
Appendix 8.16

**This case study forms part of the overarching
2017–19 ACIAR Mango Agribusiness Research Program**

Project: Enhancing mango fruit quality in
Asian mango chains

Study: Cambodia

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1 Acknowledgement

This study report for the Mango Quality project was prepared by Som Bunna from the Cambodian Agricultural Research and Development Institute.

2 Case summary

The Cambodian mango industry has been rapidly expanding since 2005. The planted area of 24,000 hectares in 2010 has increased to 65,251 hectares recorded in 2014/15. This study was undertaken to evaluate a draft mango quality manual with the focus of developing a common approach to accessing, describing and improving fruit quality in Asian mango supply chains. The outcomes will contribute to an enhanced common understanding and the study seeks to develop capacity in the process for assessment and improvement of physical and eating quality in mango supply chains.

An estimated 139,000 tonnes of mangoes (mainly green) are exported to Thailand, Vietnam and China from Cambodia. No official statistics are available on cross-border mango trade making the assessment challenging. Keo Romeat mango variety is harvested twice each year (from March to May and from October to December). The average mango price increases from USD300 per tonne to USD500–950 per tonne when mangoes are packed with protective covers. Green mangoes fetch a higher price in the off-season than in the main season. Contractors and collectors are responsible for assessing green mangoes in Kampong Speu Province. Contractors, who harvest and sort in the early morning, reported problems with off-season mangoes due to rainfall affecting fruit setting, increased defects and poor skin colour. Where paper envelopes are used in mango production, these resulted in a good skin and a brighter fruit colour. When the fruit is not covered with envelopes, a higher percentage of defects occurs. Fruit is packed in 20-kg plastic bags or 40-kg plastic crates, and then loaded into trucks or vans for transport to Phnom Penh.

Recommendations for future mango quality studies in Cambodia include:

- a cost benefit analysis of mangoes covered by paper envelope to assess the quality returns from rain protection and reduced insect damage to fruit
- an analysis and evaluation of fruit sanitation, packing with protective material and proper handling during transportation to identify optimal processes
- an additional note in the Quality Manual to acknowledge the reduction in mango quality lost by harvesting at 14% dry matter, and the contribution of VHT to protect from diseases such as stem end rot and body rot.

3 Introduction

3.1 Project background

The Cambodian mango industry has expanded rapidly since 2005. The most recent statistics from the Ministry of Agriculture, Forestry and Fisheries (MAFF, 2016) stated that the current mango area was 65,251 hectares in 2014/15 compared to 24,000 hectares in 2010. There are two major production regions: in the south and north-western provinces. Most of the trees were planted in Kampong Speu Province with a total area of 39,500 hectares (60.5% of the total mango area) and production of around 790,000 tonnes.

The Cambodian mango industry is expanding rapidly, and this is primarily been driven by regional export of Keo Romeat. Despite its popularity in regional markets there is limited

domestic trade due to Khmer consumers' strong preference for Keo Chen and other varieties. For future growth to be sustainable there is a need for greater varietal diversity. The strong regional trade networks into Thailand, Vietnam and China provide significant opportunities for the industry to capitalise on these. However, with ASEAN trade agreements (AEC) this is likely to have implications for product standards, food safety standards, and also result in greater official trade. Ultimately this will drive improvements across the sector but for Cambodia to remain competitive these changes need to be implemented now.

3.2 Study objective

To enhance common understanding and develop capacity in the assessment and improvement of physical and eating quality in mango supply chains.

3.3 Study methodology

The research design of this study included:

- participation in the drafting of the quality assessment criteria, including commercially practical subjective criteria
- collation of feedback from key supply chain stakeholders using the draft quality manual
- a target audience was interviewed in Kampong Speu Province
- field observations conducted on the farm, in Kampong Speu Province, in the CARDI laboratory and included main and off-season observations
- identifying differences in fruit maturity at different harvesting times (field observations were conducted on the farm in Kampong Speu Province)
- The mango quality survey was conducted with Ms Heng Srey Pov, from Kingdom Fruit International Company in conjunction with Mr Jay Ahn, Branch President from Foodya Company.

