



Australian Government
**Australian Centre for
International Agricultural Research**

Final report

Small research and development activity

project **ACIAR Mango Agribusiness Research Program**

project numbers AGB/016/006 Mango Information
AGB/016/007 Mango Markets
AGB/016/008 Mango Biosecurity
AGB/016/009 Mango Quality
AGB/016/010 Tropical Fruit Processing

date published 30 October 2019

prepared by Robin Roberts, Griffith University
Kath Kovac

*co-authors/
contributors/
collaborators* Peter Johnson, Griffith University
Alec Zuo, The University of Adelaide

approved by Howard Hall

final report number

ISBN

published by ACIAR
GPO Box 1571
Canberra ACT 2601
Australia

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1 Preface

This report provides a summary of the Mango Agribusiness Research Program and was prepared by Griffith University as commissioned by the Australian Centre for International Agricultural Research (ACIAR). The program examined the mainland Chinese mango market in relation to market information, consumer trends, market entry, biosecurity, and retail and online trade. These activities were supported by a regional study of tropical fruit processing. The findings and recommendations from this program will inform ACIAR in the design of longer-term research and development (R&D) programs for mango trade in the Asia–Pacific region. This report involved the collation and review of outputs from five small research activities with input from 23 reports and a mango quality assessment kit.

The authors of this report are Robin E Roberts and Kath Kovac, with special thanks to Peter Johnson from Griffith University and Alec Zuo from the University of Adelaide for their contributions. Researchers from 16 institutions participated in a variety of activities across this program. The authors regret not being able to name all the researchers involved but extend their sincere thanks to each one for their contributions. The sub-contracted institutions included:

- Australian Mango Industry Association, Australia
- Cambodian Agricultural Research and Development Institute, Cambodia
- Department of Agriculture and Fisheries, Queensland, Australia
- Griffith Asia Institute, Griffith University
- Guangxi University, China
- Kalang Consultancy Services
- MZ Communications, Shanghai, China
- Philippine Institute for Development Studies, Philippines
- South China Agricultural University, China
- Southern Centre of Agriculture Rural Policy and Strategy, Vietnam
- Sub-Institute of Agricultural Engineering and Post-Harvest Technology, Vietnam
- University of Adelaide, Australia
- University of Agriculture, Faisalabad, Pakistan
- University of Mataram, Indonesia
- University of Philippines, Mindanao, Philippines
- University of Queensland.

The research program team would like to thank the farmers, traders, processors, public service officers and supply chain stakeholders involved in mango trade in the Asia–Pacific region, who gave their time freely during the research activities.

The views expressed in this report are those of the research team and do not necessarily reflect the views of Griffith University, ACIAR or the governments of Australia, Cambodia, China, Indonesia, Pakistan, the Philippines or Vietnam.

Associate Professor Robin Roberts
Griffith Asia Institute, Griffith University

2 Executive summary

This report presents the outcomes of the 2017–19 ACIAR Mango Agribusiness Research Program. The program involved five projects:

AGB/2016/006	Supporting access to mango research information, communication, collaboration and capacity development
AGB/2016/007	Challenges and opportunities for meeting requirements of China mango markets
AGB/2016/008	Opportunities to improve biosecurity, market access and trade for selected mango markets
AGB/2016/009	Enhancing mango fruit quality in Asian mango chains
AGB/2016/010	Agribusiness research and development opportunities for tropical fruit processing in the Asia–Pacific region.

The projects contributed to a broader development outcome to help smallholder farmers and mango industry stakeholders in ACIAR partner countries and Australia derive greater income and livelihood benefits from the production and sale of mango and mango products. Collectively, the projects aimed to support improved research, industry and market development, decision-making through agribusiness research, targeted situation analysis, pilot research activities, information exchange, capacity development and partnership development.

This report summarises the outcomes of five projects from the program. The aim was to better understand and identify strategic issues, research gaps and implications for the mango trade in the longer term with the mainland China market. China was identified as a priority market for this program given the rapid expansion in its middle-class demographic, its proximity to major mango-producing nations, and the recent expansion of its own domestic production. The summarised project outputs are:

Mango information

- Supported and enhanced information access, communication, collaboration and capacity-building across the program
- Developed an online platform: Asia–Pacific Mango Network website (www.apmangonet.org)
- Facilitated an early career researcher small study program
- Evaluated the use of QR codes as communication tools for end consumers in China

Mango markets

- Delivered key information and analysis for understanding current market dynamics and supply and demand across different mango market segments in mainland China
- Produced reports addressing the challenges and opportunities for meeting requirements for mango export to China markets, including direct entry and cross-border trade, e-commerce, consumer willingness to pay, and purchasing preferences and buying characteristics

Mango biosecurity

- Gained an understanding of opportunities and strategies for improving biosecurity, market access and trade in selected mango markets in South-East Asia and Australia

Mango quality

- Produced the ACIAR Mango Quality Assessment Kit
- Undertook a preliminary study to develop a common approach to assessing, describing and improving fruit quality in Asian mango supply chains

Tropical fruit processing

- Documented the latest issues, constraints and opportunities influencing the viability and profitability of mango fruit processing in South-East Asia and Australia

The program outcomes provide input into the longer-term perspective to inform ACIAR-funded mango research projects. The projects undertook specific studies related to understanding collaboration and communication between researchers, as well as trade and market situations in mainland China. From a broader regional perspective, market entry and biosecurity, implications for mango quality, and tropical fruit processing in South-East Asia and Australia were investigated.

Recommendations to inform ACIAR Mango Agribusiness R&D planning

Recommendations linked to insights from the ACIAR Mango Agribusiness Program are summarised below.

R1	Develop mango trade and marketing networks
R2	Examine the feasibility of an ongoing, integrated, Mango Agribusiness Research Program to inform strategic directions for ACIAR R&D
R3	Undertake a 20-year meta-analysis of published regional mango studies
R4	Introduce an annual research mango research outputs showcase
R5	Lead an annual mango R&D forum with industry, academic and government institutions
R6	Revise material supporting market access requirements
R7	Undertake annual round-table, in-country consultations
R8	Progress irradiation negotiations as a market entry protocol
R9	Seek to mitigate quality issues associated with hot water treatment
R10	Determine whether a common mango quality language is possible
R11	Identify opportunities for value-added mango and tropical fruit products
R12	ACIAR Master Class endorsement – develop skilled researchers
R13	Further examine how regional research sharing through website and social media platforms can connect researchers and disseminate project outputs

3 Introduction

3.1 Program aims and objectives

The Mango Agribusiness Research Program supported a regional development outcome to help smallholder farmers and mango industry stakeholders in ACIAR partner countries and Australia derive greater income and livelihood benefits from the production and sale of mango and mango products.

The five objectives of the program were to:

1. improve communication, collaboration and capacity development (Mango information)
2. identify market development opportunities and implications in China (Mango markets)
3. identify strategic research and development opportunities for market entry (Mango biosecurity)
4. evaluate opportunities for improving mango quality (Mango quality)
5. prioritise opportunities in fruit processing in selected mango markets (Tropical fruit processing).

The projects were designed to respond to key areas of enquiry, including:

- What are the benefits of mango market and trade information for the Asia–Pacific region, and how can this better support industry and market development?
- What are the key objective attributes of mango quality for market segments in China? How do varieties perform across different segments and supply chains, and how can customer and consumer expectations be optimised?
- What innovative approaches to market entry for mango-treatment strategies can lead to increased market access and improve the competitiveness of targeted smallholder mango farmers and the broader mango industry?
- How can communication, collaboration and networking, along with access to information, be improved among the mango industry and research communities in ACIAR partner countries and Australia?

The report and supporting appendices provide input into the longer-term perspective to inform ACIAR mango research programs. Over the course of the program, researchers engaged with Australian and partner country stakeholders, public and private-sector institutions and industry associations. The program also aimed to improve understanding of Australian mango export trade through the involvement of state government departments (Northern Territory, Western Australia and Queensland) and the Australian Mango Industry Association.

3.2 Program background

The overall strategy of establishing a regional mango program responds to ACIAR and Australian government policy of gaining efficiency and effectiveness by investing in fewer, larger packages of work, and working in partnership with the private sector. Part of this strategy is to develop a stronger, market-led agribusiness focus for technical mango research in the Asia–Pacific region. Such a focus requires understanding high-level situations and trends in regional markets and trade, developing market segments, shaping consumer preferences for tropical fruit and mangoes, addressing factors that affect fruit quality from the farm through to the consumer, guiding variety selection, and informing policy conversations that influence market access.

4 Mango agribusiness research program

4.1 Mango markets

Background context

Compared with other mango import markets, the China mango market is unique in a number of ways:

- Considerable differences exist between the quality and types of mangoes produced domestically and those that are imported. By comparison, the majority of other national markets only offer (i.e. are based on) two to three varieties.
- Retail prices in China range from just over USD2.50/kg for mangoes marketed in tier-one cities (e.g. Shanghai and Guangzhou) to a peak of USD4.50/kg for some mango varieties sold in regional cities (e.g. Haikou in the south and Shenyang in the north).
- China has a broad diversity of retail formats, including approximately 33,500 supermarkets and hypermarkets and more than 112,000 speciality food stores. These range from large multi-branded, multi-channel operators to single, multinational operators such as Carrefour (now owned by Sunning) and Walmart.
- Market entry via air, sea and road is complex and challenging to navigate (see Figure 1). The process and registration prerequisites for approved fruit entry can take up to ten years to achieve. Furthermore, it can take considerable time to develop a working relationship with Chinese mango supply chain stakeholders.
- After a period of strong support and approved government import permits, the introduction of mangoes into China from 10 countries has seen an increase in demand.
- In 2012, global mango consumption was more than 6.4 kg per person; in China, the average was 0.92 kg, representing 14.3% of the world average.

This project focused on three objectives:

- to characterise the current situation and trends in mango markets and segments in the mainland China mango market
- to develop an in-depth understanding of supply and demand across market segments in mainland China, including issues, constraints and opportunities
- to evaluate the current and potential competitive advantage of targeted ACIAR partner countries and Australia in China, and identify strategic research, policy and development interventions.

Studies assessed the current market segments in the key importing city of Shanghai, China, analysed the emerging e-commerce sector for online mango sales, assessed consumers' willingness to pay (WTP) for certain mango characteristics, and examined cross-border trade to China from Vietnam.

