ACIAR Mango Quality Assessment Kit

Australian Government
Australian Centre for International Agricultural Research

Griffith UNIVERSITY
Queensland, Australia

Queensland Government

Acknowledgements

This mango quality assessment kit was developed under the ACIAR research activity project *Enhancing mango fruit quality in Asian mango chains* (AGB/2016/009). This project was co-led by the Department of Agriculture and Fisheries, Queensland, and Griffith University with partner country engagement from Cambodia, Indonesia, Pakistan, the Philippines and Vietnam. The aim of the project was to enhance common understanding in assessment and improvement of mango quality.

Disclaimer

Contents

Quick assessments

Mango whole-fruit – Australia

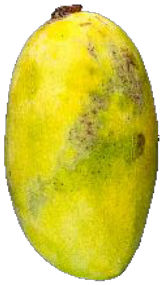
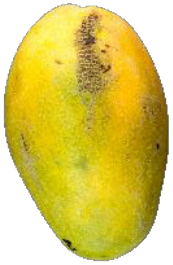
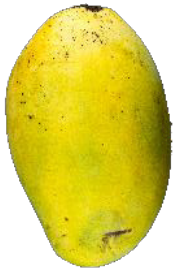
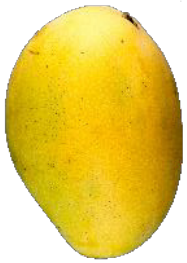
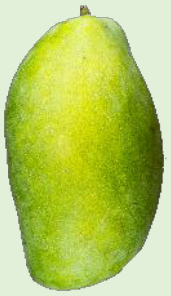
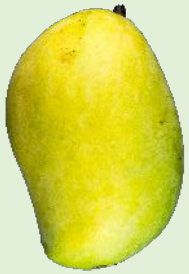
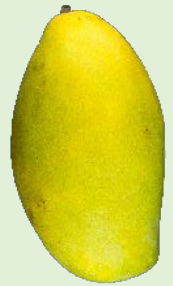
Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Blush	 No blush	 <50% blush	 50% blush	 >50% blush	 100% blush
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: Department of Agriculture and Fisheries, Queensland, 2019

Mango whole-fruit – Cambodia

Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: Brian Thistleton, 2019

Mango whole-fruit – Indonesia

Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Blush	 No blush	 <50% blush	 50% blush	 >50% blush	 100% blush
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: Universitas Mataram, 2019

Mango whole-fruit – Pakistan

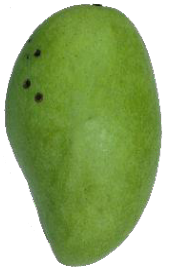
Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: University of Agriculture Faisalabad, 2019

Mango whole-fruit – The Philippines

Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: University of the Philippines Mindanao, 2019

Mango whole-fruit – Vietnam

Rating	1	2	3	4	5
Visual quality	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Skin defects	 > 25% of the surface	 10-25% of the surface	 5-10% of the surface	 0-5% of the surface	 No defects
Skin colour	 100% green	 Green > yellow	 Green = yellow	 Yellow > green	 100% yellow
Firmness	No ‘give’	Slight ‘give’ with strong thumb pressure	Flesh deforms by 2-3 mm with moderate thumb pressure	Whole fruit deforms with moderate hand pressure	Whole fruit deforms with slight hand pressure
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional – record objective measures of:

- Skin colour
- Firmness

Source: Sub-Institute of Agricultural Engineering and Postharvest Technology, 2019

Mango whole-fruit assessment – record sheet

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

Fruit No.	Visual quality	Skin defects	Primary defects	Skin colour	Blush	Firmness	Optional				
							Smell	Firmness	Colour		
									L	a	b
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Mango whole-fruit assessment – record sheet cont.

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

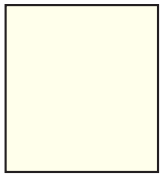
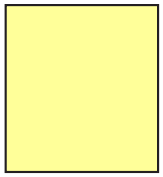
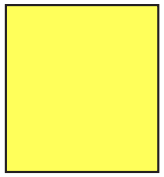
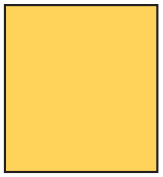
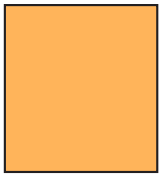
Fruit No.	Visual quality	Skin defects	Primary defects	Skin colour	Blush	Firmness	Optional				
							Smell	Firmness	Colour		
									L	a	b
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Mango whole-fruit assessment – record sheet cont.

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

Fruit No.	Visual quality	Skin defects	Primary defects	Skin colour	Blush	Firmness	Optional				
							Smell	Firmness	Colour		
									L	a	b
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											

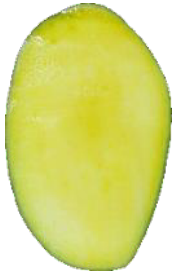
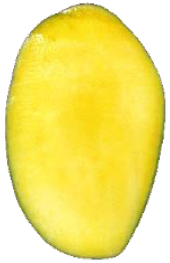
Mango cut-fruit – Australia, Cambodia, Indonesia, Pakistan and Vietnam

Rating	1	2	3	4	5
Flesh defects	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Flesh colour	 White-yellow	 Light yellow	 Bright yellow	 Yellow-orange	 Orange
					
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Taste	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Texture	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Overall rating	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional objective measures of:

- Dry matter
- Total soluble solids (TSS) or Brix
- Titratable acidity (TA)
- Flesh colour

Mango cut-fruit – The Philippines

Rating	1	2	3	4	5
Flesh defects	Very poor	Poor	Fair: Limit of marketability	Good	Very good
Flesh colour	 White - yellow	 Light yellow	 Bright yellow	 Yellow – orange	 Orange
					
Smell, aroma	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Taste	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Texture	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely
Overall rating	Dislike extremely	Dislike slightly	Neutral	Like slightly	Like extremely

Optional objective measures of:

- Dry matter
- Total soluble solids (TSS) or Brix
- Titratable acidity (TA)
- Flesh colour

Source: University of the Philippines Mindanao, 2019

Mango cut-fruit assessment – record sheet

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

Fruit No.	Flesh defects	Flesh colour	Flesh smell	Taste	Texture	Overall rating	Comments	Optional			
								Dry matter	TSS/ Brix	TA	Flesh colour
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Mango cut-fruit assessment – record sheet cont.

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

Fruit No.	Flesh defects	Flesh colour	Flesh smell	Taste	Texture	Overall rating	Comments	Optional			
								Dry matter	TSS/ Brix	TA	Flesh colour
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Mango cut-fruit assessment – record sheet cont.

Supplier:		Date packed (dd/mm/yy):		Assessor name:	
Variety name:		Assessment location:		Logger numbers:	
Batch number:		Assessment date (dd/mm/yy):			

Fruit No.	Flesh defects	Flesh colour	Flesh smell	Taste	Texture	Overall rating	Comments	Optional			
								Dry matter	TSS/ Brix	TA	Flesh colour
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											

Supporting resources

Map your supply chain – Tick the relevant cells

Assessment Stage	Whole fruit assessment					Cut fruit assessment						Library trays	Sensory profiling	Consumer acceptance
	Visual quality	Skin colour	Firmness	Skin defects	Smell	Dry matter	TSS	Flesh colour	Flesh defects	TA	TSS:TA			
Harvest														
Packing														
Disinfestation														
Freight forwarder														
Importer														
Ripener														
Distribution Centre														
Retailer														
Consumer														

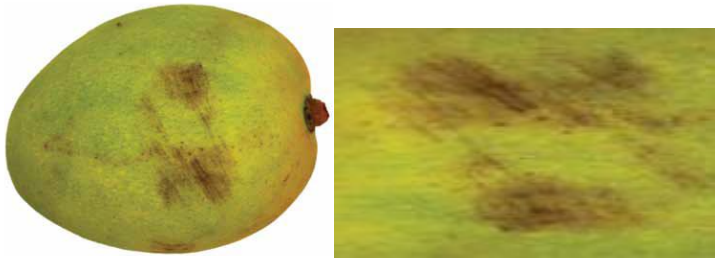
Library tray experiment procedure – Packhouse example

- Sample
  Five trays per batch of uniform fruit count sampled at the packing line end on the day of packing. Sampling date, batch number and consignment number recorded. Sample trays transported at 15 °C to assessment location within 1 day.
- Assessment

Stage	Assessment
Upon arrival (Sample trays held at 12°C)	1. Skin colour - Subjectively according to the rating scale in the Kit and objectively using a colourimeter 2. Firmness - Subjectively according to the rating scale in the Kit and objectively using a penetrometer 3. Defects - Subjectively referring to detailed descriptions and images in Supporting resources and the rating scale in the Kit
At eating soft (Sample trays held at 20°C)	Record date, rate for defects that worsen as fruit ripens (refer to Supporting resources for detailed defects)
From eating soft (Sample trays held at 20°C)	Assess daily, record end of shelf life based on marketable visual quality, and record the main defect(s) causing end of shelf life

Glossary

A. External quality attributes

Physical/mechanical damage			
Picture	Defect	Other names	Description
	Abrasion		Light brown streaks or scratches.
	Creases		Random, irregular, depressed brown lines, indentations or marks.
	Crack		

Physical/mechanical damage			
Picture	Defect	Other names	Description
	Cleavage scar		Discoloured or black areas.
	Chilling injury/skin greying		Discoloured or brown areas, light grey skin discolouration.
	Flat area		Compression damage.

Physical/mechanical damage			
Picture	Defect	Other names	Description
	Hail damage		Discoloured or black areas. Young fruit: very little scar tissue but indentations. Mature fruit: significant discoloured areas.
	Healed wounds		Injuries (cuts or punctures).

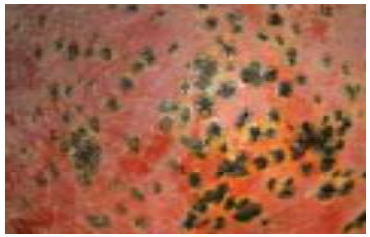
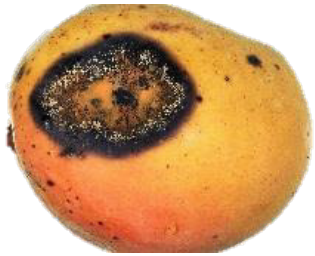
Physical/mechanical damage			
Picture	Defect	Other names	Description
	Lenticel spotting		The corky tissue in the lenticels on the skin swells resulting in small round or star-shaped spots scattered over the skin surface.
	Scald	Heat damage	Skin browning.
 	Scratches		Fine brown scratches.

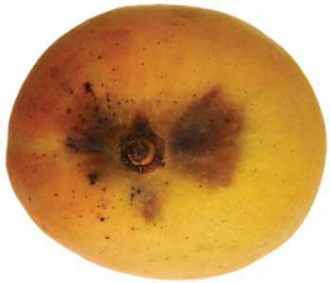
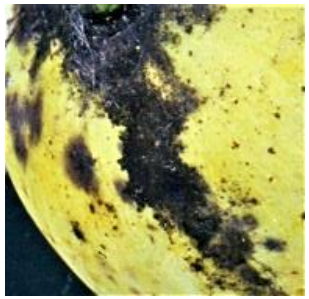
Physical/mechanical damage			
Picture	Defect	Other names	Description
	Stem puncture		Small, brown marks on the fruit, often sunken.
	Sunburn		Bleached and/or yellow patches or leathery red-brown to black and slightly depressed patches.
	Tree rub	Wind rub Branch rubbing (Pakistan)	Small, brown oval-shaped blotches and lines.

Insect damage			
Picture	Defect	Pest	Description
	Pink spot	Live scale	Scales cause conspicuous pink blemish.
	Fruit fly sting	Queensland fruit fly (*Bactrocera tryoni*)	Queensland fruit fly leave a sting mark after laying eggs under the skin.
	Pitting and sap exudate on the skin	Mango seed weevil (*Sternochetus mangiferae*)	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.

Insect damage			
Picture	Defect	Pest	Description
	Burrowed flesh rots	Mango pulp weevil (*Sternochetus frigidus*)	The weevil is present in Malaysia, the Philippines and parts of Indonesia.
	Corky spots randomly scattered on the fruit skin	Miridae, *Helopeltis* damage	Common mango defect for Carabao mango from the Philippines.
	White fruit with flour-like substance	Mango mealybug (*Drosicha mangiferae)*	Makes the fruit white due to its flour-like substance, which covers the body surface.

Insect damage			
Picture	Defect	Pest	Description
	A dark rusty stain	Thrips damage (*Thysanoptera*)	Thrips feed by rubbing and sucking the sap from the skin, dropping faeces onto the skin and leaving a dark rusty stain.
	Red banded mango caterpillar	*Deanolis sublimbalis*	Damaging to fruit development all stages, feeding on both flesh and seed.
	Fruit piercing Moth	*Eudocima phalonia*	A brown, circular, rotten area develops round the tiny puncture hole and the fruit is ruined for commercial sale.
	Fruit spotting bug	*Amblypelta nitida*	Feed by piercing fruit and sucking the juice from the tissue and cause deep-set breakdown of tissue.

Disease damage			
Picture	Defect	Causal agent	Description
 	Bacterial black spot	*Xanthomonas campestris* pv. *mangiferaeindicae*	Bacterial disease: small, irregular, raised black spots with greasy margins.
 	Body rots – anthracnose	Colletotrichum spp.	Fungal disease: dark-brown to black, slightly sunken spots on the fruit body, sometimes with slimy salmon-pink spore masses. Develops during ripening.
 	Body rots – Alternaria rot	*Alternaria alternata*	Fungal disease: dark-brown lesions with diffuse margins. A white-grey fungal growth may cover the surface of lesions. Develops during ripening, particularly in fruit that have been stored for some time.

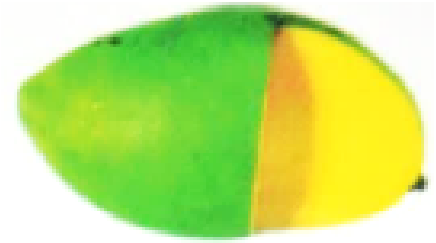
Disease damage			
Picture	Defect	Causal agent	Description
 	Stem end rot	Fungi from the Botryosphaeriaceae, and other fungi	Fungal disease: fast-growing, watery soft rot starting around the stem and penetrating deep into the flesh. Develops during ripening.
 	Sooty blotch	An unidentified fungus, probably *Stomiopeltis* sp.	Saprophytic fungal growth on the surface of fruit—blotchy, dark staining of the skin. Unlike sooty mould, sooty blotch growth cannot be easily brushed off.
 	Sooty mould	Various saprophytic fungi, especially *Capnodium* sp.	Saprophytic, velvety, black fungal growth on the surface of fruit. Unlike sooty blotch, sooty mould growth can be easily brushed off.

Disease damage			
Picture	Defect	Causal agent	Description
	Mango scab	*Denticularia mangiferae*	Fungal disease: grey to greyish-brown scabs with dark, irregular margins on the fruit surface. Older lesions may have a cracked and corky appearance.
	Dendritic spot	Fungi from the Botryosphaeriaceae, and *Colletotrichum* spp.	Fungal disease: appears as small, dark, irregularly branched spots. Develops during ripening.
	Tear stain	Mostly *Colletotrichum* spp.	A tear-stain pattern of dark spots on the fruit skin is seen where fungal spores have washed down the sides of fruit in the orchard. On unripe fruit these appear as a superficial stain on the fruit surface. As fruit ripen, typical anthracnose lesions often develop in the ‘stained’ areas.

Disease damage			
Picture	Defect	Causal agent	Description
	Powdery mildew	*Oidium mangiferae*	Fungal disease: on mature fruit that have survived infection, scarring from powdery mildew may leave pale, web-like streaks on the surface of fruit skin.

Physiological disorders			
Picture	Defect	Other names	Description
	Sapburn	Latex burn (Philippines) Sap mark (Indonesia)	Spurt sap appears as dark-brown spots or blotches.

Physiological disorders			
Picture	Defect	Other names	Description
	Misshapen		Deformed fruit, which do not develop evenly.
	Dimples		Small, circular indentations in the fruit.
	Chimera	Chimeric tissues (Pakistan)	Stripped areas or blotches of lighter or darker green colour on the skin.

Physiological disorders			
Picture	Defect	Other names	Description
	Evergreen	Balat-kawayan (Philippines)	Usually deep green colour of the peel, which does not disappear with ripening.

Other			
Picture	Defect	Other names	Description
 	Foreign matter		Visible residues of pesticides, soil or other matter on the skin of the fruit, especially around the stem.

Other			
Picture	Defect	Other names	Description
	Russet		Light-coloured blemish, appears as silver lines or blotches on the skin.
	Under skin browning	USB	Browning of the cell layers under the skin.

Other			
Picture	Defect	Other names	Description
	Buah duduk (Indonesia)		For Gedong Gincu cultivar, flat area at the bottom probably caused by nutrition deficiency.

Others not depicted

- Skin browning = detergent, temperature, or ethylene injuries
- Blotchy green skin: temperature or N fertiliser issues
- Lenticel discolouration: irradiation or N fertiliser issues
- Resin canal discolouration: nutrition, rapid temperature reduction or bacterial infections issues
- Shoulder blackening: unknown
- Intultol: a disorder characterised by dark-brown to black depression on the peel of the fruit, not localised and already apparent even while the fruit is on the tree
- Ugat: netted appearance of the peel due to prominent veins which appears during rainy season
- Ant urine.

B. Internal quality attributes

Picture	Defect	Other names	Description
	Stem end cavity		Watery patches in the flesh with discoloured strands that develops into flesh collapse leaving a distinct cavity.
	Soft nose		Flesh toward the nose of the fruit ripens more rapidly than the rest of the flesh.
	Jelly seed	Internal breakdown (Indonesia)	Similar to soft nose, but the flesh around the seed ripens more rapidly than the rest of the flesh.

Picture	Defect	Other names	Description
	Flesh browning		Dark brown discolouration of the flesh.
	Flesh cavities		Cavities in the flesh.
	White patches (ricey spots and streaks)		Discrete firm white spot or areas in the ripe flesh.

Objective methods for optional quality measurement

A. Firmness

Penetrometer

a. Sample size and selection - Select samples randomly with uniform size and comparable temperature
b. Make two puncture tests per fruit, one on opposite cheeks, avoid sunburned areas
c. Remove a disc of the skin larger than the tip to be used with a vegetable peeler or sharp knife
d. Use a tip (plunger) with 8 mm (5/16-inch) size
e. All determinations for a given lot should be made by one person to minimise operator variability
f. Hold the fruit against a stationary hard surface and force the tip into the fruit at a uniform speed taking ~2 seconds
g. Depth of penetration should consistently be to the scribed line on the tip
h. Record reading to the nearest 0.25 kg-force (0.5 lb-force)

Note:

- Regularly maintain firmness testers. Before use each day, work the plunger in and out for ~10 seconds to loosen-up springs inside the instrument. Clean the tips after use to prevent clogging of the mechanism with juice.
- Check calibration of firmness testers before use

Source: Mitcham et al. 1996

Non-destructive firmness measurement equipment is preferred and widely used.

Source: Yaptenco et al. 2013

- Impulse acoustic technique
- Vis/NIR spectroscopy

Source: Valente et al. 2009

B. Skin colour

Colourimeter

Separate values for lightness to darkness, green to red and blue to yellow scales.

Source: Mitcham et al. 1996

Alternative to ‘high end’ colourimeters

Low cost units that provide equivalent readings saved to a smartphone or tablet.

Source: Nagle et al. 2016

Spectrophotometer

Spectrophotometers are designed to provide more detailed information about the optical properties of the sample, typically dividing the information in the visible spectrum into 15 or more components.

Colourimeters and spectrophotometers are designed to give a single average reading over a spot on the sample typically ranging in size from 5 to 25 mm in diameter.

Source: Jha et al. 2005; 2006; 2007

Colour machine vision systems

For on-line use or when detailed colour information is needed for spatial analysis across a two-dimensional surface, a colour machine vision system is typically used. This non-destructive technology has been used at packing lines to sort fruit for blemishes, colour (skin), density, dry matter (NIR), shape, size, volume, and weight.

Source: Slaughter, 2009

C. Dry matter

Dry matter can be measured destructively or non-destructively. The destructive method using a food dehydrator with mango fruit slices is outlined below.

Food dehydrator

a. Select a sample of mango fruits. Appropriately label it. Cut one slab parallel to the seed and then cut the slab in half longitudinally. Turn the half-cut slab such that the cut side is placed flat on the slicer with the stem end oriented towards the blade. Slice off (thin slice plate) an ~5mm thick slice.
b. Weigh the slice using a piece of weighing paper and record it in grams to two decimal places. Place slices along with paper in the tray. When all the sample slices have been placed in the tray, place it in the dehydrator set at 54°C (130°F) cover and leave to dry for approximately 24 hours.
c. After 24 hours, weigh each slice along with paper and record its weight (paper + slice). The samples should be measured one tray at a time keeping the others in the dehydrator to prevent the slices from reabsorbing moisture.
d. After weighing, place the slices back in the same positions in the dehydrator.
e. Run the dehydrator for another hour or two with the mango slices, then reweigh and record. Compare the two dry slice weight measurements. If the weight has not changed for each sample more than one hundredth of a gram (i.e. 0.01), then the dehydration process has ended, and the last weight is taken as the final reading. Be sure that burning/charring does not occur anytime during the dehydration process.
f. Calculation use formula.

$$\text{Dry matter (\%)} = \frac{\text{Final net dry slice weight (g)}}{\text{Initial net fresh slice weight (g)}} \times 100\%$$

Before starting:

- Be sure that the electronic balance is levelled and the dehydration process is performed in a secure clean area.
- Label the food dehydrator trays.
- Set dehydrator at 54°C (130°F). Turn it on to warm up. Check the temperature a few times with a standard probe thermometer and adjust settings (if needed) to achieve the desired temperature.
- Make sure you choose the thin slicer blade for preparing mango slices.

Source: Department of Plant Sciences, 2017

D. TSS

Pocket refractometers and more sophisticated techniques like short-wave NIR spectroscopy (VIS/SWNIR) can be used to measure mango fruit TSS.

Refractometer

The refractometer has a scale for refractive index and/or for equivalent °Brix or SSC percent that can be read directly. Digital refractometers remove potential operator error in reading values. Sample mango fruit flesh should be cut from stem to blossom end and to the centre of the fruit to account for variability in SSC from top to bottom and inside to outside of the fruit. A garlic press works well for small samples.

The temperature of the juice is a critical factor for accuracy because all materials expand when heated and become less dense. Clean the refractometer between each reading and to standardise it with distilled water for which the refractive index is 1.3330 at 20°C (68°F) or 0% SSC.

Example alternative

- Short-wave NIR spectroscopy (VIS/SWNIR) technique

Sources: Mitcham et al. 1996; Yu & He, 2009

E. TA

Titrating with NaOH. TA (titratable acidity) for organic acids is mainly for citric acid in mangoes. TA can be determined by titrating a known volume of fruit juice with 0.1 N NaOH (sodium hydroxide) until the pH changes to 8.2 as indicated by phenolphthalein indicator or a pH meter. The millilitres of NaOH needed is used to calculate the TA (expressed as % citric acid) as follows:

$$TA = \frac{\text{ml NaOH x N (NaOH) x 0.064 x 100}}{\text{ml juice titrated}}$$

Source: Mitcham et al. 1996

F. Flesh colour

Colour fans/chart are widely used as a mango picking guide. Others guides include the reference colour chart published by the Royal Horticultural Society (http://rhscf.orgfree.com/).

Organoleptic eating quality

A. Consumer acceptance

Subjective assessment of consumer liking

Consumer acceptance tests can be used to determine consumer liking and acceptability of a product at any point in time across the supply chain. Such tests can be run in a controlled test environment or within a commercial (e.g. retail) setting. The public and/or retail workers can take part in these tests as all opinions are useful and valid. This section provides information on sample preparation and an example question sheet that can be used for consumer acceptance testing.

Test type	Acceptance testing
Aim	To determine overall liking of a product
Panellists required	Consumers of the product, with the aim of having a cross-section of age and gender
Testing conditions	Suitable testing environment: meeting room, retail store, market place, etc.
Sample preparation	Identical preparation for all samples. Blinding codes to prevent consumer bias
Assessment of outcome	Mean score Analysis of variance (ANOVA) when >1 sample assessed for comparison of liking

- Example of evaluation sheet for consumer acceptance testing

Acceptance testing

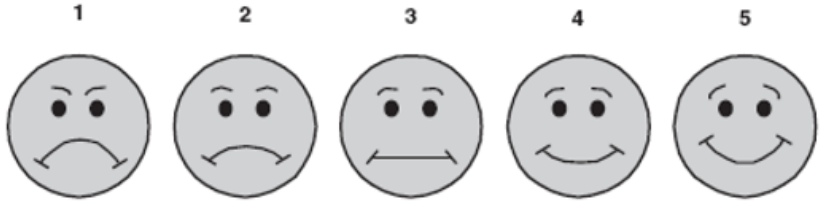
Name…….. Date ……..

Instructions:
Please smell and taste each of the products and answer the questions provided.

How much do you like the sample 123 overall? (Scale types are optional).

1 Dislike very much
2 Dislike slightly
3 Neither like nor dislike
4 Like slightly
5 Like very much

OR



(question can be repeated for aroma, flavour, texture and overall liking)

Remarks
……

If you wish to comment on any particular likes or dislikes of this sample you may do so under 'Remarks'.

B. Sensory profiling and difference testing

Objective assessments of mango aroma, flavour and mouthfeel can be made in a controlled environment (e.g. trials) and/or by workers (e.g. end of supply chain) to assess the sensory attributes of a product. Difference tests can be applied in a controlled environment to assess the change in colour, aroma, flavour and mouthfeel over time against a control sample. Recommended sensory tests include Triangle tests and Difference-from-Control tests. Profiling can be done at the retail end of the supply chain to assess the sensory attributes of products as they reach the consumer in store. This section provides further information on how to conduct these tests and example question sheets that can be used.

Test type	Profiling – to determine what sensory attributes are present and how they change over time: appearance, aroma, flavour and mouthfeel
Panellists required	>10 individual consumers
Testing conditions	Suitable testing environment, localised
Sample preparation	Identical preparation for all samples. Blinding codes to prevent consumer bias.
Methodology	Assess each product and identify the intensity of aroma and flavour as well as individual sensory attributes present
Assessment of outcomes	Mean intensity and collation of sensory attributes

- Example of profiling evaluation sheet

Product profiling

Name…….. Date ……..

Instructions:

Taste the samples provided.

1. score them for aroma and flavour intensity and
2. identify the aroma, flavour and texture attributes present

Aroma/flavour intensity – rate the intensity on the scale below

1	Low	Below level of acceptability
2	Low-medium	
3	Medium	At the level of acceptability
4	Medium-high	
5	High	High level of acceptability

Sensory attributes – identify the sensor attributes present and note any note mentioned.

Aroma	Flavour	Mouthfeel
Fresh	Fresh	Firm
Tropical	Tropical	Soft
Citrus	Citrus	Juicy
Musty/stale	Sour	Dry
	Sweet	Stringy
	Bitter	Smooth

Any other attribute(s) ……

- Product profiling attribute descriptions

Aroma attribute	Description
Fresh	Crisp salad leaves and continental cucumber
Tropical	Sweet tropical fruits with some acidity: pineapple and passionfruit
Orange citrus	Fresh orange, mandarin, tangelo
Musty/stale	Old, dank, dusty, dirty, barnyard, overripe rock melon

Flavour attribute	Descriptor
Fresh	Crisp salad leaves and English cucumber
Tropical	Sweet tropical fruits with some acidity: pineapple and passionfruit
Orange citrus	Fresh orange, mandarin, tangelo
Sweet	Honey, overripe brown banana
Sour/tangy	Lemon juice
Bitter	Bitterness with astringency

Mouthfeel attribute	Descriptor
Firm/soft	Initial bite between molars
Juicy/dry	How much juice is released during mastication
Stringy/smooth	Presence of fibres within the mango flesh

Test Type	Triangle Test	Difference-from-control test
Aim	To determine whether a significant difference exists between 2 samples (e.g. control vs. test sample).	To determine whether a difference exists between 1 or more samples and a control and estimate the size of any such differences
Panellists required	>10 trained sensory assessors OR >30 untrained assessors	20–50 untrained assessors
Testing conditions	Isolated sensory booths/individual assessment area	
Sample preparation	Identical preparation for both samples, placed in individually blind coded pots/plates. Samples to be randomised.	Identical preparation for all samples. A labelled control sample must be presented with each test sample, placed in individually blind coded pots/plates
Assessment of outcome	Refer to statistical table defining critical number of correct responses in a Triangle Test.	Analysis of variance (ANOVA) appropriate for randomised (complete) block design; the assessors are the ‘blocks’ in the design

- Example of evaluation sheet for triangle test and difference-from-control test

Triangle Test

Name..... Date .....

Instructions:

Taste the samples on the tray from left to right.
Two samples are identical; one is different.
Select the odd/different sample and indicate by placing an X next to the corresponding code.

Samples on tray	Indicate odd sample	Remarks
.....	.....	.....
.....	.....	.....
.....	.....	.....

If you wish to comments on the reasons for your choice or if you wish to comment on the product characteristics, you may do so under 'Remarks'.

Supporting resources

Difference-from-control

Name…… Date ……

Instructions:

You have received 2 samples, one labelled C (control) and one labelled with a 3-digit code.
Taste sample C and then rinse your mouth with water.
Taste the second sample and indicate on the scale below the size of the difference in firmness, relative to sample C.

Please circle your response

0 1 2 3 4 5 6 7 8 9 10

No difference Extremely different

Remarks ……

If you wish to comments on the reasons for your choice or if you wish to comment on the product characteristics, you may do so under 'Remarks'.

Supporting resources

Resources

Department of Plant Sciences 2017, 'Mango Dry Matter Measurement Protocol', University of California, USA, viewed 6 December 2017, <http://www.mango.org/Mangos/media/Media/Documents/Research%20And%20Resources/Research/Industry/Post-Harvest/Mango-Dry-Matter-Measurement-Protocol-Final_Eng.pdf?ext=.pdf>

Jha, SN, Chopra, S & Kingsly, ARP 2005, 'Determination of sweetness of intact mango using visual spectral analysis', *Biosystems Engineering*, vol. 91(2), pp. 157-161.

Jha, SN, Kingsly, ARP & Chopra, S 2006, 'Non-destructive determination of firmness and yellowness of mango during growth and storage using visual spectroscopy', *Biosystems Engineering*, vol. 94(3), pp. 397-402.

Jha, SN, Chopra, S & Kingsly, ARP 2007, 'Modelling of colour values for non-destructive evaluation of maturity of mango', *Journal of Food Engineering*, vol. 78(1), pp. 22-26.

Mitcham, B, Cantwell, M & Kader A 1996, 'Methods for Determining Quality of Fresh Commodities'. Perishables Handling Newsletter. 85.

Nagle, M, Intani, K, Romano, G, Mahayothee, B, Sardsud, V & Muller, J 2016, Determination of surface colour of 'all yellow' mango cultivars using computer vision, *International journal of agricultural and biological engineering*, 9(1): 42-50.

Nix Pro Color Sensor tool <https://www.nixsensor.com/nix-biological-uses/>

Slaughter, DC 2009, 'Non-destructive Maturity Assessment Methods for Mango', *University of California, Davis*, pp.1-18.

Valente, M, Leardi, R, Self, G, Luciano, G & Pain, JP 2009, 'Multivariate calibration of mango firmness using vis/NIR spectroscopy and acoustic impulse method', *Journal of Food Engineering*, vol. 94(1), pp. 7-13.

Walsh, KB & Subedi, PP 2014, 'In-field monitoring of mango fruit dry matter for maturity estimation', *In XXIX International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes (IHC2014)*, Brisbane, Australia, pp. 273-278.

Yaptenco, K, Angeles, M, Esguerra, E, Serrano, E, Cho, M & Choi, S 2013, Non-destructive firmness measurement as a maturity index for 'Carabao' mango (*Mangifera indica* L.) fruit, *Philippine Agricultural Scientist*, 96, 96(1): 55-65. <http://ucce.ucdavis.edu/files/datastore/234-1969.pdf>

Yu, J & He, Y 2009, 'Fast Measurement of Soluble Solid Content in Mango Based on Visible and Infrared Spectroscopy Technique', *IFIP Advances in Information and Communication Technology*, vol. 293, pp. 89–95.

Checklists

These checklists are to be used in conjunction with the Mango Quality Assessment Kit.

They outline materials and equipment required when conducting fresh mango fruit quality assessment along supply chains to domestic and export markets.

Domestic market

Materials/equipment	Purpose	Checked
Harvest		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin & flesh colour	☐
Data record sheet (hard copy/ laptop/ tablet/ mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Mark pens	Recording data	☐
Sunglasses/hat	Protection	☐
The Kit	Whole & cut fruit measurement	☐
Packhouse		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin & flesh colour	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Mark pens	Recording data	☐
Select library trays	Library trays	☐
The Kit	Whole & cut fruit measurement	☐

Materials/equipment	Purpose	Checked
Distribution centre		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Flesh colour	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Quick assessments, Supporting resources	TSS, TA	☐
Knife	Cutting fruit	☐
Marker pens	Recording data	☐
Penetrometer	Firmness	☐
Refractometer	TSS	☐
Titratable acidity titrator	TA	☐
The Kit	Whole & cut fruit measurement	☐

Materials/equipment	Purpose	Checked
Wholesaler		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin colour	☐
Data record sheet (hard copy/ laptop/ tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Quick assessments, Supporting resources	TSS	☐
Knife	Cutting fruit	☐
Marker pens	Recording data	☐
Penetrometer	Firmness	☐
Refractometer	TSS	☐
Skin colour measure equipment	Skin colour	☐
The Kit	Whole & cut fruit measurement	☐

Materials/equipment	Purpose	Checked
Ripener		
Camera/mobile phone	Taking photos	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
The Kit	Whole & cut fruit measurement	☐
Retailer		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin and flesh colour	☐
Data record sheet (hard copy/ laptop/ tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
The Kit	Whole & cut fruit measurement	☐

Export market

Materials/equipment	Purpose	Checked
Harvest		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin & flesh colour	☐
Data record sheet (hard copy/ laptop/ tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Mark pens	Recording data	☐
Sunglasses/ hat	Protect when harvesting	☐
The Kit	Whole & cut fruit measurement	☐
Packhouse		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin & flesh colour	☐
Data record sheet (hard copy/ laptop/ tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Mark pens	Recording data	☐
Select library trays	Library trays	☐
The Kit	Whole & cut fruit measurement	☐

Materials/equipment	Purpose	Checked
Importer/wholesaler		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Skin colour	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Quick assessments, Supporting resources	TSS	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
Refractometer	TSS	☐
Skin colour measure equipment	Skin colour	☐
Titratable acidity titrator	TA	☐
The Kit	Whole & cut fruit measurement	☐
Ripener		
Camera/mobile phone	Taking photos	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin defects	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
The Kit	Whole & cut fruit measurement	☐

Materials/equipment	Purpose	Checked
Distribution centre		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Flesh colour	☐
Data record sheet (hard copy/ laptop/tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Quick assessments, Supporting resources	TSS	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
Refractometer	TSS	☐
Titratable acidity titrator	TA	☐
The Kit	Whole & cut fruit measurement	☐
Retailer		
Camera/mobile phone	Taking photos	☐
Colour fan/chart	Flesh colour	☐
Data record sheet (hard copy/ laptop/ tablet/mobile phone)	Recording data	☐
Quick assessments, Supporting resources	Skin & flesh defects	☐
Knife	Cutting fruit	☐
Mark pens	Recording data	☐
Penetrometer	Firmness	☐
The Kit	Whole & cut fruit measurement	☐