4 Mango supply chain: baseline survey

Background

The Cambodian mango industry has expanded rapidly with an estimated 65,250 hectares of trees planted in the last 10 years (MAFF 2016). Mango is Cambodia's major horticultural export product, with an estimated 139,000 tonnes of mainly green mangoes exported to Thailand, Vietnam and China in 2015/16 (Vinning, 2016). This informal export trade is difficult to measure as there are no official statistics gathered on cross-border mango trade. Keo Romeat mango is harvested twice per year, with the first harvest from March to May and second harvest (off-season) from October to December.

Four domestic contract farmers and two export contract farmers, who trade with Thailand and Vietnam were interviewed in Kampong Speu Province (see Figure 1). The interviews revealed the independent farm production of Keo Romeat for domestic and export was in decline and contract farming was on the increase. Contractor farming experience is variable, ranging range from one to 11 years' experience. Contract farmers' costs per annum are based on plant ages, with 3 to 4-year-old plants costing USD3 per tree, 6 to 8-year-old plants costing USD9 per tree, and 10 to 15-year-old plants costing around USD18-20 per tree. The capacity of an individual contractor ranges from 5,000 to 6,000 trees per contract, while it ranges from 800 to 23,300 trees per commune group. Green mango can be classified as grade 1, grade 2, small size, mixed size and packed fruit, and

price varies accordingly (see Table 1). The result received from Thai and Vietnam trader on price with main and off-season with differences of grade.

Grade 1 green mango main-season price ranged from USD330 per tonne to USD430 per tonne, with the average price of USD380 per tonne. There was no price difference for grade 2 during the main season, but off-season saw the maximum price increase to USD330 per tonne. Small mangoes ranged from USD80-150 per tonne regardless of harvest season and mixed-sized mangoes showed an increase in the off-season average price to USD440 per tonne. Mango packed with protection made from cotton paper increased prices to between USD500 and USD950 per tonne.

Table 1. Price green mangoes with main and off-season based on grading

Grading	Main season (USD/tonne)			Off-season (USD/tonne)		
	Min	Max	Average	Min	Max	Average
Grade 1	330	430	380	380	550	460
Grade 2	200	200	200	200	330	250
Small size	80	150	110	80	150	110
Mixed size	180	500	300	350	580	440
Packaged	500	950	660	-	-	-

Source: Author's analysis



Figure 1. Interview with collector

Source: Author's images

Notes: Map location, interview with contractor and shop front

5 Results and discussion

5.1 Field observation from main and off-season

Field observations were conducted on-farm in Kampong Speu Province and in the CARDI laboratory in order to identify the differences in fruit maturity at different harvesting times (see Table 2).

Table 2. Mango observations, average by harvest date

Harvest date (maturity)	Weight (g)	Colour*	Firmness	Shoulder (mm)	Beak (mm)	Flesh colour			Dry matter (%)
						L*	a*	b*	
13 Mar 2018	577.80	1.04	1.00	2.32	2.38	78.85	-2.23	47.50	13.60
20 Mar 2018	566.11	1.08	1.00	2.54	2.04	76.98	-0.69	49.53	14.31
2 Mar 2018	510.17	1.07	1.00	2.91	2.09	75.27	1.64	55.14	15.29

Source: Author's analysis

Notes: Colour*- Skin colour rating scale (1 to 6)
n =48

Main season fruit

The study proposed 50 fruit samples for each harvest period, but only a total of 48 mangoes were available. The average fruit weight declined from the first to third harvesting date. The skin colour did not vary significantly from the first to third harvesting as all fruits were covered with paper packing. The fruit shoulder varied following the second and third harvesting (2.51–2.91 mm), and the fruit beak size decreased from 2.38 mm to 2.09mm. The flesh colour L* a* b* became a light yellow, and dry matter increased from 13.60, 14.31 and 15.29%.

The result from fruits ripening at 7 days and 14 days are presented in Supporting document 7.1. The amount of 90 fruits for 7 days period, fruit remained 87 followed 7 days, and another remained fruit 76 followed 14 days. Both fruit weight reduced 15.15% and 26.51% followed stored at 7 days and 12 days. Skin colour L* a* b* shown fruits ripened at 14 days become yellow than 7 days, it also for flesh colour mean that the flesh colour started from light yellow to yellow-orange. At started during picking time the dry matter for fruit ripened increasing 19.24% and 19.46 %, the Brix content for Keo Romeat variety closes to 15%.

The other trial, to identify the mangoes shelf-life and fruit quality follows the storage, these activities directly to supporting the traders, who has idea and starts their business to supply the ripe mango for differences distance. Amount of 20 fruits for each treatment has been used (storage period 7 days, 14 days and 21 days), with three replications.