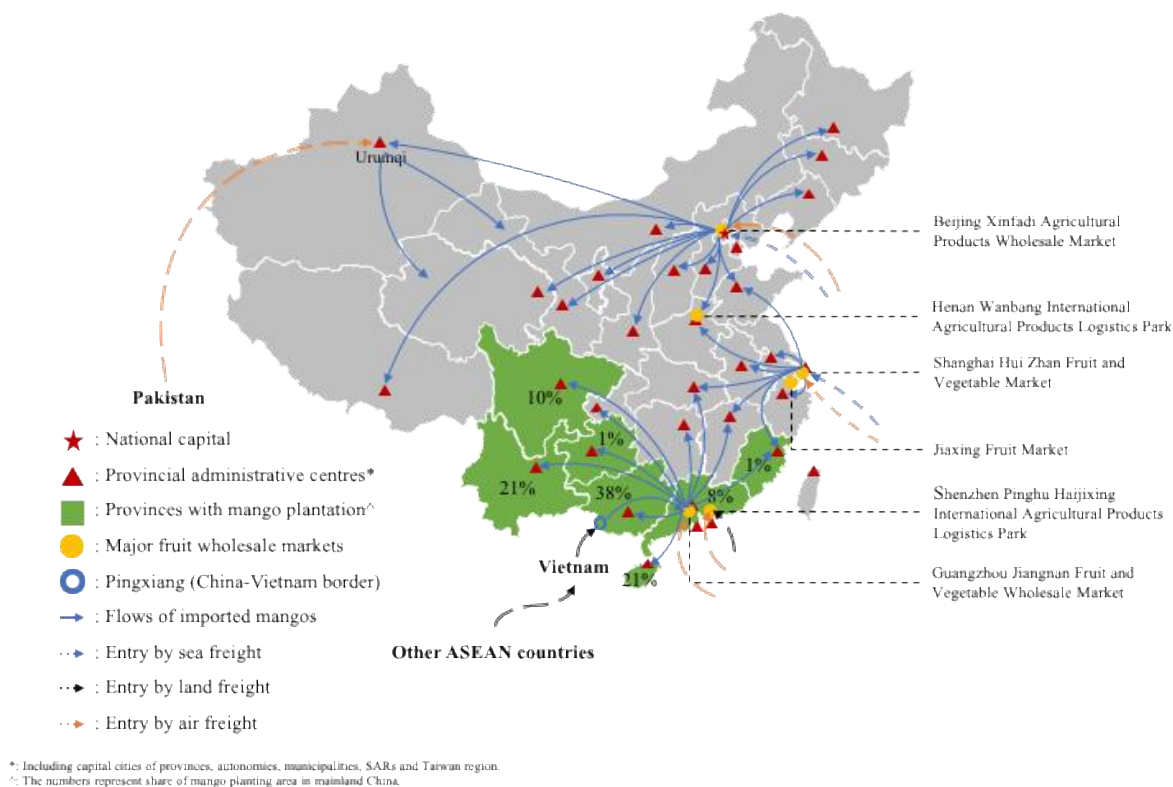


Figure 1. China mango production, markets and import hubs

Source: author's analysis

4.1.1 China market segments and the emerging e-commerce sector

This analysis involved two studies that aimed to develop an in-depth understanding of mango supply and demand, and of key issues, challenges and opportunities across market segments in mainland China.

Study 1: Market segments

This study interviewed supply chain stakeholders engaged in import trade of mangoes in the city of Shanghai (for full report, see Appendix 8.6). Central interview themes included: procurement and distribution, buyer requirements and preferences, import regulations and pricing, logistics, marketing, consumption trends, quality issues and product losses.

Results

The in-depth interviews found that half of all stakeholders (n=26) thought the imported mango market in Shanghai has significant potential for expansion. This is due to a number of factors, including:

- a high level of consumer trust in quality, appearance and taste
- rising consumer buying power
- better post-harvest practices and transport
- an increase in the number of high-end stores
- the potential elimination of tariffs.

The remainder of the interviewees had more pessimistic views of the market, viewing it as small, hard to predict or even declining in prospects for future growth.

The major mango varieties imported to China are R2E2 (Australia); Kent (Peru), which competes with R2E2; Nam doc mai (Thailand); and green mangoes (Vietnam). Research revealed a particularly high demand for the Australian R2E2 variety, which is considered the premium-quality mango for the Chinese gift market during the Spring Festival new year celebration (January to February).

Stakeholders identified a number of issues relating to mango supply chains (see Table 1), with the most significant being poor disease control. These issues have varying effects on the cost and quality of the final product. Fruit quality was also an important consideration for stakeholders: Chinese consumers prefer sweet, unblemished mangoes with smaller seeds, which are ready to eat at purchase.

Table 1. Stakeholder-identified supply chain issues

Issue	Effect
Poor disease control	Reduced mango shelf life
Poor temperature control	Increased losses
Long transportation time	
Vapour heat treatment and hot water treatment protocols	Poor display quality (blemishes and other defects, under or overripe)
Poor ripening practices (pre or post-arrival)	Increased product costs
High freight costs (particularly air freight)	Increased losses
High costs of phytosanitary treatments	
Short supply and unpredictable supply windows due to seasonality	
Packaging preferences (5 kg or 10 kg)	
Competition from domestic market	Expected to increase as quality and availability improve, resulting in price competition

Source: author's analysis

Study 2: E-commerce as a rapidly expanding market segment

This study reviewed previous studies and analysed one year's worth of daily data from more than 1,000 mango sellers on two of the largest Chinese online shopping platforms, JD.com and TMall.com (for full report, see Appendix 8.7).

Results

The analysis revealed that online sales of fruit and vegetables are expanding rapidly. Most fruit sold online originates from China; Australia (highest average price, but a short season); Myanmar; Thailand (second-highest average price, available all year round); Taiwan; and Vietnam. Imports are all priced higher than Chinese fruit, except for Vietnamese imports. Because quality cannot be assessed by an online purchaser, sellers need to convey this information well by using descriptions and images. The study found that other factors affecting price included availability of place of origin; variety; seasonality; customer satisfaction rating; and same-city, 24-hour delivery service.

4.1.2 Chinese mango consumption behaviours

Consumer behaviours were observed using a consumer preference study in the tier-one cities of Shanghai, Beijing and Guangzhou, as well as two other major cities (Xi'an, in the northwest, and Shenyang, in the northeast). The research design involved a literature review, an in-store experimental auction in Shanghai (n=133), and an online survey covering these five cities (n=1,055) (for full report, see Appendix 8.8).

Results

The survey revealed that more than 75% of all respondents bought mangoes at least once per week when in season, with purchases typically ranging between 1 kg and 3 kg. Most respondents preferred to buy from specialty fruit stores or supermarkets because they are conveniently located in shopping centres and residential areas. E-commerce and modern retail outlets were also popular channels for purchasing, whereas wet markets, nearby farms and social media contacts were the least preferred. Convenience was the overriding factor for most consumers, overruling credibility or trust in the seller. Furthermore, most mangoes were purchased for consumption as fresh fruit.

Respondents identified many factors that are more important than price when considering their WTP for mangoes. Fragrance and skin colour were identified as having a particularly significant influence on consumer WTP. The other top factors were: taste, fresh appearance, food-safety accredited and ripeness. More than 85% of respondents purchased domestic mangoes; however, more than half also bought imported mangoes (mostly from Australia and Thailand), which were perceived as safer to eat – especially for higher-income consumers.

The in-store choice experiment showed that most consumers prefer a medium-sized (100–300 g) mango with strong aroma, yellow skin, small seed, and evidence of origin claims (e.g. a sticker or labelling). The in-store auction experiment also suggested that, controlling mango varieties and consumer heterogeneity, Chinese consumers value fruit flavour and sweetness. Importantly, they are willing to pay more for these two attributes; specifically, a one-point improvement (on a scale of 0 to 10) in fruit flavour by respondents increased their WTP by 5.6%, while a one-point improvement in sweetness increased WTP by 4.3%. Flesh smoothness and sourness did not seem to influence consumers' WTP. Furthermore, consumers appeared to accept price premiums on imported mangoes (46% more for Thailand and 144% more for the Philippines) over domestic Sichuan mangoes.

The study concluded that the key to increasing markets sales in China will be providing effective communication about improved quality and food safety to consumers, in order to promote fresh mango consumption.

4.1.3 China–Vietnam cross-border mango trade

This study involved a review of published studies, and interviews with border agents, importers, wholesalers and retailers at the China–Vietnam border (for full report, see Appendix 8.5). The study also observed border-trade practices, and wholesale and retail markets engaged in the trade of mangoes. Two checklists were developed for the interviews – one for border agents/importers and the other for wholesalers/retailers. The checklists identified key issues to ensure appropriate information was captured during the interview sessions. These issues were:

- border entry systems and regulations
- mango varieties
- place of origin
- seasonality
- pricing and volumes
- spatial flows and distribution
- recent trading trends and future prospects.

Interviews with market traders and visits to retail markets in Nanning and Guangzhou were included. These were important for an improved understanding of the competitiveness of mangoes imported from Vietnam.

Results

The study encountered difficulties engaging with mango traders. Many importers at the border and wholesalers and retailers in China refused to participate, so in-depth discussion was rarely achieved. Interviews did suggest that cross-border trade to China has grown significantly in the past five years (reportedly to >160,000 tonnes/year) and is currently much larger than official numbers indicate – but this is difficult to calculate. Much smaller amounts enter China through phytosanitary routes from other countries.

Cross-border trade is generally excluded from official Chinese customs statistics and is classified as small-scale trade. Observations of border-trade practices found that trade involves transferring mangoes from large Vietnamese trucks into smaller Chinese vans to pass through customs, and then reloading the fruit onto large Chinese trucks for widespread distribution. The businesses involved in the trading, including transportation and distribution to the Chinese wholesale market, are often family owned.

The export of large volumes to China increases the price gained by Vietnamese growers. The opposite effect occurs in China: Vietnamese imports mean lower prices for Chinese growers, but better prices for consumers and processors. To compensate for short supply, China imports mangoes of Cambodian origin.

Interviewees highlighted that the price of Vietnamese mangoes is very competitive due to the low cost of production, lack of phytosanitary requirements, and transport into China by truck. Changes to China's current border-trade phytosanitary regulations could have significant negative impacts on the Vietnamese export trade. The quality of Vietnamese mangoes is generally very high and often determines destination (i.e. highest quality goes to tier-one cities). However, the study found that the Vietnamese origin of mangoes is often hidden from consumers and is rarely listed in stores. This is explained by the consumer survey discussed in Section 4.1.2, which found that Chinese consumers perceive mangoes from Vietnam as having a low food-safety level, and therefore are less likely to trust their quality.

4.2 Mango biosecurity

Background context

- Many countries are seeking to expand their mango trade opportunities into the lucrative Chinese market. However, China's certified phytosanitary status means access must be negotiated and protocols must be conformed to.
- Some exporting countries are not able to meet the formal technical requirements to gain market entry into China. Historically, exporters and importers use informal trade channels to gain market access.
- China is committed to formalising the import of fresh mangoes. However, some exporters are reluctant to adopt the formal import pathway because informal channels – such as through Hong Kong – are still in operation and cost less.
- The value of China's mango imports has increased overall since it became a member of the World Trade Organization (WTO) in 2001 (see Figure 2). However, it is unknown what the impact of increased domestic mango production will have on the imported mango trade.
- It is important to note that informal mango trade between Hong Kong and mainland China is not reliably captured in official statistics.

This project focused on four objectives:

- to examine and document the current import protocols and informal trade channels for mainland China
- to understand technical issues and barriers for each partner country
- to document issues and opportunities
- to develop a detailed five-year plan including short, medium and long-term timelines for technical priorities and strategic development.

The research design included an initial review of current investigations, followed by an evaluation of existing protocols between partner countries and the target market of mainland China. Meetings and workshops were undertaken with partner country stakeholders to gain an understanding of the commercial reality of opportunities, issues and impediments related to current mango export trade.

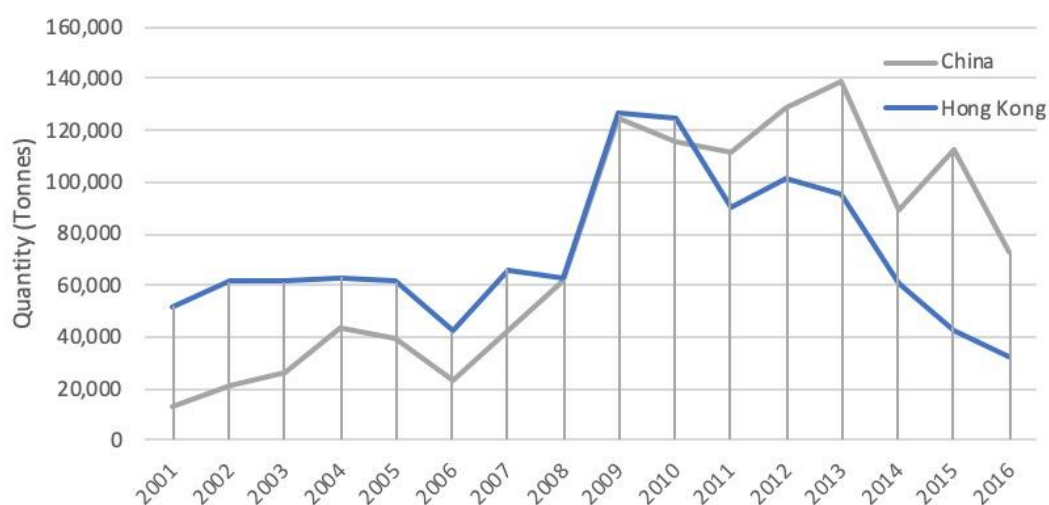


Figure 2. Mango imports, 2001–2016

Source: ITC, 2017

4.2.1 Understanding market entry and biosecurity issues for mango trade with mainland China

The first phase of the study looked to the current import protocols and informal trade channels for mango trade with mainland China to identify the broad issues and opportunities. Next, published studies were reviewed and field research/interviews with supply chain representatives (importers, wholesalers, traditional and modern retailers, supermarkets, and specialised fruit shops) were undertaken in Shanghai. Finally, meetings with market representatives and the China Inspection and Quarantine Services captured public and private-sector insights. Australia, the Philippines and Vietnam were individually studied as key exporting and partner countries (for full report, see Appendix 8.9).

Results

Imports into mainland China are characterised by numerous aggregators, vendors and distributors (see Figure 3). The study found that this extended supply chain reduces profits for the exporter and reduces value for the consumer.

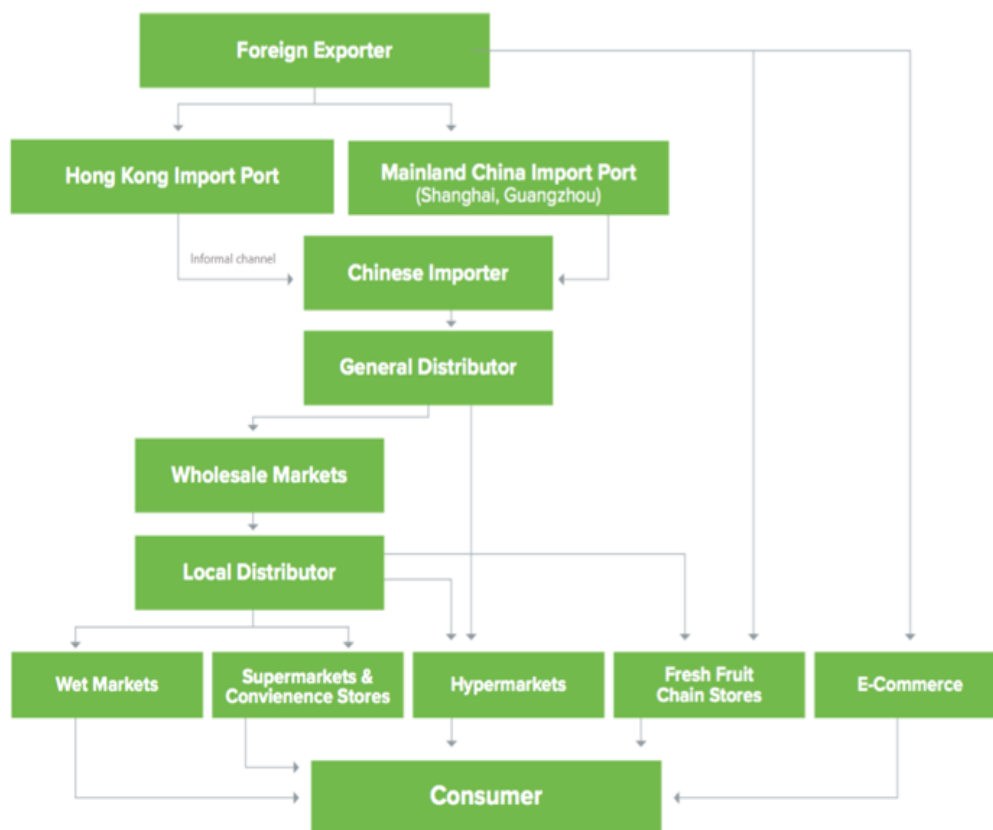


Figure 3. Fresh mango imports framework, China

Source: PMA, 2016

Historically, China has been a difficult and costly market to enter due to its biosecurity/phytosanitary protocols. As a result, many importers and exporters have come to rely on the informal trade via Hong Kong, which avoids the phytosanitary requirements for export to the mainland.

One of the biggest obstacles exporters face to access the formal Chinese import market is pest and disease control, especially for fruit fly. China’s accepted phytosanitary measure for fruit fly is heat treatment – either hot water treatment (HWT) or vapour heat treatment (VHT). VHT is preferred because it causes less damage to the fruit’s skin. A SWOT analysis revealed the strengths, weaknesses, opportunities and threats of the different phytosanitary measures used to gain entry into markets (see Table 2). China does not

currently accept irradiation as a treatment, despite it having been proven effective internationally. Interviewees expressed concern regarding phytosanitary treatments speeding up mango ripening, which affects quality at the retail level.

As the pest and disease status of both importing and exporting countries changes with time, import/export protocols will likely change to address these new conditions. The study found that current practices in exporting countries may not be sufficient to meet new or modified requirements, and, as such, producers may require greater extension support from their governments.

Table 2. SWOT analysis: market entry systems

Strengths	Weaknesses
<p>VHT: less detrimental to quality on sensitive varieties; widely accepted internationally</p> <p>HWT: transfer of heat is more efficient than VHT, making it a quicker alternative; relatively inexpensive to install; able to treat large volumes rapidly</p> <p>Irradiation: quick treatment; very cost effective; able to maintain cold chain integrity</p> <p>Fumigation: quick and cost effective; minimal infrastructure required</p> <p>Systems approach: can be applied at the farm level; large-scale infrastructure investment is not necessary</p>	<p>VHT: very expensive; can be damaging to fruit and shorten shelf life</p> <p>HWT: only suitable for some varieties; can damage fruit and shorten shelf life</p> <p>Irradiation: can cause fruit quality problems, including ripening and tissue collapse; not currently accepted by China</p> <p>Fumigation: Montreal Protocol aims to phase out methyl bromide; new fumigations not effective enough for probit 9 (i.e. zero infestations within consignments); not accepted by China for mango</p> <p>Systems approach: Not widely accepted for fruit fly at present</p>
Opportunities	Threats
<p>VHT: cost of VHT plants is reducing and technical skills in exporting countries is improving, which reduces damage associated with heat treatments</p> <p>HWT: new varieties are more heat tolerant and fruit damage is less likely</p> <p>Irradiation: more countries accepting as a phytosanitary treatment; technology is improving regarding quality management; possibility of China accepting irradiation as a treatment in the future</p> <p>Fumigation: Low-dose methyl bromide treatment shows promise treating fruit fly without fruit damage; relatively new and requires research to ensure efficacy and potential adoption by trading partners</p> <p>Systems approach: becoming more accepted as efficacy data is accumulated and processes proven to be effective against pests of quarantine concern</p>	<p>VHT: high cost of the treatments makes it difficult for treated fruit to compete with informal trade; limited treatment facilities in some partner countries</p> <p>HWT: quality issues associated with treatments</p> <p>Irradiation: public perceptions of irradiation still tend to be negative; different varietal responses and quality impacts associated with the treatment; inconsistent dose patterns across consignments (due to packing configurations) has led to patches of exceptionally high dose rate, resulting in blemished fruit</p> <p>Fumigation: methyl bromide phasing out under the Montreal Protocol; only used as an emergency measure for suspect consignments</p> <p>Systems approach: not accepted at an international level</p>

Source: author's analysis

Another major obstacle to market access is China's extensive quarantine procedures. To help navigate the complex rules and regulations, exporters need to consider developing enduring relationships with importers/retailers. The domestic cool chain supply of mangoes was not investigated in this study.

Progressively, Chinese authorities are emphasising formal channels in an effort to move away from informal trade and have begun enforcing penalties for traders caught evading duties and quarantine requirements. Formal trade is more efficient and can make use of

the rise in cool chain infrastructure/transport development, and the adoption of e-commerce makes payment more reliable through formal pathways. Furthermore, China has lowered or waived tariffs/duties since becoming a member of the WTO, which has contributed to a reduction in informal trade.

However, many exporters are still not keen on formal trade, likely because it reduces profits. In addition, importers have difficulties sourcing enough mangoes through formal channels to meet demand for high-quality fruit, and face competition from the cheaper informal trade. A final concern highlighted by stakeholders was that, historically, geopolitical issues have impacted on trade in the Asia–Pacific, and these are likely to continue.

At the time of writing this report, the only countries with formal mango market access to China are Australia, Pakistan, Peru, the Philippines and Thailand. Exporters who have signed a free-trade agreement with China are at an advantage, as their tariffs on imports are low or zero. China’s new free-trade zones are also speeding up import customs; interviewees reported that current turnaround times for these zones are between six and 48 hours. Free-trade zones are located in the cities and provinces of Tianjin, Shanghai, Fujian, Guangdong, Liaoning, Shaanxi, Henan, Hubei, Chongqing, Sichuan, Zhejiang and Hainan (Asia Briefing, 2019). The most recent approved free-trade zones, as at 2019, are Heilongjiang, Hebei, Shandong, Jiangsu, Yunnan and Guangxi.

The tax on mangoes imported into mainland China exists for many of China’s trading partners, whereas Hong Kong does not impose tariffs on trading partners. The tariffs the mainland imposes have been mapped by the International Trade Centre (see Figure 4).



Figure 4. Tariffs applied to mangoes imported to China

Source: ITC Trade Map, 2017

4.2.2 Case studies: Australia, the Philippines and Vietnam

The country studies reviewed past research and undertook interviews with central supply chain stakeholders and quarantine experts. These studies analysed each country's scientific and commercial capacity to meet requirements for direct market access into China (for full reports, see Appendices 8.10, 8.11 and 8.12). The key findings are summarised in Table 3.

Table 3. Market entry systems, Australia, the Philippines and Vietnam

	Australia	The Philippines	Vietnam
Main pests and diseases	Fruit fly	Fruit fly, pulp weevil, seed weevil	Anthracnose, bacterial spot, fruit fly, leafhopper, thrips
Main treatments (for exports to China)	Either vapour heat treatment (VHT), high temperature forced air (HTFA) or hot water immersion (HWI)	VHT, extended hot water treatment (HWT) Fruit often bagged on tree for fruit fly	VHT (main target pest is fruit fly) Fruit often bagged on tree for fruit fly
Technical and other issues	Not enough VHT facilities (only three) China accepts HWT but some varieties are too sensitive (e.g. Australian varieties)	Eight VHT facilities Excessive maximum residue limits Use of unregistered chemicals Low production, hard to meet volumes and quality requirements High cost of inputs (e.g. VHT and refrigerated transport/freight)	Traceability issues Chemical residues
Industry feedback	More grower education needed about biosecurity in different markets Costly to service different markets	Improved collaboration with government needed Moving away from contract farming would improve quality and prices for farmers	Move to formal trade will mean new production, processing and treatment requirements
Recommendations	VHT alternatives needed (e.g. HWI, irradiation, HTFA) Focus on superior quality to achieve premium pricing Collaboration between in-country mango exporters to reduce opportunistic trade Improve importer relationships to facilitate consistent supply	Help growers to produce more export-quality fruit Improve liaison between quarantine officers and the importing country Develop more cost-effective VHT facilities	Implement standardised agricultural practices Use of VietGap and/or GlobalGap certified orchards Train farmers on chemical usage and export requirements for chemicals and accepted MRLs, and provide regulation updates

Source: author's analysis

4.3 Mango quality

Background context

Mainland China is the main export destination for mango trade in the Asia–Pacific region. Understanding quality drivers and the supporting characteristics is fundamental.

- Mango quality assessment methods and procedures vary considerably depending on production location, variety, supply chain development and intended use, and this impacts greatly on the development of import/export product specifications.
- Mango fruit in regional markets is highly variable and quality requirements are unclear. As a result, importers, retailer and consumers are frequently disappointed.
- The opportunity exists to improve fruit quality through a shared approach to measuring quality, which could help to evaluate and improve mango trade.
- Current market fundamentals for mango trade in China are promising.
- Regional markets, including mainland China, are becoming more diversified and sophisticated.
- A common challenge for all exporting countries is to satisfy the demand-intensive domestic and international markets, and to develop cost-efficient strategies for premium quality and timely shelf life.

This project focused on three objectives:

- to develop a common, objective language for describing physical and eating quality in fresh mango supply chains across project partner countries (i.e. to develop a draft mango quality manual)
- to enhance common understanding and develop capacity in the assessment and improvement of physical and eating quality in mango supply chains (i.e. to road-test the draft manual in partner countries)
- to evaluate opportunities to improve quality in select mango supply chains and key market segments in mainland China.

The project involved four key activities: developing a Mango Quality Assessment Kit; a series of country studies to road-test the kit; supply chain simulation studies for the supply of mangoes from Australia and the Philippines to mainland China; and an in-market assessment study of imported and local mangoes in China to understand the drivers to improve mango quality. This project reported research and country study outcomes from Australia, Cambodia, Indonesia, Pakistan, the Philippines and Vietnam.

4.3.1 Developing the Mango Quality Assessment Kit

The draft kit was developed based on feedback from the partner countries of Cambodia, Indonesia, Pakistan, the Philippines, Vietnam and Australia (the lead research country). The subjective and objective characteristics involved in quality assessment were agreed upon (see Table 4) and were included in the final Mango Quality Assessment Kit (for full report and final kit, see Appendices 8.13 and 8.23, respectively).

Research in partner countries revealed the most common capabilities and skills needed, and the best support materials to help farmers improve mango quality and hence their economic benefits and livelihood.

Table 4. Mango quality assessment product characteristics

	Subjective assessment criteria	Objective assessment criteria
Whole fruit	Visual quality Skin defects Primary defects Skin colour Blush Firmness Aroma	Smell Skin colour Firmness
Cut fruit	Flesh defects Flesh colour Flesh smell Taste Texture Overall rating	Dry matter Total soluble solids/Brix Titratable acidity Flesh colour

Source: author's analysis

4.3.2 Road-testing the Mango Quality Assessment Kit

The Mango Quality Assessment Kit was tested in the partner countries and Australia (for full reports, see Appendices 8.16 to 8.21).

Results

The thoroughness of the road-testing varied significantly among the partner countries. In some cases, only one or two respondents used the kit, or numbers were not supplied, while others involved many respondents. Likewise, some studies used very few replicates when assessing mangoes, while others used significant numbers of fruit. Further variation was introduced by some countries testing green mangoes instead of ripe fruit.

Overall, the kit was viewed as useful by supply chain stakeholders. Companies found it helped to guide their workers in sorting fruit, and thus to reduce guidance needed from owners or managers, to achieve quality control and a better price. Other claims were that it offered the same quality standard for all market participants, which enabled fairer prices and reduced disputes. However, these claims cannot be supported, as the kit does not determine standards.

Respondents generally found the kit most useful at the farm or packhouse level, and least useful at the retail level. Retailers do not always assess quality; when they do, their most important parameters are usually flavour and appearance. Respondents found some aspects to be useful along the supply chain, e.g. skin defects and Brix are useful parameters for wholesalers. Some traders did not think an assessment kit was necessary, because they hold similar knowledge in their minds and can easily classify fruit based on experience.

In general, across the partner countries, stakeholders took 15 to 30 minutes to assess one mango using the kit. Some varieties are more amenable to assessment than others – e.g. in the Philippines, the kit cannot be used for assessing blush, aroma and firmness of Carabao mangoes, which are the main variety, because these mangoes have no blush, have limited aroma and have very thin skin that is easily damaged.

Summaries from the in-country studies provided feedback to improve the kit, including:

- simplifying the assessment criteria and reducing sample sizes to reduce assessment times (the main indicator should be ripeness, which is determined by colour; then defect presence, and finally size)

- adding more images, standards and maturity indices
- re-grouping the 'skin defect' section into two categories for progressive (e.g. sap-burn) and non-progressive (e.g. scarring) defects
- making the kit more practical by including chemical analyses and rating external qualities
- adding assessment of pesticide residue levels
- adding pulp temperature recording using a probe after HWT.

4.3.3 Supply chain and simulation studies: mango exports to China

For this project, two studies looked at real-time supply chains and laboratory-based simulations for mango exports from Australia and the Philippines to mainland China (for full reports, see Appendices 8.14 and 8.15).

Results

Several conditions were found to affect quality and shelf life along the supply chain – in particular, temperature and, to a lesser extent, pallet position (which affects air circulation and box ventilation) in shipping containers. Box design for shipping is also a consideration, as better design would improve ventilation.

Ensuring containers are fully loaded also appeared important, but this can be difficult. For example, in the Philippines, post-harvest damage of the easily bruised and sap-burn prone Carabao variety leads to up to 50% rejection of the fruit by importers, and therefore to low volumes for exports.

After transport, different cultivars appeared to vary in shelf life and quality. The shelf life of fruit was much longer in the simulated trials, in which it is easier to control variables such as temperature and post-harvest treatments.

It is important to note that these studies stressed that supply chain monitoring and simulation need more extensive testing to validate their conclusions. Drawing useful comparisons between the supply chain study and the simulated trial (see Table 5) is challenging. The studies used unrelated fruit material; lacked replicated treatments, conditions and controls; and did not record calibration or record fruit information, such as maturity.

Several other considerations must be taken into account with regard to these studies:

- Minimal information was included on conditions before, during and after VHT treatments, which vary greatly between machinery and protocols used for market access.
- The variability in the conditions in the Australian study, if valid, demonstrates the complexities of monitoring commercial mango shipments and the potential benefits of coordinating investigations.
- The primary aim of the activity – independent assessment of the quality tool – appears not to have been critically assessed.
- Testing of an assessment tool requires careful experimental design that considers the variables discussed above (e.g. source of fruit, calibration of instruments and loggers, standardisation of treatments and use of appropriate controls). Independent assessors whose skills are validated prior to commencement and verified during the activity would also be beneficial.

Table 5. Australian and the Philippines supply and simulation studies

Parameter	Australia		The Philippines	
	Supply chain study	Simulation study	Supply chain study	Simulation study
Cultivars	R2E2	R2E2, 1243 & Van Dyke	Carabao	Florida, Apple and Zambales
Source of fruit	Field graded sample (Giru, Qld)	Nth Qld	2 consignments Davao region	Bankerohan wholesale market
Harvest dates	3 Dec	20 Dec for 1243 and Van Dyke, 8 Jan for R2E2	Unknown 24–27 July 2018	Unknown, but 2 days prior to purchase
Mango wash or sanitiser	Yes	Unknown	100–150 ppm chlorinated water 3–5 min	150 ppm chlorinated water 3 min
VHT disinfestation	Yes (commercial settings)	No	Yes (10 min 46°C)	No
Fungicide treatment or other heat treatment	Unknown	Scholar 52°C 5 min	No	± 52–55°C water
Forced cooling	Unknown	No	Cold shower 40 min plus fan	Cold shower 40 min plus fan
Start of temperature monitoring	2 days after harvest	1 day after harvest	1 day after delivery to packhouse	Unknown
Maturity measurement	No (commercial)	Yes (NIR Felix quality meter)	No (106 days after flower initiation)	No (107 days after flower initiation)
Target temperature	13°C	14°C/22°C	10°C	10°C/20°C
Fruit trays pelletised	Yes (15 layers fruit)	No	Yes (5 layers fruit plus 1 empty)	No
Modified atmosphere	Yes, including CO ₂	No, no CO ₂	No	No
Temperature and humidity loggers	Yes, in transit	No	Yes, in transit	No
Chemical ripened	No	Yes	No	No
Assessment days	At importer 27 days and later with in-country collaborator	1, 3, 7, 8, 9, 11, 13 days, plus 15, 17, 21 and 23 for stored	3, 6 days	0, 3, 6, 9, 12 days, plus 0, 4, 8, 12, 16, 20, 23 for stored
Assessment method	UQ/Asia–Pacific quick assessment manual whole fruit (residual shelf life)	UQ/Asia–Pacific quick assessment manual whole fruit (extended shelf life)	UQ/Asia–Pacific manual plus Nix Pro	UQ/Asia–Pacific manual plus Nix Pro
Residual shelf life determined using quality tool	Reliability questioned	Confounded	Table-ripe stage (stage 5)	Table-ripe stage (stage 5)
Freight transfer	Sea (modified atmosphere container)	Air and simulated sea	Sea	Simulated sea
Case study locations	Townsville–Shenzhen	Cairns–Brisbane	Davao–Shanghai	Davao–MPBL

Source: author's analysis

4.3.4 Opportunities to improve mango quality in the China market

This project used an observational approach to assess the quality of imported mangoes from Australia, the Philippines and other sources, as well as of domestic mangoes, and investigated ways to improve the supply chain (for full report, see Appendix 8.22). It should be noted that the project design and small sample size make it difficult to draw broad conclusions. Further quantitative measurements should be undertaken.

Results

Interviews with wholesalers and retailers revealed that Australian and Philippine imported mangoes are highly regarded for their quality and taste; as such, they are well placed for the high-end Chinese market. However, only limited varieties were tested, and so more market assessment in a larger study is needed.

The project identified three main price points for mangos, ranging from CNY14/kg to CNY140/kg. Price depended on whether the fruit was domestic/local (lower price, but widely available) or imported and with a high level of blush and quality packaging (higher price, but less available).

Wholesalers tended to assess quality based on size, colour, shape and lack of blemishes. Short stalks were preferred to reduce sap-burn, and the amount of fibre in fruit was identified as a potential concern to consumers. In-market observations have been summarised in Table 6 according to three areas of enquiry: desired quality attributes, retail expectations and sustaining chain relationships.

Table 6. China market study: observations

Area of enquiry	Observations
<i>What are the key quality attributes being sought by supply chain participants in the export market of mainland China from the farm to the consumer, and to what degree are they achievable?</i>	It was not clear exactly what the Chinese consumer preferences were due to the large range of price segments, including a gift segment. Preferences vary widely, including in terms of fruit size and sweetness (Brix), acid levels, degree of skin blush, textural preferences, including limits and variability with variety and other taste and flavour attributes. Chinese customers anecdotally prefer fruit that is very sweet, low acid, and low fibrous texture. They appear to prefer R2E2 over Kensington Pride.
<i>In the supply chain case study, what is the 'cost' of not meeting retail expectations and how can 'benefit' be realised to increase market size in terms of value?</i>	Retail expectations are largely repeat purchases of the same varieties and so varietal preference is somewhat ruled out. A variable not clearly linked to variety was stage of ripeness. Retail buyers can be dissatisfied if the fruit have only two to four days' shelf life before the product must be sold. The cost of not meeting firmness and skin colour criteria is price discounting of the consignment. Too much fruit-to-fruit variation in expected quality can also result in a discount.
<i>What are the differences in quality preferences and how do they impact on supply chain relationships in sustainable supply and financial terms?</i>	Buyers commented that product supplied directly from exporter to importer in China is expected to be fresher and have higher quality and longer shelf life compared with mangoes supplied through Hong Kong.

Source: author's analysis

Imported fruit sold as well-packaged gifts was identified as an important market segment, partly due to high-end quality and partly because a high price is linked to social status. However, as Chinese producers improve their product and bring new varieties to market, exporting countries may find attaining the high-end market position in China challenging.

The project did not identify a clear position regarding consumer preferences and quality–price relationships, or variations between cultivars for retailers and consumers.

4.4 Tropical fruit processing

Background context

Mangoes are particularly good candidates for processing, since the characteristic flavour withstands the steps associated with preservation and therefore the product retains its consumer appeal. For mango processing to be sustainable, three elements are essential: adequate supply of quality raw material, technology to deliver products with consumer appeal, and market demand.

- In some countries, mango varieties mature sequentially over several months, thereby extending availability for processing. In regions where mango variety selection is more conservative, processors often rely on alternative fruits for continuous operation.
- Many processed mango products are well known to consumers across the Asia–Pacific region. Technologies that support the processing of fruit for frozen cubes and cheeks, jams, juices, purees and confections are now commonplace.
- The emergence of technologies such as high-pressure pasteurisation and low-pressure processing are delivering new products throughout the Asia–Pacific region.
- These products appeal to consumers by focusing on health, novelty and timesaving attributes.
- Fruit processing is directly linked to total production, because return for effort provides chain partners with income-generating opportunities through loss reduction and access to lucrative remote markets.

This project focused on three objectives:

- to identify the current market situation and trends affecting the fruit processing sector across selected case study countries in South-East Asia with a specific emphasis on issues, innovations, constraints and opportunities relevant to the mango sector
- to identify the current market situation and trends affecting the fruit processing sector across selected case study countries in Australia, with a specific emphasis on issues, innovations, constraints and opportunities relevant to the mango sector
- to identify research and innovation opportunities in either basic or applied research for development that would deliver significant benefits to the mango processing sector and mango fruit growers.

The aim of this project was to identify the latest issues, constraints and opportunities regarding the viability and profitability of mango processing in Australia and select South-East Asian countries (for full report, see Appendix 8.24).

4.4.1 Understanding the processing sector

Two stakeholder workshops were held to gather perspectives and ideas from public and private-sector stakeholders with experience related to processing operations and trade.

Results

A number of issues were raised across the two workshops. Common themes are identified in Table 7; however, it is important to note that the number of mentions does not necessarily reflect the gravity of each topic. All presentations given at the workshops have been recorded on the Asia-Pacific Mango Network website (www.apmangonet.org).

Table 7. Common tropical fruit processing issues raised in workshops

Issue raised	Number of mentions	
	Australia	South-East Asian countries
Collaboration with similar organisations for synergy in processing development	17	4
Assistance meeting standards for local and international trade	16	5
Market intelligence	29	16
Assistance with R&D	38	21
Raw material sourcing	9	10
Assistance with appropriate government policies development	7	14
Awareness of the value chain	10	12
Raw material varieties and availability	6	12
Extension support	1	8
Packaging design, functionality and labelling	7	1
Access to finance	10	–

Source: author's analysis

The unique qualities of mango present opportunities for a range of processed products. The focus for commercial operators is to increase the rate at which products are processed. Regardless of the size of the business, an investment in capital-intensive items is required, including accredited premises, equipment and packaging to deliver beneficial outcomes. The mainstream types of products processed from mangoes are snack foods (dried and gum straps), pulps, purees, juices, frozen (cheeks and pieces), and preserves (savoury and sweet) (see Table 8).

Table 8. Common processed mango products

Product	Process	Main producing countries
Snack foods	Dehydration, vacuum-frying, low-pressure frying, freeze-drying, air-drying, high-pressure pasteurisation	Indonesia, Pakistan, the Philippines
Pulps, purees, juices, cordials	Pulping, juice extraction	Australia, the Philippines, Vietnam
Frozen cheeks, cubes, spears	Individual quick freezing	Australia, Pakistan, Vietnam
Whole and cut fruit packing, natural syrup, sweetened	Old technology: canning, heat-induced plastic packing	The Philippines, Vietnam
Preserves, sweetened jams and jellies, pickling	Heat processing (with pasteurisation)	Australia, Indonesia, Pakistan

Source: author's analysis

4.5 Mango information

Background context

- ACIAR has supported a significant number of mango-related projects over the last two decades.
- Mango R&D projects have delivered significant impact for farmers, communities and industry in at least eight Asia–Pacific countries
- Mango project outcomes require further amplification and socialisation of research outputs in the region to deliver extended benefits to researchers and industry stakeholders.
- The role of new media in improving return for effort and efficiencies across mango research projects is not well understood.
- It is unclear whether small projects could encourage early career scientists to undertake research activities in the agribusiness sector.
- The ACIAR Mango Information project was developed to strengthen communication, collaboration and networking through improved access to mango-related research information among production, industry and research communities in partner countries and Australia engaged in the program.

This project focused on three objectives:

- to promote engagement, collaboration and partnerships among key stakeholders
- to improve information access and communication to facilitate exchange of learnings between project partners
- to support participation and capacity development for young agribusiness researchers and industry personnel.

The aim of this project was to support and enhance information access, communication, collaboration and capacity for mango agribusiness at regional and country levels in the Asia–Pacific region. Specifically, this project supported and engaged with the aligned mango agribusiness projects – Mango Markets (AGB/2016/007), Mango Biosecurity (AGB/2016/008), and Mango Quality (AGB/2016/009) – to coordinate activities and optimise investment efficiency. The mango agribusiness projects had a supply focus from Australia, Cambodia, Indonesia, Pakistan, the Philippines and Vietnam, and a demand focus towards mainland China.

The program proposed a structured series of activities, including the development of an online web platform and social media page that profiled researchers and tested and evaluated the use of digital tools in building relationships and sharing information (for full reports see Appendices 8.1, 8.2 and 8.3). Further, a study sought to understand the relevance of new technology, including QR code stickers placed on imported mangoes, for connecting with Chinese consumers.

4.5.1 Collaboration and engagement across the mango agribusiness program

Across the mango agribusiness projects, more than 60 scientists and stakeholders were engaged from 20 organisations in seven countries. Two workshops were held in two cities in China over the two-year program (2017–19).

Results

Survey results from the workshops reported a high degree of satisfaction with the workshop activities, with attendees finding in-person communications and collaborating on activities extremely valuable. Further, an MOU between Griffith University and the

Chinese Academy of Tropical Agricultural Sciences was established to facilitate collaboration in China and support cohesion between the researchers within and across the projects. This relationship is continuing, and new research activities are evolving.

An early career researcher (ECR) program was developed across the four projects (Information, Markets, Biosecurity and Quality) to investigate issues relevant to mango trade, biosecurity and marketing. Eight ECRs planned their studies and were matched to mentors (see report in Appendix 8.1). Topics covered included:

- Evaluation of online and social communications to connect mango researchers in Vietnam
- Engaging with Chinese consumers: A QR code study
- Mango market segmentation analysis: Shanghai and Guangzhou
- Evaluation of technical issues and commercial constraints in the export of Australian mangoes to China
- Evaluation of technical issues and commercial constraints in the export of Philippine mangoes to China
- Evaluation of technical issues and commercial constraints in the export of Vietnam mangoes to China
- Monitoring temperature and quality of Australian mango exports to China
- Evaluation of Carabao mango quality in export supply chains from Philippines to China.

An evaluation study was undertaken with ECR program mentors and mentees to provide feedback. Overall, researchers considered the ECR projects to be highly successful. Positive feedback related to the opportunity for professional networking, skill development and knowledge-building, and the program was expressed as a highlight by the mango researchers involved. Issues raised for consideration by the respondents were: small funding allocations were not sufficient (\$5,000); and mentees would have preferred to work in a group and undertaken field research in a project, rather than working independently. An ECR model for future project use was not presented.

4.5.2 Connecting researchers through a central web platform and Facebook page

A central independent web platform – the Asia-Pacific Mango Network (www.apmangonet.org) – was developed and launched online in December 2018 (for full report, see Appendix 8.2). Further, a social media page was set up on Facebook with a complementary name (Asia-Pacific Mango Network) to link with the website.

Results

A number of resources were developed for distribution and communication via the website and the Facebook page. The online posts included:

- 44 researcher profiles – biography and image
- 11 researcher stories – current project outputs and research interests
- Workshop presentations – from March 2018 and March 2019
- Mango research activity reports – Agribusiness and Horticulture regional programs
- Newsletters – ‘Simply Mango’
- Additional mango reports from outside the current program
- Links to the social media group page – Facebook.

Researchers in the program rated the website as the most useful resource, even though most users visited the site less than once per month. The newsletter was rated as the least effective resource by researchers in the program, given its long preparation time and high neutral ranking in an online communications survey.

4.5.3 Connecting mango researchers in Vietnam: Online and social media communication

This study used a survey to evaluate the usage and perceived usefulness of online and social media communication for mango researchers in Vietnam (see full report, Appendix 8.3). It also established a ‘Vietnam Mango Researchers’ Facebook page on which researchers could share information, with the intention to observe communication behaviour.

Results

Although 63% of respondents visited the Facebook page at least once, its ongoing usage was generally quite low. The survey showed that Skype, Facebook, Dropbox and Zalo (a Vietnamese social media app) are the most frequently used tools among researchers. Although most researchers engaged with social media daily, relatively few used them specifically for mango research (see Figure 5). Respondents reported that they most commonly use online and social media to share information on conferences, upcoming events and some research results, as well as to connect with other researchers.

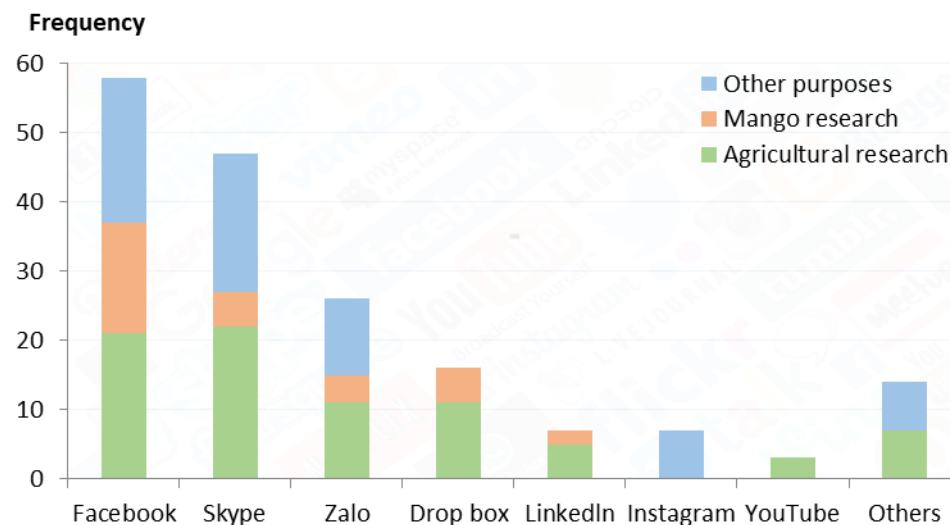


Figure 5. Social media usage among Vietnamese mango researchers

Source: author’s analysis

Researchers reported low levels of confidence in the reliability of information shared on social media. Furthermore, many researchers are passive in their use of social media. This likely stems from a lack of understanding of the benefits social media could have for their work, and for the mango industry more broadly.

4.5.4 Understanding QR technology use in China

This study evaluated the current use and effectiveness of QR codes on mangoes as a consumer communication method within a select mainland China market (for full report see Appendix 8.4). An A4 poster for Australian mangoes with a QR code linked to a website, promoted the country of origin, production site and fruit usage and was displayed in store (see Figure 6). The technology used to support the scanning captured the number of times the QR code was scanned and measured consumer engagement through the application.



Figure 6. QR code promotion poster

Source: research material

Results

The poster was displayed in store during fresh mango tastings. The QR code on the poster only saw moderate engagement with customers (9–10%). The study suggested a number of ways that engagement might have been increased, including:

- incentive coupons to redeem after scanning
- retailer co-promotion
- adding code to actual product
- larger signage
- linking QR code to a targeted site or a WeChat platform, rather than to a generic website.

Platforms used with QR codes for fruit and vegetables generally included certification systems (i.e. product info/quality, supply chain tracking), WeChat profiles (connecting consumers with growers) and websites. QR codes are mostly used to show provenance, as well as to communicate safety/quality information, for marketing/promotional purposes, and social media/nutrition information.

Although QR codes are a viable and versatile technology that is popular in China, the team found that they are underused or ineffectively used by Australian exporters. They are expensive to develop, and so need careful appraisal.

The study also looked at adoption rates of QR codes in retail shops. Most had low or moderate adoption, which is in contrast to stakeholder feedback regarding the imperative to have a QR code when marketing fresh produce in mainland China.

5 Insights

This section discusses the challenges in retailing and cross-border trade transformations in mainland China, market entry and mango quality requirements influencing R&D perspectives. In the context of partner country research institutions, we also consider capacity-building to inform sector development in the region.

5.1 Mango trade adaptation and changes

Expectations for the Chinese retail market

- Research concerning marketing and consumer behaviour in the Chinese mango trade is emerging, but currently provides an incomplete view to guide exporters of mangoes from the region. Much of the research has treated China as a homogenous market. This is potentially a flawed premise, given there are 56 ethnic groups in China, with geographical differences between northern and southern regions and urban versus rural communities. Furthermore, there are varying geographical regions, provinces and autonomous regions, and differing levels of economic development across the nation. Consumers with different backgrounds from different regions and generations vary in their purchasing behaviours. This field of research needs to be further pursued.
- An opportunity exists to undertake targeted marketing strategies for the traditional Spring Festival (Chinese New Year) and other major festivals for premium-quality imported mangoes and/or tropical fruits.
- The purchase frequency of mangoes (imported and local) in summer is much higher than imported mangoes purchased in winter. There is a lack of detailed understanding of the social customs and values related to tropical fruit purchased season-to-season to inform export stakeholders in the preparation of marketing collateral.
- Markets that are anticipated to grow within two to three years are high-end supermarkets, fruit specialty stores, the new O2O retail model (online-to-offline fresh stores), and e-commerce. Growth is predicted to come from selling high-end mangoes in high-end stores.
- Growth in online channels over the coming decade will see improvements in cold chain logistics, more efficient transport and deliveries, and the emergence of big e-commerce platform players. These changes will be critical for the fast growth of the e-commerce sector and directly linked to imported foods marketed in China.
- Mango exports will perform better at the higher end of quality and market appeal. Taking advantage of this will require an understanding of optimal packaging and the retail 'offer'.
- Suggestions from in-market chain stakeholders include improving marketing and supply chain relationships, shortening the supply chain by selling direct to retailers (thus avoiding wholesalers), R&D into temperature control of post-harvest storage and transportation to maintain freshness, and better promotion/advertising and packaging.
- Consumer education has become an imperative for managing and highlighting mango flavour difference and product best-use practices.

Cross-border trade: Vietnam, Myanmar, Cambodia

- To date, Vietnamese trade of key tropical fruits (e.g. dragon fruit, durian, longan) has resulted in significant market success. However, there is limited understanding as to how this was achieved.
- Understanding consumer demand and preferences for mango varieties, sources, volumes and timing of supply to different Chinese market segments would inform decision-making at an in-country project level (e.g. current R&D projects under way in Cambodia, the Philippines and Vietnam).
- Vietnam exporters will need to consider contingency planning for the eventual escalation of regulatory requirements for cross-border trade.
- It will be important to capture research outcomes from the myriad of mango R&D projects that are under way in order to inform policy-making and assess future scenarios and risks (i.e. if China changes/closes border trade and the regulations).

5.2 Market entry barriers and prospects

Challenging regulatory requirements for mango imports

- The average time to commence trading for import approvals is generally ten years.
- Exporters do not appear to consider or plan for the strategic long-term commitments required to comply with all procedures to import goods into mainland China.

Biosecurity protocols vary in different markets

- Although some exporters are well acquainted with biosecurity protocols, there is still a greater number who are unfamiliar with the procedures. For them to develop a formal strategy for trade with China, it is necessary to advance the level of education of regional mango exporters and producers regarding trade profitability, longer-term market potential and familiarity with regulatory requirements.

Advancing market entry and engagement in the dynamic China market

- *In the short term.* Due to the size of the Chinese market, developing stakeholder networks that are engaged in the supply and import ends of the chain would facilitate a more coordinated approach to addressing access issues and market development.
- *In the medium term.* Although some stakeholders consult the Chinese quarantine department for market entry advice, language differences and information access often present barriers. Furthermore, exporters usually have little or no experience in influencing the process. Developing training on compliance for Chinese protocol management (to be delivered by specialist, third-party providers) would support a coordinated regional approach.
- Materials that are available to support market access at the commercial level need revising. Furthermore, additional training material on compliance with Chinese protocols, pesticide management for export markets, and traceability systems needs to be developed. For example, exporters were unfamiliar with the types of preconditioning techniques that would help mitigate some of the quality issues associated with the use of HWT and thus develop a cost-effective alternative to VHT.
- *In the longer term.* Mango exporters want irradiation to be recognised as a viable alternative to heat-based treatments. A review process is needed for existing country-specific protocols after a period of trade has occurred, subject to bilateral negotiation with China.

5.3 Influences and dynamics of mango quality

Advancing mango quality, measurement tools and metrics

- The overarching purpose for developing an objective measurement tool for mango was to describe mango fruit quality for investigation purposes. From a stakeholder perspective, this enables the assessment of harvest, production, packing, transport and ripening. The tool needs to be time efficient, but, most importantly, it also needs to be repeatable and have defined levels of accuracy.
- The sorting and grading that occurs on the farm at harvest requires a rapid assessment approach. This minimises the risk of damaged and sunburnt fruit, as well as cross-contamination from infected fruit. Fruit that have already commenced ripening or are excessively large or small can also be segregated.
- Sorting at the packhouse serves at least two purposes. First, it monitors the harvest process on-farm to ensure that the fruit specified by harvest managers is being picked, with a focus on maturity, size and colour. Second, it enables managers to observe any defects incurred during the harvest process due to handling (cuts and bruises), sap-burn and other issues, and to act to minimise losses.
- At the packhouse, quality mangoes are sorted into size and first, second and third-grade fruit. The sophistication of grading and sorting (quality assessment) is dependent on mango price: without an increased return, the extra cost of assessment will not be recovered.
- A number of defects that only start to manifest when mango fruit ripen are not accounted for in a quick assessment at the packhouse stage. These include under-skin browning, scald, soft-nose, stem cavity and resin canal discolouration. In addition, in-transport effects, such as controlled-atmosphere-induced softening, excessive ripening and high carbon dioxide levels impact the external appearance.
- Agents receiving fruit work to maximise returns to farmers/traders while maintaining their confidence. They must also ensure that fruit they supply to retailers meets or exceeds specifications, while also remaining financially viable.
- Observations and feedback from the in-country studies revealed that in undersupplied markets the quality threshold is lower, while in oversupply situations even premium fruit can be dumped. As reported, this means that a fruit defect that is unacceptable in a premium line may be acceptable early in the season, and that the supply chain adjusts in response. Another consideration is the comparison between on and off-season production in Asia–Pacific regional markets.
- The vagaries of the marketplace are not generally monitored year-on-year. The feedback through the supply chain is moderated by the value of a supplier/trader relationship to the agent, wholesaler, retailer and, ultimately, the consumer. This means that increasing mango price is difficult to separate from improved farmer, handling or marketing contexts.

It is important for chain participants to understand the ‘quality’ framework versus what are simply product characteristics, which vary by country and by variety. Consideration needs to be given to how mangoes differ in cultivar responses, susceptibility to specific defects, variation in mature-eating characteristics and the ability to be transported. Market-specific cultivars, social behaviour, infrastructure and handling may impact definitions of quality. Capitalising on export opportunities requires a coordinated approach to quality research.

Outputs from real and simulated supply chain studies

- The Australian containerisation and shipping study was the only one that involved monitoring a commercial shipment. This study revealed the sources of greatest variability in storage conditions. The temperature loggers indicated large differences between positions of boxes on pallets and positions of pallets within the container.
- No clear relationship was found between transport temperatures and fruit residual shelf life in the Australian study. However, the study gave no indication that temperature loggers were calibrated, and this potentially presented an inaccurate record. Further, no control fruit were retained to allow for the production defects to be separated from the transport-induced changes.
- The maturity of the R2E2 fruit used in the Australian study was also unclear. The accepted Australian standard for commercial maturity for R2E2 fruit is 13%. The simulated storage trial using R2E2 fruit recorded 19% maturity, as measured by the Felix quality instrument.
- The Philippine study started with a sampling and assessment strategy that allowed for statistical analysis and the detection of significant defects.
- As in the Australian study, there was no evidence of instrument calibration, but significant effects were observed due to temperature and position. It is unclear whether the container packing system (with a layer of empty banana boxes) used in the Philippine study was a simulation exercise and not a reflection of commercial supply chain conditions.

At this stage, there is a need for rigorous, documented and targeted supply chain and simulation trials for partner countries seeking to improve their mango quality export proficiency. Future research would require a coordinated approach that seeks to build capacity through training workshops and field studies. These studies should demonstrate good research design, including replication protocols, appropriate controls, instrument calibration, and detailed fruit quality criteria that incorporate maturity.

Furthermore, training researchers to assess fruit quality (pre and post) would develop their capacity to deliver validated results. Engaging practitioner ‘assessors’ will be essential for the successful use of a rapid assessment tool. The developed tool could then be built carefully in the experimental design stage to account for each variable (e.g. source of fruit, calibration of instruments, loggers, standardisation of treatments and use of appropriate controls).

China in-market assessment study

- This mango quality activity does not provide sufficient detail and is not clear how the contracted methodology in the proposal related to the reported results.
- The proposed methodology intended to interview two wholesalers and two retailers in each of the cities of Guangzhou, Shanghai and Haikou in mainland China. However, the report reveals a total of 12 interviews in Guangzhou, 13 in Shanghai and five in Haikou.
- It is unclear how the results presented are linked to the instruments. For example, the flesh colour stated in the report indicates a scale of 4 to 12 and the colour scale used has not been noted, and it is therefore unclear how the variable ‘liking’ is linked to ‘flesh colour’. As such, most of the discussion in the paper relating to variables is ambiguous.

Sensory and consumer research in food product design and development is a specialised craft that requires explicit knowledge and training to understand how consumers think and what attributes they desire. Training and developing researchers as mango quality and sensory investigators is a complex activity. A twofold approach to delivering training – relating to research study plan and instrument design (surveys and interview checklists) –

is required for capturing appropriate information from stakeholders to inform export development. This process must incorporate statistical thinking in sensory analysis.

Workshops that aim to identify leaders and up-and-coming researchers in each partner country to undertake a dedicated course with an expert panel of instructors would facilitate the process of instructor training. A train-the-trainer approach would then help to develop a core group of partner country researchers, who could train in-country teams and a wider number of dedicated, qualified practitioners. Such an approach was demonstrated successfully in The University of Adelaide Master Class series undertaken in a number of partner countries over the last three years.

Improving communication and collaboration between farmers and supply chain stakeholders

- Year-round monitoring and reporting on mango quantity, price, country of origin and dominant varieties in the major Chinese markets is needed to improve the chain. Further investigations are also required to better associate quality parameters with price using larger sample sizes, more varieties and across different times of the year.
- Some importers and exporters in South-East Asian countries are unwilling to divulge information, which results in unreliable data.
- Supply chain stakeholders (especially farmers) should be encouraged to use websites and social media to improve information-sharing and transparency, which will ultimately result in improved quality and price.

5.4 Tropical fruit processing

Fresh mango production suffers high losses, not only at farm level but also during distribution and marketing. Processing is an important approach for optimising return for effort for all chain participants, especially farmers and cooperatives. A wide range of processing operations are in place in the Asia–Pacific region, which are driven by regional and local supply. The largest mango-producing nations (India, Thailand and the Philippines) have commissioned a number of multi-use technologies.

- Results from the Indonesia workshop revealed that, although interest was high, mangoes are not a priority crop for the Indonesian government.
- Most mangoes are consumed by local populations, which causes a restriction on local supply for processing purposes.
- The fruit processing sector is evolving but is hampered by a lack of in-country expertise. Some countries have limited institutional support for processing, and growth is largely coming from small community-based enterprises that have initiated processing with new technologies, such as low-pressure frying and air-drying, and using pouch-style packaging.
- All partner countries expressed a desire for accreditation and food-safety-standard training; however, with the exception of Vietnam, technical courses to deliver community-based capacity-building were not available.
- Mango supply in South-East Asia and Australia is seasonal, and Australia has widely dispersed growing regions that range from Western Australia to the east coast of Queensland.
- A number of small enterprises in countries such as Indonesia, the Philippines and Vietnam have established multi-fruit processing ventures using techniques such as freezing, drying and powdering.
- Partner countries discussed the potential to acquire mobile processing units, which are available internationally, for regional communities. These units would be ideal for

isolated production areas and could help to develop regional community micro-businesses.

- The supply of mangoes rarely meets market demand, in part due to their seasonal nature, and thus intermittent supply. As a result, it is difficult to ensure the optimal (that is, continuous) use of expensive processing facilities.
- A disparity exists among processors regarding their knowledge of standards and regulatory obligations, and their ability to conform to relevant market requirements. Universal compliance is necessary to maintain the integrity of the industry.
- SMEs do not have available personnel to commit to research and product development, and in many cases, processors are unaware of the facilities available to provide assistance in-country.
- Mangoes are a good option for the most advanced processing techniques, which result in extremely high-quality products that can secure a premium price. However, processors are often unaware of farming practices that may impinge on the quality of their finished products and hence their access to demanding markets.

Collaboration between value-chain partners assists with information exchange and lobbying for more favourable government support. Small-scale processing at the farmer level is common not only in the mango industry, but throughout the fruit farming sector. Targets for assistance in progressing towards SME status that include safety and shelf life should be investigated to ensure that their market reach becomes greater.

5.5 Developing and engaging with regional researchers

- Appropriate platforms and modes of communication are crucial for shaping approaches and coordinating activities across programs with multiple projects and numerous research activity teams. Researchers highlighted that clear communication protocol across projects, including regular information streams, was important for project success.
- Information-sharing from technical leads to researchers and vice versa presented a challenge, particularly regarding timeliness and mode of communication. The role and choice of media channels, including online and app-style formats, is better suited to communicating with a team – for example, WeChat when connecting with Chinese scientists, and WhatsApp when connecting with Vietnamese and Filipino researchers.
- The development and implementation of online tools demonstrated that digital media can be useful. The Asia-Pacific Mango Network website and Facebook page are in the early stages of engagement. The website played an important role as a general information portal for mango researchers in the region. Engagement with the Facebook page increased over time through improvements to features, such as post format and the introduction of a group event.
- A number of challenges have emerged in developing and implementing these digital tools. Time constraints are a major factor: a networking page often takes a long period of time to develop a community and build engagement. For example, Growcom Australia, a peak representative body for horticulture, took ten years to gain 3,342-page likes. The APMN Facebook page target audience (mango researchers) is even more niche. Further, the website and Facebook page rely on organic growth without any advertising income. In recent years, it has become tougher to increase organic reach due to competition from greater amounts of paid content. As such, an opportunity for further website development could examine the inclusion of cross-channel promotions, such as search advertisements. Additionally, because the APMN target audience comprises various countries in the Asia–Pacific region, the preferred communications platforms by each country could vary (as confirmed in the study).

6 Conclusions and recommendations

6.1 Conclusions

This report summarises the outcomes of the five projects undertaken in the mango research program. The overarching goal was to better understand and identify strategic issues, research gaps and implications for mango trade with the mainland China market in the longer term. The contracted outputs and milestones delivered were:

Mango information

- Completed collaboration plans for sharing across the research program
- Profiles of projects, researchers with at least one researcher story from each country communicated via social media or website activity
- Recommendations for ongoing collaboration
- Online portal and social media
- ECR small study program with summary evaluation and recommendations
- QR code evaluation study undertaken in mainland China

Mango markets

- A report documenting current market situation and trends for mango trade in China
- A report documenting cross-border trade from Ping Xian–Lang Son border
- A report with detailed analysis of market segments, challenges and opportunities
- A report of the e-commerce situation for online mango trade in mainland China
- Detailed analysis of consumer WTP, purchasing preferences and buying characteristics
- Completed ECR – market segmentation small study

Mango biosecurity

- An overall report documenting the current import protocols and trade channels for mango imports to mainland China, including technical issues, barriers and opportunities, and a detailed five-year plan for short, medium and long-term timelines for technical priorities and strategic development
- Completed ECR small studies for documenting market entry and biosecurity challenges for Australia, the Philippines and Vietnam

Mango quality

- A Mango Quality Assessment Kit produced for distribution
- Reports documenting market assessments by partner countries and Australia
- A completed report analysing the implications for mango quality in export and simulated supply chains to mainland China
- A report presenting the results and implications for physical eating characteristics preferred mango quality characteristics

Tropical fruit processing

- A report presenting the profiles of established and emerging processing technologies, common impediments to processing, factors that have contributed to success, and recommendations for ongoing collaborations on all aspects of mango and tropical fruit processing as an outcome of two workshops (South-East Asia and Australia)

6.2 Recommendations

While it is recognised that some mango industry issues are unique to specific cultivars or countries, the majority of regional industry issues and challenges have common ground across the Asia–Pacific partner countries.

R1 Develop mango trade and marketing networks

In the short term, stakeholder networks need to be developed at both the supply and the demand ends of the chain, particularly among Chinese businesses interested in establishing longer-term imports from partner countries. This will coordinate approaches to trade, access issues and market development for partner countries seeking to export.

R2 Examine the feasibility of an ongoing integrated Mango Agribusiness Research Program to inform strategic directions for ACIAR R&D

An integrated Mango Agribusiness Research Program that targets emerging export markets in partner countries and Australia would be advantageous. This program could engage the expertise of key research, industry and government institutions with regional, technological and market/trade relevance.

R3 Undertake a 20-year meta-analysis of published regional mango studies

A plethora of mango studies has been completed over the last two decades. A regional review of published studies by discipline would socialise existing institutional knowledge to inform future R&D program development and project team capacity. This review should be updated every five years.

R4 Introduce an annual mango research outputs showcase

An annual mango researcher workshop hosted by an Asia–Pacific country in the region would encourage interaction and generate public/private partnership networking and engagement across the region. The workshop should be in collaboration with an international research institution (e.g. the International Society of Horticultural Science) and regional Mango Industry Associations.

R5 Lead an annual mango R&D forum with industry, academic and government sectors

An annual Asia–Pacific trade, biosecurity and fruit processing forum involving public and private-sector stakeholders would facilitate exchange of ideas between regional mango industries related to industry impediments, remedies and successes. This initiative should look to establish mango handbooks or guides for strategic industry areas.

An initial regional forum held within the main forum and involving multi-disciplinary stakeholders would help to explore options, ideas and concepts for new approaches to fruit fly management/disinfestation through research activities.

R6 Revise material supporting market access requirements

In the medium term, revision of material supporting market access at the commercial level is required. Further training material on compliance with Chinese protocols, pesticide management for export markets, and traceability systems also needs to be developed.

R7 Undertake annual round-table, in-country consultations

An annual in-country consultation with public and private-sector stakeholders engaged in mango/tropical fruit trade with mainland China would help to establish formal networks in each partner country. A good example is the Australia–US mango export working group; this model demonstrates how a coordinated approach to gaining direct access to the Chinese market might be developed.

R8 Progress irradiation negotiations as a market entry protocol

Looking to the longer term, irradiation needs to be further considered as a viable alternative to heat-based treatments. Existing country-specific protocols should be reviewed after a period of trade has occurred, with the aim to remove any inefficiencies. This would be subject to bilateral negotiation with China. Furthermore, local cultivars within partner countries require research to determine if they can maintain export quality after irradiation.

R9 Seek to mitigate quality issues associated with hot water treatment (HWT)

Preconditioning techniques for alleviating some of the quality issues associated with HWT need to be researched. This will help to develop more cost-effective alternatives to VHT.

R10 Determine whether a common mango quality language is possible

In the trade context, quality assessment serves several purposes, which are influenced by seasonal supply, marketing, fruit fragility and perishability. The assessment process has to be financially beneficial for the trader. The nature of this benefit changes along the chain, and understanding of the potential value of a common quality language is needed.

R11 Identify opportunities for value-added mango and tropical fruit products

A review of opportunities for value-added mango products, such as dried fruits, undertaken on a regional scale and within partner countries would help to develop the processed fruit sector. This study should seek to identify and quantify economic benefits from developing premium-quality products, beyond the use of rejected fruit, with inputs from public and private-sector stakeholders.

R12 ACIAR Master Class endorsement – develop skilled researchers

Developing expertise in research design, sensory analysis, consumer behaviour, statistical methods, and market entry planning and compliance delivers more robust program outputs. Integrated training programs that focus on developing practitioner ‘assessors’ would provide the skills needed to successfully use tools such as the Mango Quality Assessment Kit. A workshop program aimed at identifying leaders and up-and-coming researchers in each partner country would facilitate this process.

High-level market entry training packages developed in conjunction with China Inspection and Quarantine Association (CIQA) that are targeted at business, regulators and policy-makers would help partner countries address protocols and manage regulatory and compliance requirements.

For industries to meet current and future residue-testing requirements, testing services in partner countries require capacity-building in areas of testing standards, accreditations, sample turnaround times and production of standards.

R13 Further examine how regional research sharing through website and social media platforms can connect researchers and disseminate project outputs

Maintaining the APMN website as a two-way accessible tool with regular communications, including webinars and research presentations of current project outcomes, will provide ongoing access to an important resource. The website should include timely details of current studies and further develop mango researcher profiles.

A larger study is needed to identify, evaluate and recommend the most useful social media platforms for Asia–Pacific agribusiness researchers.

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8 Appendices

- 8.1 MI Capacity building and collaboration study
- 8.2 MI Socialising project outputs study – online and social media
- 8.3 MI Socialising research study – Vietnam
- 8.4 MI QR code study – China
- 8.5 MM Cross border study – China
- 8.6 MM Market assessment study – China
- 8.7 MM E-commerce study – China
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- 8.9 MB Market entry study – Asia–Pacific
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- 8.11 MB Market entry study – Australia
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- 8.13 MQ Activity outputs study
- 8.14 MQ Supply chain study – Philippines
- 8.15 MQ Supply chain study – Australia
- 8.16 MQ Quality kit study – Cambodia
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- 8.22 MQ Quality study – China
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- 8.24 Tropical fruit processing study