performance of any consignment to any market or at any point in the supply chain.

Figure 1. The SLI is the time from when the average skin colour in a sample of fruit reaches 60% yellow to when 10% of the fruit show rots.

Figure 2 shows the range in the SLI for the 41 loads of Kensington Pride mangoes sampled at market arrival and held at 18–20˚C. The news is not good and explains why retailers have lost confidence in mangoes. Almost 20% of the loads had no saleable life at all and only 29% had a SLI of 7 days or more.

What affects saleable life?

By monitoring quality at different points from receival at the packing shed to market dispatch, we found that the following factors reduced the SLI:

- high ripening temperatures
- mixed ripening
- poor disease control in the orchard
- ineffective postharvest treatment
- delays during handling

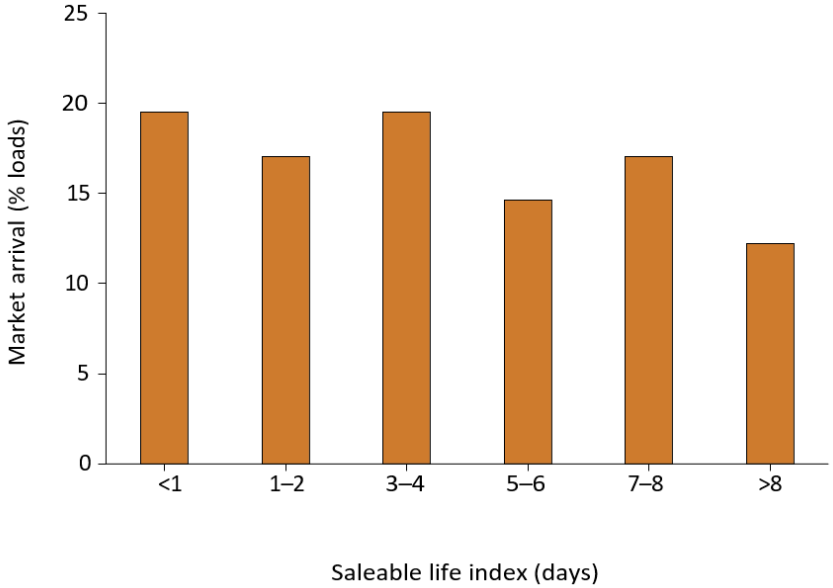


Figure 2. The range in the SLI for the 41 loads of Kensington Pride mangoes sampled at market arrival. Only 29% of loads had a SLI of seven days or more.

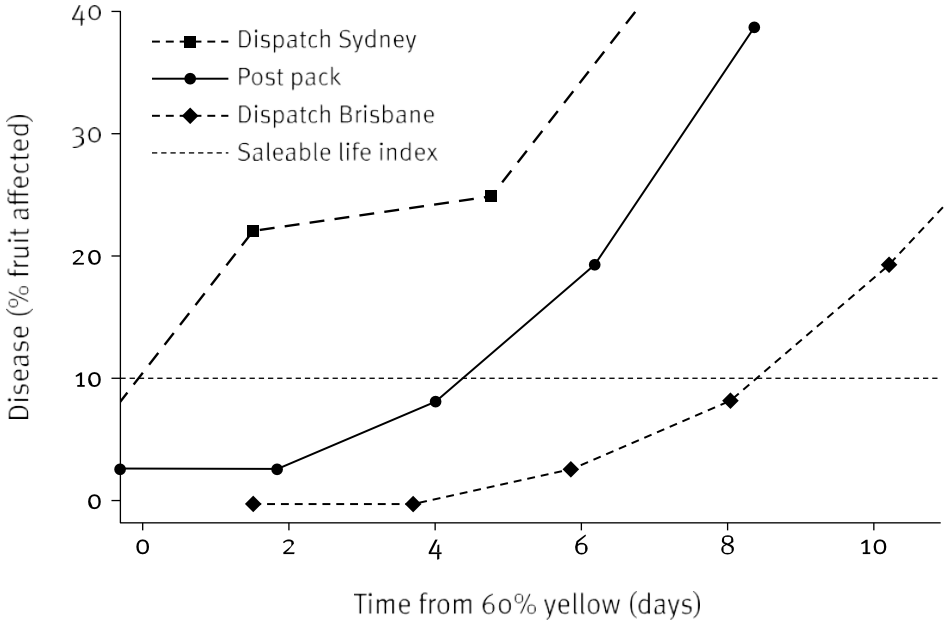
The effect of handling practices on the SLI is shown in Figure 3. A consignment from one grower was split between Brisbane and Sydney. Fruit sampled after packing had a SLI of 4 days. In Brisbane, the load was ripened using ethylene and this increased the SLI to 8 days. The load in Sydney was exposed to temperatures above 24˚C for 4 days (up to a high of 32˚C), and this decreased the SLI to 0 days.

Figure 3. Disease development in a split load to Brisbane and Sydney. Controlled ripening with ethylene increased the SLI from four to eight days, while high ripening temperatures decreased the SLI to zero days.