The fruit weight was similarly, but skin colour it was normally for 7 days, 14 days and 21 days. But skin defect was found more followed the 14 days and 21 days storage periods. Generally, the fruit firm shown 3-4 mean that the fruit firm started sprung to firm soft and it cause to fruit damages. The disease increased (stem end rots) following the storage life. The fruit flesh colours become a yellow-orange. Dry matter increases and relates to the Brix content, meaning that if dry matter increases, Brix content also increases.



Figure 2. Mango quality assessment, CARDI laboratory

Source: Author's images

Notes: Left, start of experiment; middle, ripening mangoes; right, Brix assessment



Figure 3. Mango flesh colour at different maturities

Source: Author's images

Notes: Skin and flesh colour, harvested fruit: 13 March (1a), 20 March (3a) and 27 March 2018 (5b)

Off-season fruit

The assessment of green mangoes conducted on 18 October 2018 while mangoes transported from Kampong Speu province to Phnom Penh. Ten mangoes were collected for assessment in the CARDI laboratory, the result for skin colour was 56.65 , $a^*=-17.21$ and $b^*=34.45$, the flesh colour was $L=79.16$, $a^*=-7.39$ and $b^*=31.12$. The average fruit weight was 426 ± 72 , Brix content at green stage was 5.35% and dry matter at harvesting was 12.47% (see Figure 2, Figure 3, Figure 4, Table 3 and Supporting documents 7.1 and 7.2).

Table 3. Mango skin, flesh colour and fruit weight, October 2018

Fruit (T)	Skin colour			Flesh colour			Weight (gram)	Brix at green stage (%)	Dry matter (%)
	L*	a*	b*	L*	a*	b*			
1	57.91	-19.87	34.45	76.91	-19.87	38.84	590.91	6.00	14.22
2	57.95	-15.12	39.71	79.61	-4.88	26.58	387.60	5.30	12.00
3	59.00	-16.22	29.54	81.94	-6.79	28.89	382.10	5.20	10.23
4	56.05	-18.26	34.80	79.56	-4.46	17.55	433.91	5.20	10.73
5	49.67	-10.30	28.62	78.86	-7.30	27.68	419.15	5.00	12.86
6	54.90	-16.52	30.10	77.98	-6.00	36.85	503.85	5.10	12.56
7	58.59	-18.34	36.60	80.15	-6.03	36.00	374.10	5.20	10.48
8	57.05	-20.69	38.34	77.44	-5.50	42.42	378.40	6.00	15.24
9	56.49	-19.78	38.92	80.38	-7.04	32.53	358.70	5.50	13.50
10	58.83	-17.00	33.39	78.78	-6.03	23.90	428.51	5.00	12.86
Mean	56.64	-17.21	35.45	79.16	-7.39	31.12	426±72	5.35	12.47

Source: Author's analysis

Note: Brix at green stage and dry matter at harvesting for off-season, October 2018



Figure 4. Mango flesh colour at harvest, when ripe and following disease/incident in storage

Source: Author's images

Notes: Flesh colour mature of mango at ripe stage and disease found following storage time



Figure 5. Fruit defects, off-season, 2016–2018

Source: Author's images

5.2 Interview with contractor and trader

An interview was conducted with Ms Heng Srey Pov, Purchasing Supervisor, Cambodia Company, Kingdom Fruit International Company (see Figure 6). Kingdom Fruit operations encompass whole of chain operations: harvest, packing, ripening and export. Kingdom Fruit International currently assesses mango quality by checking: skin colour, fruit firmness, skin defects, fruit smell, flesh colour, flesh defects and consumer acceptance. Ms Srey Pov said mature mangoes are important as the company exports ripe mangoes. Using the assessment manual, they assessed the skin colour, skin defects, smell, flesh colour, flesh defects, as well as the relevance to the company's assessments. It was found that the scoring system was somewhat difficult to use/follow. One sample took under 15 minutes to assess. The respondent suggested the use of the manual would assist the company to comply with export requirements, thereby increasing national pride in allowing export of Cambodian mangoes to Europe.



Figure 6. Mango quality, Kingdom Fruit International

Source: Author's images

The research team assessed green mangoes and interviewed contractors and collectors in Kampong Speu Province to Phnom Penh. The contractors reported that off-season mango faced many problems due to rainfall that affected fruit setting, fruit defects and skin colour. Mango covered with paper envelopes resulted in good skin colour, while around 50% of fruits not protected faced dark/damaged skin, and 5% fruit defects about. The contractor harvested at 9 am, all mangoes were sorted and packed with the plastic bags (approximately 20 kilogram per bag or approximately 40 kilograms per plastic crate), they then loaded mangoes into the truck or van with three to six layers of fruit (see Figure 7).



Figure 7. Mangoes sorted, packed and transported to Phnom Penh market

Source: Author's images

6 Conclusion and recommendations

6.1 Conclusion

The study found mango production during off-season is best optimised with bagging to protect the fruit from the rainfall and pests. Post-harvest handling should be improved, including as fruit sanitation, protective packaging and proper loading and unloading during transportation. It was found that improper handling (by current mechanical means) can affect the fruit reducing shelf life. Contractors reported off-season mango faced problems due to rainfall affecting fruit setting, defects and skin colour. Where paper envelopes were used, fruit resulted in good skin and brighter colour. A higher percentage of defects was found for fruits not protected (50% dark skin, approximately 5% fruit defects). Contractors harvested and sorted in the early morning and all fruit was packed in 20-kg plastic bags or 40-kg plastic crates and loaded into trucks or vans for transport to Phnom Penh. Mangoes harvested at a specific stage of maturity performed very well in terms of fruit quality (dry matter 14.31%), while mangoes harvested at an earlier stage resulted in dry matter below 13% resulting in a poor-quality taste (less sweet). Delaying harvesting time resulted in the fruit ripening quickly, becoming soft and reducing shelf life. Mangoes stored in ambient showed weight loss follow the storage periods. Water loss caused skin defects, wilting

and loss of Brix content. The appropriate storage period was only 14 days, which extended shelf life, and to which vapour heat treatment (VHT) should be applied. In conclusion, results revealed the maturity of fruit at harvest is important to determine mango quality at out-turn in distant markets.

6.2 Recommendations

Recommendations for future mango quality studies in Cambodia include:

- A cost benefit analysis of mangoes covered by envelope paper to assess the quality returns from rain protection and reduced insect damage to fruit.
- An analysis and evaluation of fruit sanitation, packing with protection material and proper handling during transportation to identify the optimal processes.
- An additional note in the Quality Manual to acknowledge the reduction in fruit quality loss to the mango by harvesting at 14% dry matter and the contribution of VHT to protect from diseases such as stem end rot and body rot.

7 References

MAFF, 2016, Cambodian Ministry of Agriculture Forestry and Fisheries Annual Report 2016.

Vinning G, 2016, *Value chain analysis of the Cambodian mango industry*, ACIAR Project AGB/2014/020 Final Report

8 Supporting documents

8.1 Fruit quality in differences of fruit ripening followed storage on fruit weight, skin and flesh colour, dry matter and Brix content, October 2018

Sample ripening fruit	Start weight (g)	End weight (g)	Skin colour *			Flesh colour**			Dry matter (%)	Brix content (%)
			L*	a*	b*	L*	a*	b*		
7 days ripening 90/87	519.5±87	440.84±72	65.63±2	7.70±5	43.15±4	64.86±3	10.43±2	61.38±4	19.24	14.88
14 days ripening 90/76	506.7±73	372.39±59	60.77±3	10.67±2	46.08±4	62.24±4	15.00±2	64.03±3	19.46	14.59

Source: Author's analysis

Notes: * and ** - Chroma meter CR400, Conical Minolta
n = 10

8.2 Fruit quality followed storage time on fruit weight, skin colour, skin defect, fruit firmness, disease, flesh colour, dry matter and Brix content for season fruit, October 2018

Storage period (days)	Weight (g)	Skin colour			Skin defect	Fruit firmness	Disease	Flesh colour			Dry matter (%)	Brix content (%)
		L*	a*	b*				L*	a*	b*		
7	510.1	62.51	10.98	43.78	1.67	3.67	1.67	63.17	13.75	59.47	15.79	17.65
14	473.1	66.65	6.37	44.10	2.50	3.00	2.80	67.81	8.19	56.76	18.33	18.16
21	450.4	64.76	9.12	43.60	2.67	3.60	2.50	65.64	8.16	54.88	18.92	19.42

Source: Author's analysis