Measuring the SLI

The following step-by-step guide for measuring the SLI will help you to compare consignments, handling systems or performance between seasons.

1. Sample two trays representative of the load (about four layers from the top of the pallet) and hold at a constant temperature, preferably 18–20˚C.
2. Record the skin colour rating of each fruit every day using the mango skin colour guide. Calculate the average—add the ratings for each fruit and divide by the total number of fruit. The start of the SLI is when the average skin colour reaches stage 4.
3. At the same time as you record fruit colour, record the number of fruit showing any signs of rot. Use the mango defect guide to help you identify fruit rots. Don't count defects such as sapburn and skin browning. They affect appearance but are not used to measure the SLI.
4. Stop assessments when 10% of the fruit show rot development.
5. Count the number of days from when the average skin colour reached stage 4 to when 10% of the fruit showed rot development—this is the SLI.



APPENDIX 6: SHELF LIFE ASSESSMENT

Mango shelf life can be defined as the time fruit spend on the retail shelf before losing quality and becoming unmarketable. Shelf life assessment of mango fruit is typically completed at 20˚C and 65% relative humidity to simulate average retail display conditions.

Measuring shelf life is an important requirement in consumer or market-focused research for quantifying fruit postharvest performance. It may form part of studies that determine the inherent robustness of fruit to tolerate domestic or export supply chain handling. It can also be a key assessment parameter when evaluating the impact of implementing handling practices and technologies that show potential to reduce rates of fruit quality loss.

End of shelf life criteria have been developed for four main Australian mango varieties and are based on fruit softening, rot development and visual appearance quality. Individual assessor preferences can influence a decision to record when fruit reaches the end of shelf life. This appendix provides instructions for objectively determining the end of shelf life.

Measuring shelf life

Sample two or three representative trays from a consignment. Record the orchard, pack date, fruit batch and count details from the tray label. Contact the grower for shipment details, including the harvest and dispatch date. Using a permanent marker, label each fruit with a unique code or number. Inspect and rate fruit for initial appearance quality, recording firmness, skin colour and any quality defects that may have occurred during harvest, packing and transport. Take photographs of fruit in trays from above. Maintain the fruit at a near constant 20°C and 65% relative humidity for shelf life assessment. Monitor the storage conditions with a calibrated temperature and relative humidity data logger.

Regularly monitor individual fruit for softening, rot development and visual quality as described below. The monitoring frequency can be adjusted to suit the fruit ripening stage. Fruit that are hard or rubbery in firmness can be checked every 3-4 days. When fruit reach firm-soft, monitor any changes in quality every 1-2 days. The end of shelf life is generally recorded as the date at which fruit become unmarketable. The residual shelf life can be calculated from the receival date. Key reasons for the end of shelf life should be recorded.

Fruit softening

Australian mango varieties such as Calypso®, Honey Gold, Kensington Pride and R2E2 are typically consumed when the fruit are fully ripe with a firm-soft flesh firmness. Once the fruit become over-ripe, consumer acceptance decreases. Over-ripe mangoes are soft and will deform with slight hand pressure (firmness rating score of 4, see page 13). Over-ripe fruit are also characterised by the loss of desirable flavour and texture. Objective tools such as durometers (e.g. Turoni 53215 TT) are helpful for determining when fruit are over-ripe. A minimum of two durometer readings per cheek at the equatorial region of each fruit should be completed. Mark the site of measurements and avoid re-measuring in the same spot. Table 1 shows an example of cut-off durometer readings for the end of the shelf life based on fruit softening and corresponding flavour loss.

Variety	Durometer reading *(Shore units)*
Calypso®	≤ 42
Honey Gold	≤ 38
Kensington Pride	≤ 22
R2E2	≤ 42

Table 1. Average durometer1 readings that correspond to the end of shelf life for four Australian mango varieties.

1Average of four readings per fruit using a Turoni 53215 TT durometer with a 5mm-diameter spherical probe.

Rot development

Individual fruit should be monitored regularly for rot development. Use the mango quality assessment manual to identify rots (see pages 30-34). Record the date of the first sign of any rot as this will qualify as the end of shelf life even if fruit softening and flavour are acceptable.

Visual appearance quality

The end of shelf life can also be associated with the development of extremely poor visual quality. Postharvest quality defects, including chilling injury, under skin browning, heat damage, severe skin browning, severe skin shrivel and resin canal discolouration, typically contribute most to extremely poor visual appearance. Other quality defects such as sapburn, physical damage and pre-existing lenticel discolouration are typically excluded. While these defects affect appearance quality, they are not directly related to shelf life. Use the mango quality assessment manual (see pages 30-50) to diagnose harvest and postharvest defects.

Once fruit reach the end of shelf life, they can be cut open for inspection of internal quality and/or the provision of flesh samples for soluble solids content, titratable acidity and other organoleptic analysis.

Notes: