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Final report C1

project

Improved domestic profitability and export competitiveness of selected fruit value chains in southern Philippines and Australia

Component 1 – Analysis of the constraints to selected tropical fruit (Papaya) supply chains and implementation of improved quality systems for the southern Philippines and Australia

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2 Executive summary

'Solo' papaya production over the past decade has developed into a major industry in the southern Philippines and this area is now the major source of papaya for export and domestic markets.

A multidisciplinary team conducted a value chain analysis (VCA) of papayas produced in Tupi, South Cotabato, and marketed in supermarkets in Metro Manila and outlying provinces. Since the primary aim of VCA is to deliver consumer-defined value, two consumer focus groups were conducted followed by surveys of 232 consumers and conjoint analysis. Results indicated that papaya consumers valued and would pay for freedom from blemish and decay; and fruit with sweetness and good colour (yellow-orange).

Interviews with major chain stakeholders showed that information flows were partial at best, relationships were basic or transactional and there was a general lack of consumer insight by chain members. Mapping product flows from the farm to the distribution centre in Metro Manila revealed losses from disease, non-uniform ripening, fruit immaturity and mechanical damage. Product performance was, therefore, highly variable. Results from consumer research combined with chain mapping enabled each activity from farm to market to be characterised as (i) value adding, (ii) necessary but non-value adding or (iii) wasteful. These performance measures enabled the identification and implementation of improvement opportunities to reduce losses, improve product quality, build better relationships and deliver consumer-defined value. Quality improvement opportunities included improving sweetness through correct harvest maturity; freedom from decay through hot water treatment, which reduced the effects of the diseases anthracnose and stem end rot by 33–100%; and treatment with ethephon, a ripening regulator. Modified atmosphere packaging (MAP) and 1-methylcyclopropene (1-MCP) prevented premature ripening during the three day sea shipment. However, the high incidence of decay using MAP and the failure of fruit to soften with 1-MCP treatment were limiting technique constraints.

Two trial shipments to Metro Manila supermarkets and surveys to determine market response to improved fruit quality confirmed that consumers were willing to pay more and buy more. The consumer value thus created could be used to motivate growers and other chain members to commit to activities that improved fruit quality.

Four training sessions on papaya production and postharvest handling; enhanced information flows in the chain; and chain-wide participation in quality improvement activities resulted in a 37–73% reduction in the number of papayas that were rejected or 'bad orders' supplied by growers and shippers to the key collaborator.

Initial research of the Singapore market, conducted by a student group from the University of Queensland sponsored by ACIAR in September 2012, found that Philippine 'Solo' papaya had great potential. Harvesting and postharvest handling guidelines were then developed to help meet the export requirements. Three trial shipments were sent to Singapore in 2013, one of which was fully monitored by the project with Dr Tim Sun and two researchers from UPLB following the shipment. It was found that Philippine 'Solo' papaya was under supplied in the market. Organising enough supply from the Philippines to Singapore with the required quality was the primary limitation. Apart from the Singapore market this project also sent two shipments to the Middle East in 2012.

In Australia chain mapping and interviews with chain participants identified fruit diseases, which caused wastage of up to 25% during summer production, as the major limitation to industry profitability. Trials of ripening temperatures, effect of pre- and postharvest chemicals, hot water treatment and tree age were undertaken to develop solutions to this wastage. Subsequently, changes to summer ripening temperatures have been adopted by collaborators to reduce disease without affecting other quality attributes. There remains a need to further reduce disease problems and develop a more consumer value-oriented approach to papaya chain improvement.

3 Background

The tropical fruit industry in the Philippines is significant both domestically and for export production. Papaya is among the top ten economically important fruits in the Philippines. It ranked ninth in terms of production volume and area planted in 2008 (BAS 2012) when the research commenced.

The production of papaya is concentrated in Mindanao, particularly in the regions of SOCCSKSARGEN, Northern Mindanao and Davao that accounted for 65% of national output. In 2008, of the total 182 907 mt produced, around 93% was consumed domestically and only 1.3% was exported.

The growing awareness of consumers of the fruit's high nutritional value, including a rich content of active components that protect the human body from diseases (USDA Nutrient Database 2005), provided an opportunity for market expansion both in the local and export arenas.

The bulk of the papayas marketed in Metro Manila and outlying provinces come from South Cotabato in Mindanao. As in other crops, when supply areas of the fruit move further away from the consumption centres quality and quantity losses occur. The inherent high perishability of papaya aggravated by rough and multiple handling as the fruit moves along the supply chain leads to quality decline. Quality decline is exacerbated by rapid fruit ripening and disease development and then compounded by poor harvesting practices, packing and transportation.

A further impediment to increasing tropical fruits productivity is that farmers are not coupled with market signals, and there is little incentive for them to adopt improved varieties and management techniques that may be available.

An opportunity existed for a papaya supply chain study to improve the competitiveness of firms and reduce losses. In this approach players in the chain from producer to consumer learn how to work together to identify and share critical information that helps each one to meet the needs of others in the chain. As a result closer relationships are developed allowing chain-based problems to be more easily addressed and opportunities captured. The individual competitiveness of each firm is improved by improving the competitiveness of the chain as a whole.

Global retailers are favouring (or demanding) a supply chain management approach in dealing with their suppliers because it improves product traceability and ensures that the needs of retailers and their consumers are communicated to all the members of the chain, especially producers. There is some evidence that such a business model can be translated, with caution, from firms in developed economies to those in developing economies. This is especially important as developing economies are seen by global retailers as new sources of supply for fresh food products.

From an R&D point of view, an advantage of adopting a supply chain management approach for improving industry competitiveness is that it provides a producer-to-consumer, systems-based framework for identifying the constraints affecting current production, postharvest, distribution and marketing activities. In this way it captures the issues of all sectors of the industry, all the processes in the chain, and the players in the chain, as well as the institutional environment within which the chain operates.

To achieve the above outcomes, this study aimed to identify and implement improvement opportunities to reduce losses and maintain papaya fruit quality through value chain analysis. A 'value chain' is a supply chain whose systems and behaviours are focused on delivering value to its customers and, most importantly, to the end consumer (Collins 2010). Bonney *et al.* (2007) indicated that sustainable competitive advantage has two fundamental requirements: a strategic orientation that is focused on consumer value, and value chains that are coordinated and responsive to the dynamic needs and wants of the final consumer. In contrast to more traditional supply chain approaches, which focus upstream, value chain approaches focus downstream understanding what consumers value in a commodity and aiming to deliver it as effectively and efficiently as possible (Clark *et al.* 2010).

The Australian papaya industry is only very small compared to the Philippines with a mean annual value of production of around $20 million and a volume of 16 800 t per year. Most of the production (95%) is located in Queensland with minor production occurring in the Northern Territory, Western Australia and New South Wales (Vawdrey 2008).

The Australian industry is also undeveloped due to high levels of losses from disease, particularly during the wet season, and inconsistency of product flavour and fruit ripening behaviour. While the industry had invested in research and development to improve cultivar performance, the need for a supply chain approach for reducing costs and to better meet customer requirements had been identified, particularly to improve management of new elite lines. Thus, the plan for Australia was to further study the papaya supply chain, then determine what the research priorities were, conduct the research, and implement changes.

This component's Filipino and Australian research was expected to have direct implications for the respective papaya industries and in addition the plan was to use the value chain analyses as a case study for development of other tropical fruit industries.

This component aligned with the ACIAR Philippines Country sub-program 1 'Increasing the market competitiveness of Philippines agricultural products'. It was expected to draw on conclusions from ACIAR projects HORT/2003/071 'Integrated pest management and supply chain improvement for mangoes in the Philippines and Australia', PLIA/2005/159 'A constraints analysis of mango supply chain improvement in Pakistan' and HORT/2005/157 'Optimising mango supply chains for more profitable horticultural agri-enterprises in Pakistan and Australia'. The methodology was also partly based on an Indonesian project PHT/1997/161 'Market based analysis of constraints to banana industry development in Indonesia and Australia' and a project in the Philippines ASEM/2000/101 'Improving the efficiency of the agribusiness supply chain and quality management for small agricultural producers in Mindanao' that had utilised a supply chain approach to developing options for industry improvement and benefit flows to smallholders.

4 Objectives

Objective 1. To finalise component planning and identify collaborative opportunities

1. Identify collaborating R&D partners to undertake collaborative research in the Philippines to facilitate supply chain analysis and interventions to improve supply chain performance.
2. Identify and mobilise commercial partners who can champion improvements in tropical fruit supply chains and where benefits and cost savings are shared by all members of the chain.

Objective 2. To identify opportunities and constraints through supply chain analysis for Philippines papaya

1. Identify present market needs and likely future opportunities for Philippine papaya in domestic and exports markets.
2. Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain.
3. Develop training resources to be used to improve supply chain performance.

Objective 3. To enhance profitability and competitiveness through supply chain improvement for Philippines papaya

1. Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain.

Objective 4. To enhance profitability and competitiveness through supply chain improvement for Australian papaya

1. Identify and mobilise commercial partners who can champion improvements in papaya chains and where benefits and cost savings are shared by all members of the chain.
2. Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain.
3. Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain.

5 Methodology

A summary of the activities for the Philippine (sections 5.1 to 5.3) and Australian (section 5.4) objectives are provided here. More detailed methodology is provided in the report Esguerra *et al.* (2012) (see Appendix 2).

5.1 Objective 1. To finalise component planning and identify collaborative opportunities

5.1.1 Identify collaborating R&D partners to undertake collaborative research in the Philippines to facilitate supply chain analysis and interventions to improve supply chain performance

The component leaders travelled to Los Baños in the first phase of the project to meet the Philippines collaborators and to establish a joint research approach. The team visited Mindanao to understand papaya commercial practises and to discuss the project with potential export collaborators.

5.1.2 Identify and mobilise commercial partners who can champion improvements in tropical fruit supply chains and where benefits and cost savings are shared by all members of the chain

Preliminary approaches were made to commercial export and domestic supply chains. Selection of the commercial collaborators was the critical step in the likely success of the project and project partners were expected to champion improvements in tropical fruit supply chains and to share benefits and cost savings with all members of the chain.

Four export companies were investigated as potential collaborators for export investigations, however agreements could not be finalised.

Since collaboration with these major companies exporting papaya could not be finalised, efforts of the Philippine researchers focused on the domestic supply chain with papayas coming from the southern Philippines and distributed in Metro Manila.

5.2 Objective 2. To identify opportunities and constraints through supply chain analysis for Philippines papaya

5.2.1 Identify present market needs and likely future opportunities for Philippine papaya in domestic and exports markets

Domestic supply chain mapping

Initial supply chain mapping, documentation of the postharvest handling practices, and fruit quality assessment were conducted in three major supply areas in the southern Philippines—namely Davao, Misamis Oriental (Balingasag, Tagoloan, Cagayan de Oro City) and Bukidnon (Lantapan, Valencia, Balingasag).

A papaya supply chain from South Cotabato that accounted for the bulk of shipments to Metro Manila (both for wet markets and institutional buyers) was investigated. Buying stations, wholesale and retail markets (Divisoria, Balintawak, Nepa-Q mart), consolidators' and consignees' warehouses, and supermarkets (SM branches, Rustans, Makro, Market Market, Walter Mart, Robinsons) were visited. This led to the identification of a commercial collaborator which we named *The Company* (the name was withheld for confidentiality reasons) who agreed to do an analysis of their supply chain.

An initial value chain analysis (VCA) of this domestic Philippine papaya chain was conducted in January 2010 by a joint Australian-Philippine team comprised of Professor Ray Collins and Dr Tim Sun from The University of Queensland, and UPLB researchers including Dr Elda B Esguerra, Dr Matilde V Maunahan and two other agricultural economists, Dr Dormita R del Carmen and Ms Gloria D Masilungan.

The team conducted key informant interviews with the purchasing officer and quality control head (Round 1), and focus group sessions were conducted with junior managers, supervisors, merchandisers, auditors, forecasters, quality control (QC) officers (Round 2) of *The Company* to map the material, information and relational flows within *The Company* and with its suppliers and customers.

One of the papaya suppliers (as filler fruits) of *The Company* was visited at Divisoria market to determine product sourcing, problems and quality concerns, as well as information and relational dynamics.

Three representative supermarkets and one retail store being supplied by the cooperating company were also visited for interviews with junior managers, supervisors, team leaders, merchandisers and some consumers, whenever possible. The Round 1 activities of VCA were a very insightful and fruitful exercise that provided a guide for the Round 2 activities, which also involved interviews with key stakeholders as well as validation of information obtained.

Benchmark data on per cent rejection, called ‘bad orders’ or ‘BO’, at *The Company* warehouse-cum-packinghouse was collected within three days of delivery in April 2009. The causes of rejection were also evaluated. Two months after training was conducted in Tupi, information was again obtained to determine the changes in the proportion of rejects. Another set of data relating to two trial deliveries was again obtained in March 2012.

Understanding consumer preferences

A consumer focus group discussion (FGD)—a qualitative way to get insights for quantitative research—was held in cooperation with ACIAR Philippines personnel at the Australian embassy. A second FGD was conducted at the University of the Philippines Los Baños (UPLB) to validate results obtained from the first FGD and also to serve as a basis for developing a structured questionnaire for formal consumer surveys.

The survey questionnaire was formulated and pre-tested prior to interviews and surveys. Questionnaires were sent out to private companies and government agencies as well as to several households in Metro Manila and adjoining provinces of Laguna. There were 232 respondents with valid answers and the data was run using SPSS.

Conjoint analysis was then conducted since the joint effects of product attributes on final purchase decisions are often not accounted for in ordinary consumer surveys. In this study the conjoint methodology suggested by Hair *et al.* (1998) was followed using a full profile approach. A survey questionnaire was developed by utilising the results of the earlier consumer survey. Papaya attributes ranked as most important by consumers in the previous survey were used as input in generating product profile combinations using the orthogonal design (fractional factorial design) in the SPSS (9.0) conjoint software.

Market research in Singapore

Initial market research in Singapore was conducted in September 2012 by a group students from the University of Queensland sponsored by ACIAR. Using proven market research tools, such as SWOT and Porter’s value chain analysis combined with standard qualitative data collection methods such as focus groups and in-depth interviews, the research found that Philippine ‘Solo’ papaya had great potential in the Singapore market.

In 2013 three trial shipments were send to Singapore, with one shipment fully monitored and studied. For the monitored trial shipment value chain analysis was used to map the material, information and relational flows in the export papaya value chain from South

Cotabato to Singapore. This involved key stakeholder interviews with a progressive farmer co-operator who had invested in hot water treatment technology and is motivated to export (together with other interested smallholder suppliers) and an exporter shipping to Singapore. Market research in Singapore examined what the various stakeholders *viz*. consumers, retailers and wholesalers wanted and whether or not their needs were being met and how. Improvement activities and opportunities were then identified and implemented to reduce losses, maintain produce quality and add value for the benefit of the whole value chain.

The fully monitored market study in Singapore was conducted by Dr Tim Sun, Dr Matilde Maunahan and Ms Wella Absulio of UPLB and also the staff of the exporter.

5.2.2 Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Quality improvement activities

Value chain analysis focused on understanding what consumers value in a product and then delivering it as effectively and efficiently as possible. Having identified the points in the value chain where quality is lost and where value can be created, the improvement opportunities were investigated.

Improvement projects included:

Improvement projects	Methodology
Improving product quality through fruit maturity Value addressed—sweetness	Fruits were harvested, labelled according to the harvesting index: M1—'Silay' (fruit with yellow streak at the blossom end), M2—first fruit above 'Silay' and M3—second fruit above 'Silay' and packed in cartons. Fruits were air-shipped to Manila and immediately transported to the laboratory. Upon arrival, fruits were unpacked, divided into two lots, distributed according to the treatments and washed in 1% alum solution. The first lot served as a control while the second lot was treated with 2000 ppm ethephon for induction of ripening. After treatment, fruits were air-dried and allowed to ripen at 25±0.9°C. The physico-chemical properties (firmness, total soluble solids, titratable acidity) at green and ripe stage were evaluated. Ripening behaviour (peel colour change, visual quality rating, firmness by finger feel) was monitored at a regular intervals. Weight loss and sensory properties were also evaluated. A comparison of the quality of papaya fruits supplied by three growers/shippers to *The Company* was also done to determine differences in quality.
Regulation of ripening: 1-Methylcyclopropene (1-MCP) treatment to retard ripening Value addressed—ripeness (peel and pulp colour)	'Sunrise' papaya of two different maturities, PCI 1 (<10% yellow peel) and PCI 2 (25% peel yellow colour), were harvested from two different farm locations at Tupi, South Cotobato. The fruits were sorted, wrapped in newspapers and packed in wooden crates. A total of 60 fruits were packed per crate. For 1-MCP treatment, the wooden crates were lined with a 0.05 mm polyethylene bag (PEB). Pre weighed 1-MCP was then placed inside the crates and water was added to produce a concentration of 100 nl L^{-1} of 1-MCP. The PEB was immediately sealed using a rubber band and the fruits were exposed to 1-MCP gas for 24 hours under ambient conditions (28–30°C). After the desired exposure time, the PEB was opened and fruits were then loaded in a non-refrigerated container van and sea shipped for three days from General Santos City to Manila. Evaluation was done four days after 1-MCP treatment. At PHTRC-UPLB, half of the fruit samples were treated with 2000 ppm ethephon then ripened at 25°C. Fruits that were untreated served as a control. Daily observations of visual characteristics such as peel colour change and disease incidence and severity were subjectively determined.

Improvement projects	Methodology
Modified atmosphere packaging (MAP) during sea shipment Value addressed—ripeness (peel and pulp colour)	Based on the results of the trial on harvest maturity and ripening regulation using ethephon, a second experiment was conducted in April 2011 where fruits at two stages of maturity were used. The objective of this handling trial was to determine whether the use of ethylene adsorbent (EA) in packs of S1 and, especially, S2 papaya fruits would retard ripening during the three day non-refrigerated sea shipment period from South Cotabato to Manila. Two methods of using EA were tested. One was the use of EA inserted in packs of papaya with the crate lined only with used cartons (the usual packing method), and the other was the use of a polyethylene bag (0.05 mm thick, with 50 diffusion holes) as a liner in wooden crates (for modified atmosphere packaging) and sachets of EA inserted in the packs of papaya fruits. In both treatments, 30 EA sachets were distributed in different parts of the pack. Papaya fruits were obtained from two main suppliers (Nimes and Concepcion) of the cooperating firm and shipped together with the commercial batches of fruits for delivery to *The Company* in Paranaque City. Evaluation was done five days after harvesting, which is the usual duration from harvest to arrival of papaya fruits from the farm to the buyers.
Reducing heat treatment time with different temperature/time combinations Value addressed—freedom from diseases	Various time/temperature combinations of hot water treatment were tested in this study, which was conducted in the packinghouse in Tupi, South Cotabato of one of the suppliers of *The Company*. The improvised hot water tank was fuelled with liquefied petroleum gas (LPG). Thermocouple probes were positioned in different portions of the tank to monitor water temperature. The temperatures tested were 53˚C, 55˚C and 57˚C at dipping times of one, three, and five minutes. The recommended hot water treatment (HWT) (50˚C for 10 minutes) was also done for comparison. Papayas were packed in wooden crates after cooling and transported the following day to Manila together with the commercial loads of the grower-supplier.
Effect of delayed hot water treatment (dHWT) on degree of disease control Value addressed—freedom from diseases	The papaya fruits delivered by *The Company* to the different stores came from different grower-suppliers in Tupi, South Cotabato. Regardless of variety, onset of decay limits saleability. The response of different varieties was evaluated with fruits coming from different growers in Tupi. Application of HWT (49–51°C, 10 minute dip) was done four days after harvest when fruits were still at the colour break to almost 30% yellow peel colour stages.
Comparison between on-farm HWT and dHWT Value addressed—freedom from diseases	‘Sunrise’ papaya fruits were hot water-treated (50°C, 10 minute dipping time) within the day of harvest in the packinghouse in Tupi of one of the suppliers of *The Company*. After drying and cooling, papayas were packed in wooden crates and transported the following day to Manila. Upon arrival in Manila papayas (not subjected to HWT on-farm) from the same harvest and shipment were obtained and subjected to HWT after almost four days from harvest to heat treatment. In this delayed HWT papayas were still at colour break to almost 25% yellow peel colour. Untreated fruits served as control. Papayas were packed in cartons and ripened under ambient conditions (28–30°C).

5.2.3 Develop training resources to be used to improve supply chain performance

Capability building of stakeholders in the chain

Training of papaya growers and shippers

In collaboration with the C3 component of the Fruits Program, a two day training on Papaya Production and Postharvest Handling was conducted at Tupi, South Cotabato on 24–25 May 2011. The training was a joint effort of the Municipal Agricultural Officer (MAO), who was responsible for the invitation of participants; the Growth for Equity in Mindanao (GEM) program of USAID; and the C1 and C3 project team.

Having identified and technically addressed the chain improvement opportunities that will deliver what consumers value in 'Solo' papaya, two separate half-day training sessions on the proper postharvest handling of the fruit were conducted on 18 May 2012 in the production areas in Tupi, South Cotabato. The objective was to provide feedback to the growers and suppliers on the results of both the consumer and postharvest studies, for them to have a better understanding and appreciation of why improvements are needed, and to encourage them to do their part in ensuring improved product quality in order to maximise value adding along the chain.

Training of *The Company* personnel

A one-half-day training on Papaya Postharvest Handling was conducted at *The Company* warehouse in Merville, Parañaque City on 29 July 2011. The training was aimed at familiarising company personnel (involved in papaya from procurement to merchandising) on the different handling techniques to maintain quality and to minimise damage and losses at different steps in the chain from arrival at the warehouse to product display in retail stores.

Training of stakeholders involved in Singapore export

One-day training on improved harvesting and postharvest handling practices was conducted in Tupi, South Cotabato on 30 November 2013. There were 24 participants consisting of grower-suppliers, harvesters, packinghouse personnel (classifiers, packers, HWT operators), and the quality control officer of the company that exports to Singapore. The outcome of the Singapore market study was fed back to the participants, the nature and causes of rejection were identified, and measures to reduce rejection were discussed.

Baseline performance analysis

To measure the effectiveness of training benchmark data on per cent rejection, called 'bad orders' or 'BO', at *The Company* warehouse-cum-packinghouse was collected within three days of delivery in April 2009. The causes of rejection were also evaluated. Two months after training was conducted in Tupi information was again obtained to determine the changes in the proportion of rejects. Another set of data from two deliveries was again obtained in March 2012.

5.3 Objective 3. To enhance profitability and competitiveness through supply chain improvement for Philippines papaya

5.3.1 Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Market	Methodology
Domestic consumer response to quality improvements	Two shipment trials were conducted to determine market response to quality improvements in papaya. These were done in collaboration with *The Company* and two Metro Manila supermarkets to which it supplies fruits. 'Solo' papaya was sourced from *The Company*'s 'best supplier' co-operator in Tupi, South Cotabato. The interventions included harvesting at the recommended maturity and hot water treatment to control disease. Treated fruits were labelled with stickers. For the first trial involving an upscale supermarket, only *The Company*'s daily store inventories of treated papayas and the usual harvest were monitored, since an actual consumer survey was not allowed. The second trial included a two-day survey (using a one-page questionnaire) in another supermarket, coupled with a free taste test and hanging of a promotional tarpaulin poster on "Why Papaya Is Good For You". The team was provided with a small but visible area beside the actual fruit display near the entrance to the fresh produce section to conduct the product sampling and brief interviews. Customers passing by and/or those actually choosing papayas were asked to taste bite-size slices of treated fruits and then, if willing, were requested to answer questions on purchase decisions and provide some socio-demographic information.

Market	Methodology
Simulation of Middle East sea shipments	Green mature to colour break stage and defect-free 'Sunrise' papaya fruits were sourced from a member of the association in Tupi, South Cotabato. Fruits were individually wrapped in newspaper, packed in 15 kg carton boxes and air-shipped to Metro Manila. Upon arrival papayas were immediately transported to PHTRC, UPLB. Fruits were unpacked, sorted and randomly distributed to the different treatment combinations. HWT was done at 50°C for 10 minutes and then fruits were hydrocooled either in tap water or 125 ppm azoxystrobin for five minutes. They were allowed to dry and cool before packing. Fruits were subsequently half-wrapped with white paper. Zeolite bags with pinpricks were used for the MAP. EA were added into each MAP bag. Twelve treatment combinations were undertaken (see Appendix 2). Fruits were packed in cartons each containing six fruits. Simulating Middle East (ME) sea shipment, papayas were stored at 13°C for 14 days and then ripened naturally or induced by dipping in 2000 ppm ethephon at 25°C. A second experiment was conducted to determine the degree of disease control if HWT is modified by reducing the treatment time from 10 minutes to one, three or five minutes while increasing the temperature of the water. As in the first experiment, 'Sunrise' papaya fruits harvested at the mature green to colour break stage were used. Fruits were treated for 24 hours after harvest. Temperatures tested were 53°C, 55°C and 57°C with dipping times of one, three and five minutes. This was followed by hydrocooling for 5 minutes, either in tap water or in 125 ppm azoxystrobin. The usual 50°C, 10 minute dip was included for comparison. Untreated fruits served as control. Since it was shown in the first trial that ripening of papayas can be retarded even without MAP, the second trial did not use MAP. Papayas were placed in polystyrene cups and packed in cartons. Storage periods at 13°C were 18 and 21 days, based on the feedback of the shipper. After the desired storage period papayas were transferred to 23°C for ripening. Evaluations of peel colour and disease incidence were done after three and five days at 23°C. The same indices or ratings for the different parameters, as in the first experiment, were followed.
Actual Middle East sea shipment	Sea shipments in Dubai and Abi Dhabi were done by a company based in Davao in 2012. The papaya suppliers and the exporter followed the harvesting and postharvest handling guidelines developed by the project.
Simulation of Singapore sea shipment	'Sunrise' papaya fruits were obtained from a Matutum Tropical Fruit Association (MATROFA) member at colour stages 2 (colour break) and 4 (more green than yellow). Fruits were air-freighted to Manila and transported to PHTRC, UPLB. Fruits were again sorted as to peel colour and freedom from defects then subjected to hot water treatment (50°C, 10 minute dip) followed by hydrocooling either in water or in 125 ppm azoxystrobin. During cooling half of each treatment was treated with 2000 ppm ethephon by wiping only the stem end. After cooling papayas were placed in polystyrene caps, packed in cartons (eight fruit per carton, with a net weight of about 5 kg) and stored at 15°C or 18°C for seven days. After removal from storage papayas were ripened at 25°C and ripening behaviour was monitored daily. This market requires that the papaya should arrive in Singapore at near-ripe stage after seve day sea shipment and be ready for distribution to supermarkets.
Actual Singapore sea shipment	Together with some smallholder growers, the co-operator had established linkages with a Davao-based exporter and started shipping to Singapore in February 2012 following the guidelines for sea shipment developed by the project.

5.4 Objective 4. To enhance profitability and competitiveness through supply chain improvement for Australian papaya

5.4.1 Identify and mobilise commercial partners who can champion improvements in papaya chains and where benefits and cost savings are shared by all members of the chain

Two target supply chains were identified in consultation with industry, with a focus on access to selected domestic markets and those who are able to drive supply chain improvement and motivate their chain partners to work with them. The supply chain represented the two major growing regions of 'Tableland' and 'Coast' in north Queensland.

A third supply chain from coastal north Queensland was engaged in the third year of the project as a result of the initial studies. This third business was an innovative company that was prepared to make large investments in supply chain improvement.

5.4.2 Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Two consignments for each supply chain and season of activity were monitored for quality and handling practices and conditions. Results were reviewed and analysed to determine areas for improvement.

The handling systems were mapped and monitored to identify significant areas of fruit quality deterioration in the physical supply chain. A process of sequential sampling was undertaken to identify key practices that influence quality. After sampling, fruit samples were held under standard conditions and assessed daily.

The fruit sampled was of commercial quality and harvested and handled under industry best practice. Fruit quality and handling conditions were monitored from the packhouse to the wholesalers' stands in Brisbane and Sydney.

The quality and handling practices and conditions of papaya in each stage of the chain—such as in storage, grading, transportation, ripening, buying, selling, processing, packaging and merchandising—were monitored. Monitoring fruit quality and conditions at specific points in the chain identified practices that reduce quality and areas for improving product handling and reducing wastage.

As a result of the monitoring, performance was benchmarked and steps identified where quality is lost. Processes where improvement is possible were discussed with the three key businesses and the other members of the supply chain. They identified areas where basic information was lacking and improvements were possible. Thus a number of interventions were trialled to test potential supply chain improvements. These were based on the monitoring results, recommendations from the literature, and experience with similar tropical fruit products in the supply chain.

Improvement projects included:

Improvement projects	Methodology
Two papaya hybrids, ethrel vs no ethrel, four ripening temperatures in wet season (see Appendix 3) Value addressed—disease	Commercially mature papaya fruit of hybrids 1B and RB1, harvested during the wet season (March 2010) from sites near Mareeba (Tablelands) and South Johnstone (Coast), were subjected to four ripening temperature treatments (18°C, 22°C, 26°C and 30°C) for 2.5 days followed by two days at 14°C to investigate their effects on subsequent fruit disease expression and overall fruit quality. Prior to ripening fruit were dipped in Sportak® (55 ml/100 L) and Ethrel 480 (250 ml/100 L) or Ethrel alone.
Experiment—location, two papaya hybrids, three ripening temperatures in dry season (see Appendix 4) Value addressed—disease, peel colour	Commercially mature papaya fruit of hybrids 1B and RB1, harvested from a site near Mareeba (Tablelands) and South Johnstone (Coast), were subjected to three ripening temperature treatments (22°C, 26°C and 30°C) for 2.5 days followed by two days at 14°C to investigate the effects of simulated on-farm ripening and transport conditions on subsequent fruit disease expression and overall fruit quality.
Six fungicide sprays, coastal location, wet season (see Appendix 5) Value addressed—disease	Commercially mature papaya fruit of 'Sunrise', harvested during the wet season (April 2010) from the DAFF South Johnstone Research Station, were ripened at 26°C (2.5 days), cold-stored (two days at 14°C) and then assessed over nine days at 23°C for disease development. Fruit had previously been sprayed in the field with one of six fungicides plus an untreated control, consisting of (1) Copper hydroxide as Kocide, (2) Cuprous oxide as Red Copper, (3) Copper hydroxide + metalaxyl-M as Ridomil Gold Plus, (4) Dimethomorph as Acrobat, (5) Metiram+ pyraclostrobinas Aero, and (6) Chlorothalonil as Bravo WeatherStik.

Improvement projects	Methodology
Treatments with hot water, fungicides, chitosan early in wet season (see Appendix 6) Value addressed—disease	Treatments were: • Control (no treatment) • Hot water dip (48°C for 20 minutes) • Hot spray (51°C for 5 minutes) • Fungicide treatment (Sportak®—55 ml per 100 L) • Chitosan coating (1.5% solution)
Papaya harvested from trees 15, 17, 19, 24 and 29 months of age (see Appendix 7) Value addressed – disease	Disease development assessed for papaya trees 15, 17, 19, 24 and 29 months of age.
Papaya treated with fungicides (Diczbalis *et al*. 2011) Value addressed—disease	After harvest 1B papaya were treated with Sportak® (5 rates) or not treated, and also with Amistar® and Scholar®.
Assessment of commercial Sportak® use patterns and evaluation of sample dips and sprays for prochloraz concentrations (Diczbalis *et al*. 2011) Value addressed—disease	Sportak® solutions were taken from grower packing sheds and subsequently analysed for pH and concentration of prochloaraz (active ingredient).
Optimum maturity harvest date new papaya hybrid (see Appendix 8) Value addressed—sweetness	Harvesting of fruit at 20–49% colour break produced the optimum trade-off in terms of postharvest shelf-life and internal quality.

In all cases the trials were replicated. Laboratory simulations were with fruit sourced from commercial operators from the two major growing regions in north Queensland. The methodology used is described in detail in the individual trial reports in the Appendices of this report or in Diczbalis *et al.* (2011).

5.4.3 Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

The monitoring of commercial consignments from the three collaborating businesses and discussions with key members of their supply chain identified postharvest rots as a major contributor to supply chain failure. While all trial interventions had the objective to reduce disease, the role of pre-shipment ripening temperature was the intervention considered to have the most immediate impact on the supply chain and specifically on ripe fruit performance. The lowering of ripening temperatures during the wet season was adopted by all three collaborating businesses. The subsequent changes in the handling systems (see 5.4.2) were studied to determine if supply chain performance was improved and if there were any unintended consequences on supply chain performance and delivery of fruit to meet customer specifications.

Fruit quality and handling conditions were monitored from the packhouse to the wholesalers' stands in Sydney and Melbourne. Data recorded included supply chain process flow, temperature profiles through the supply chain, quality assessments at different points in the supply chain and discussions with key supply chain members.

6 Achievements against activities and outputs/milestones

Objective 1. To finalise component planning and identify collaborative opportunities

no.	activity	outputs/ milestones	completion date	comments
1.1	Identify collaborating R&D partners to undertake collaborative research in the Philippines to facilitate supply chain analysis and interventions to improve supply chain performance	Collaborating R&D partners identified to undertake collaborative research in the Philippines to facilitate supply chain analysis and interventions to improve supply chain performance	PC 2009	A multidisciplinary team composed of socio-economists, a community development specialist, postharvest physiologist and engineer were identified to undertake value chain analysis. Interventions were identified.
1.2	Identify and mobilise commercial partners who can champion improvements in tropical fruit supply chains and where benefits and cost savings are shared by all members of the chain	Commercial partners identified and mobilised to champion improvements in tropical fruit supply. Refined methodology acceptable to project partners.	PC 2009	The original intent for the development of an export chain to China or Japan was not achieved as collaborators would not commit to whole of chain improvement. Thus the project focused on a domestic papaya supply chain with fruits coming from South Cotabato in the Southern Philippines and distributed in various supermarkets in Metro Manila and outlying provinces. Engaged the collaboration of *The Company* supplying papaya fruits to different supermarkets in Metro Manila and outlying provinces.

PC = partner country, A = Australia

Objective 2. To identify opportunities and constraints through supply chain analysis for Philippines papaya

no.	activity	outputs/ milestones	completion date	comments
2.1	Identify present market needs and likely future opportunities for Philippine papaya in domestic and exports markets	Scoping study report submitted to ACIAR	PC 2010	Only the Philippines domestic market supply chain was scoped. Market needs were identified through consumer research. Export market (Middle East and Singapore) needs were identified only during the later part of the project through market linkage promoted by the MAO of Tupi South Cotabato and the GEM program of USAID.

no.	activity	outputs/ milestones	completion date	comments
2.2	Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain	Two supply chains' performance mapped and confirmed; impacts on performance quantified; key informants identified ; improvement opportunities scoped	PC 2010–2011	The value chain analysis (VCA) used in the project was different from the usual supply chain analysis in that the focus was on delivering consumer-defined value. Capability building on VCA provided by the Australian collaborators (Ray Collins and Tim Sun) proved to be very useful and a new learning experience for Philippine researchers. Three supply chains were mapped but only one was pursued to undertake value chain improvements. Two rounds of interviews with stakeholders in the supply chain identified strengths and weaknesses in information flow and relationships. Consumer surveys combined with chain mapping enabled activities along the chain to be characterised as value adding, necessary but non-value adding or wasteful which served as a basis for identifying improvement opportunities.
2.3	Develop training resources to be used to improve supply chain performance	Farmers and supply chain businesses informed about key project findings	PC 2011–2013	Training materials were developed and used during the training of papaya growers, shippers, traders and *The Company* personnel involved in papaya procurement and merchandising. The training held in Tupi, South Cotabato was jointly implemented by C1 and C3 papaya projects of the Fruits Program in cooperation with the Municipal Agricultural Office of Tupi and GEM program of USAID. It was held on 24–25 May 2011 in Tupi, South Cotabato with 55 participants. Material for five training modules on postharvest handling was developed, as were postharvest handling guides in cartoon form. Training of 26 *The Company* staff on papaya postharvest handling was held on 16 July 2011. Two separate half-day trainings of 18 grower-suppliers and six harvester-labourers on the proper postharvest handling of papaya were conducted in May 2012 in the production areas in Tupi, South Cotabato. Training on papaya harvesting and postharvest handling of papayas for the Singapore market was held on 30 November 2013 in Tupi, South Cotabato. There were 24 participants consisting of grower-suppliers, harvesters, packinghouse personnel and quality control staff of the exporter.

PC = partner country, A = Australia

Objective 3. To enhance profitability and competitiveness through supply chain improvement for Philippines papaya

no.	activity	outputs/ milestones	completion date	comments
3.1	Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain	Improvement plans developed by two supply chain groups	PC 2010	Grower-shippers as well as *The Company* realised the benefits of hot water treatment for disease control but it appeared that neither stakeholder wanted to venture further with a hot water treatment facility due to the initial costs involved. The local government of Tupi was willing to provide funds for a hot water treatment facility with the impending export shipments to Singapore and the Middle East. However, instead of the local government, the GEM program of USAID provided the hot water tank and the plastic crates to the association. Realising the benefits of improved handling system, one grower-shipper invested in a modest packinghouse with hot water treatment facility. He was the co-operator during the two Middle East sea shipments, which was not sustained due to the problem of payments.
		Improvement plans refined by supply chain groups	PC 2012	The trials were done in collaboration with *The Company* and two Metro Manila supermarkets to which it supplied papayas. The shipments included labelled fruits (with stickers) harvested at the recommended maturity and subjected to hot water treatment for disease control. *The Company* realised that treated fruits had better quality and appearance. Consumer surveys were allowed only in the second trial, where a free taste test and hanging of an educational poster on the benefits of eating papaya were also done. In both trials, treated fruits sold better and faster than the usual harvest. Interviews indicated that consumers were willing to pay more, buy more, and purchase more often those papayas of improved quality. Harvesting and postharvest handling guidelines for sea shipment to Singapore developed by the project resulted in sustained export but was limited to only 200 cartons of 5 kg per carton. With increased volume, quality problems arose due grower-suppliers having limited production. Other farmers were watching the result before taking action.
		Improvement plans developed by extra supply chain groups	PC 2012–2013	Baseline performance analysis indicated 37–73% reduction in papaya rejection or 'bad orders' of the grower-shipper within the three day holding at *The Company* packinghouse.

PC = partner country, A = Australia

Objective 4. To enhance profitability and competitiveness through supply chain improvement for Australian papaya

no.	Activity	outputs/ milestones	completion date	comments
4.1	Identify and mobilise commercial partners who can champion improvements in papaya chains and where benefits and cost savings are shared by all members of the chain	Commercial partners identified and mobilised to champion improvements in tropical fruit supply. Refined methodology acceptable to project partners.	A 2010	Three major papaya supply chains were engaged. Supply chain performance in the wet and dry season was measured from harvesting to ripening and transport to wholesale markets. The three businesses are identified as the major and most innovative commercial chains in the Australian papaya industry.
4.2	Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain	The supply chain performance mapped and confirmed; impacts on performance quantified; key informants identified ; improvement opportunities scoped	A 2010–2013	Mapping and validation completed. Postharvest diseases were identified as the major reason for supply chain failure. Fruit rots particularly in wet season harvested fruits are a major contributor to supply chain losses and lack of confidence in the supply chain. Improvements to disease control were tested as disease was a major cause of wastage. Improvements in pre- and postharvest temperature management and ripening were identified and tested.
4.3	Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain	Improvement plans developed by two supply chain groups	A 2011	The two original collaborating businesses and the additional collaborator each adopted lower ripening temperatures for wet season fruit as a major supply chain improvement.
		Improvement plans refined by supply chain groups	A 2012	This change to supply chain practice was monitored and evaluated to ensure that improvements were available in commercial practice and that there were no unintended consequences of changing practices. Recommendations for improvements to preharvest fungicide schedules and the application of postharvest chemicals were finalised.
		Improvement plans developed by extra supply chain groups	A 2012	In addition to the third collaborator trialling the supply chain improvements the improved practices have been promoted to the papaya industry through industry meetings and publications. This has resulted in the partial adoption of improvements.

PC = partner country, A = Australia

7 Key results and discussion

Comprehensive results of the research conducted in the Philippines are reported in Esguerra *et al*. (2012), see Appendix 2 in this report. A summary of the work follows:

7.1 Objective 1. To finalise component planning and identify collaborative opportunities

A brief summary of the outcomes for this planning objective is provided in section 6.

7.2 Objective 2. To identify opportunities and constraints through supply chain analysis for Philippines papaya

7.2.1 Identify present market needs and likely future opportunities for Philippine papaya in domestic and exports markets

Domestic supply chain mapping

The town of Tupi in South Cotabato is currently the major source of 'Solo' papaya fruits distributed in different supermarkets and wet markets in Metro Manila and outlying provinces. Papaya supply chains are typically multi-layered and disaggregated, with high levels of wastage. From the farm until the papaya reaches the retail market or the supermarket it undergoes 10 to 12 handling steps. In *The Company* warehouse rejection ranged from 14–30% per shipment. Rejection was due to mechanical damage (bruising and compression) and latex stain and diseases, notably stem end rot (see Appendix 2, Table 2). A wide variation in the maturity of the fruit was also identified as a major problem, resulting in ripe papaya fruits having a taste described as 'flat' or not sweet.

Value chain analysis

Information and relational flows

VCA looked at both the effectiveness and efficiency of the chain to see where it could become more competitive. It identified opportunities for improvement to meet consumer-defined attributes in the product. The major players or stakeholders in the chain were engaged in mapping the material, information and relational flows to determine what drives the chain as a system.

The results of the interviews pointed to strong and two-way information flows among junior managers, supervisors and even merchandisers. These are the personnel of *The Company* who are in the supermarket outlets and who are in contact with consumers. Information is freely shared on a timely basis among them. Moreover, all the chain members are aware of *The Company*'s goals of a 15% increase in sales and reducing 'bad orders' (rejects) to 5%.

One upscale supermarket allowed store observations and an interview with their supervisor (SPV). This supermarket maintains a good relationship and open communication with *The Company* staff. However, despite this open communication, the inconsistent quality and supply of papayas remains the major concern of the store SPV. Lack of sweetness and bitterness of the fruit were the common complaints of consumers; complaints that are usually addressed by just replacing the fruit. The SPV identified the need for technical training of *The Company* staff on proper postharvest handling.

Regarding the broker of papaya to *The Company* and the grower-cum-shipper, trust is apparent with the broker responsible for sourcing and delivering the papayas to *The Company* warehouse in Paranaque, while the grower-cum-shipper takes charge of harvesting, packing and shipping. The role of the broker is valued by *The Company* since he eliminates risks such as sourcing of fruits. There is apparently poor consumer insight at the grower-cum-shipper's level, as he is only concerned about the blemish-free and colour break stage maturity requirements of *The Company*. It is interesting to note, however, that just like other growers in Tupi, he harvests not only the colour break but also the other two fruits immediately above. He does not consider sweetness as a quality attribute since, according to him, consumers are only attracted to good-looking fruits.

In all interviews with the stakeholders, except the grower-cum-shipper, problems reported with regard to papaya were as follows: inconsistent quality, immaturity, poor ripening or failure to ripen, low or no sweetness, bitterness, and decay. Growers, on the other hand, indicated that pests and diseases were major problems.

From these series of interviews and mapping, the flow of information is characterised as partial between the grower/shipper and *The Company* and the relationship strength is only basic or transactional. On the other hand, a strong relationship and two-way information flows exist between input suppliers and the grower and grower/shipper. Between *The Company* and the consumer the relationship is also basic and information flow is only partial.

Mapping the product/material flow

Mapping the flow of papayas from the farm to *The Company* packinghouse (Figure 1) revealed losses along the supply chain. The maturity index used is the appearance of a trace of yellow at the apical portion of the fruit (termed 'Silay' or S1). At harvest there are 10–15% field rejects attributed to immaturity, off-shape or deformation, insect damage due to scale insects and white flies, old bruises, decay, and 'choco' spots.

To identify improvement possibilities, the activities in the chain from the input supplier to the consumer were categorised as:

- value adding (V) (create an attribute that consumers value and will pay for);
- necessary but non-value adding (N); or
- wasteful (W).

In the case of the grower/shipper fertilisation and harvesting (in terms of maturity) are considered as value adding activities as these determine the quality of the fruit, particularly the level of sweetness. For the broker receiving papaya at the port and transporting them to the packinghouse/warehouse of *The Company* are necessary but non-value adding. At *The Company* packinghouse the value adding activities are sorting and ripening with ethephon (Ethrel). Re-sorting and re-packing are value adding but can also be considered as wasteful due to repeated handling that damages the fruit. Rejects are considered as waste. At the supermarket the value adding activities are cutting the fruit into halves and packing them in polystyrene trays with plastic film overwrap or having the papayas minimally processed (peeled, sliced and packed) or served as fresh cuts. Most of the activities in the supermarket, such as replacing old stocks and replenishing the display, are necessary but not value adding.

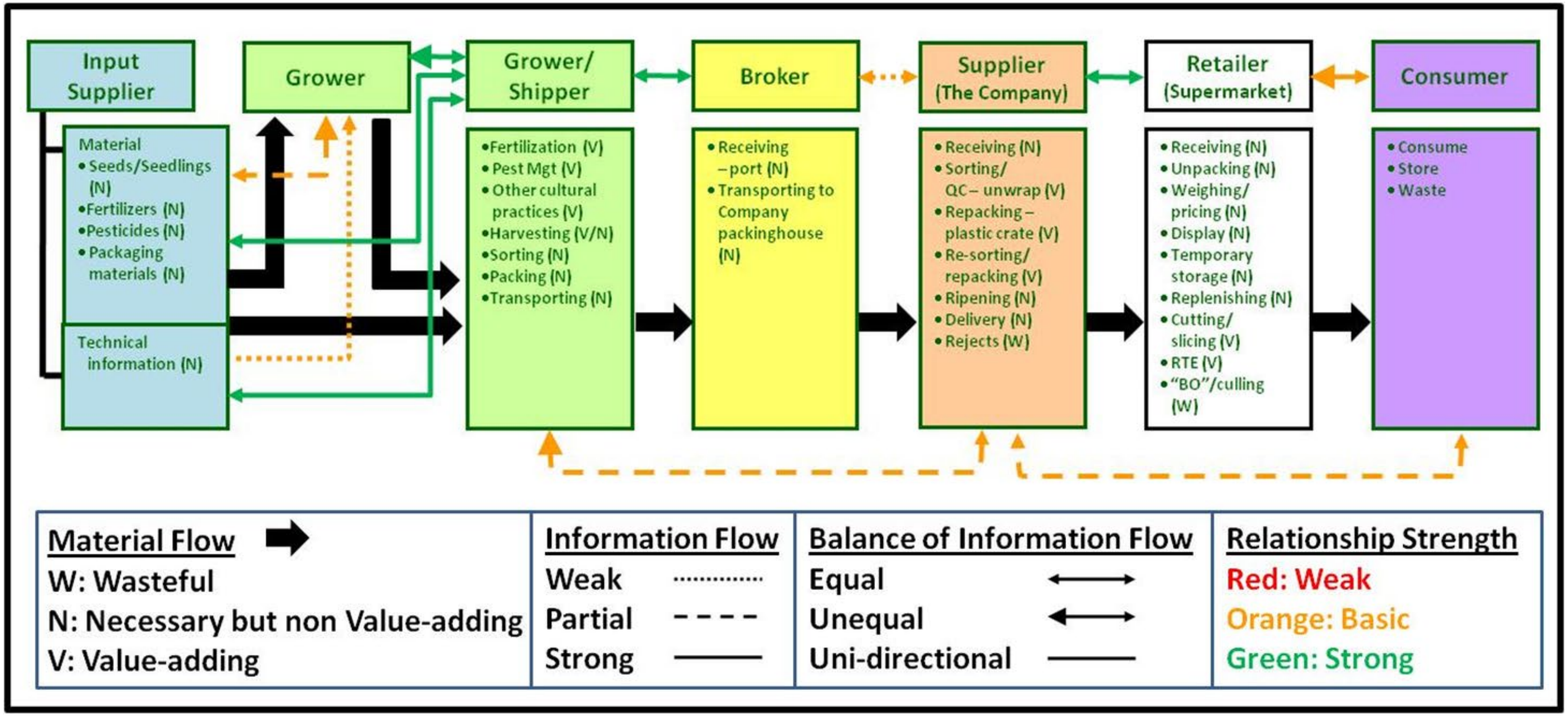

Figure 1. Current state of the papaya value chain indicating the information flow, strength of relationships among the stakeholders and the categories of material flow.

Based on the analysis of the current state of the value chain, the desired (improved) state of the chain is presented in Figure 2. The stars indicate the improvement opportunities to meet the quality attributes desired by consumers in a papaya fruit.

The results of the experiments on quality improvement opportunities that focused on maturity, regulation of ripening and disease control are presented below.

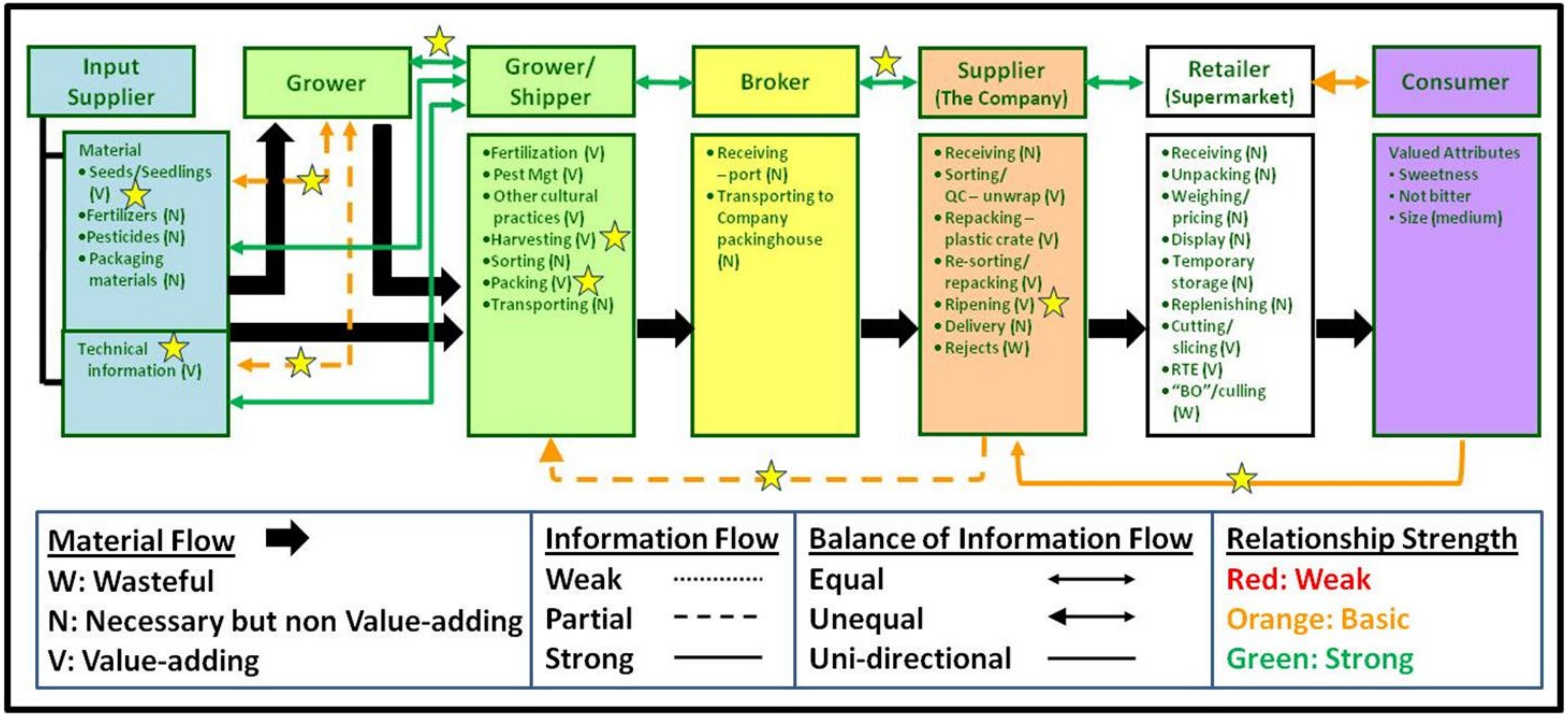

Figure 2. Desirable future state of the papaya value chain.

Understanding consumer preferences

Focus group discussions

The results of two focus group discussions (FGD) revealed that papaya is mainly purchased and consumed for its health benefits and rarely as a gift, unlike other fruits such as banana and mango. Respondents buy papayas from public markets, supermarkets and fruit stands; the first being the most common. Frequency of purchase among FGD participants varied from once to twice a month. In fruit selection consumers are very particular about appearance, followed by ripeness and, lastly, size. Based on appearance they prefer fruits that are smooth, with good colour (yellow-orange) and are bruise/defect free. They usually buy papayas at the ready-to-eat stage of ripeness. Lack of sweetness is what usually disappoints papaya consumers, which they attribute to immaturity of the fruit. Accordingly, they are willing to pay for better quality papaya but only to an upper limit of PhP 35 per kg.

Consumer survey using structured questionnaire

Of the 232 papaya consumers who participated in the survey the great majority were female (83%), aged 40–59 years old (56%), married (63%) and generally employed (77%). The common household size is less than five (48.6%), though 42.9% have five to seven members. Over 40% of respondents buy papaya frequently—16% purchase daily or two to three times a week—and 28% buy papaya once a week. By income group the majority of the mid to high income earners are frequent buyers (daily to twice a week). These parameters could form a basis for segmenting the market and developing marketing strategies to increase papaya sales.

Papayas are most commonly bought in public markets (41%), followed by supermarkets (27%) and fruit stands (27%). While public markets still predominate supermarkets are becoming more popular as consumers increasingly prefer more modern markets as a source of fresh produce. In the Metro Manila area supermarkets have a 79% share of the total food market (Catelo 2005).

Based on the usage, attitude and image survey, the main reason for buying papaya was for health and nutritional concerns (61%), followed by a liking for its taste (20%) and impulse buying (8%). Consumers were generally concerned with the overall quality attributes of papaya, topmost among which were sweetness (27%), overall quality (15%) and colour (15%).

Based on external attributes consumers preferred medium-sized fruits with full yellow peel colour and free from blemishes and decay. For the internal attributes pulp with a yellow-orange colour, average sweetness and 'just right' firmness/texture were desired. The aforementioned quality attributes that consumers value in a papaya are indicative of improvement opportunities that can be captured either separately or in combination with each other as has been suggested earlier, and consistent with the recommendations of Thomas (2005) for other fruits and vegetables. These are (1) by improving the inherent potential of the variety, (2) by optimising the conditions under which the plants are grown, and (3) by optimising the handling and storage of the produce. In developing quality improvement plans Collins (2009) suggested to focus on the question: "Where is the consumer value in what we are proposing to do?".

The majority (62%) indicated satisfaction with their current purchases of papaya. However, some were disappointed in the quality of fruit bought because of such attributes as lack of sweetness (37%), uneven ripening (19%), poor texture (11%), off-flavour (11%), and bitterness (11%). The main cause of disappointment with internal attributes was immaturity of fruit. Nevertheless, even with the availability of other fruits, 91.7% were still willing to buy papaya, but more importantly, 87.3% were willing to pay more for good tasting fruit.

Respondents were also asked to rate the importance of each attribute identified earlier in their purchase decision using the following scale: 1 = very important, 2 = important, 3 = indifferent, and 4 = not important. Based on these ratings the top five quality attributes in order of importance were: absence of decay/damage (1.34), sweetness (1.39), maturity (1.56), texture (1.60), and price (1.68). Price, though not a product attribute, is always a consideration in the consumer's purchase decision and was ranked fifth in this survey.

Assessing papaya attributes preferred by consumers using conjoint analysis

Consumers buy products based on attributes that appeal to them. Since not all the attributes they look for are typically present in one piece of fruit consumers usually make trade-offs by settling on combinations of desired attributes. In the case of papaya for example, some consumers may value peel smoothness more than sweetness at a given price level, while others may value sweetness more than peel smoothness even at a higher price. The joint effects of product attributes and price on final purchase decisions are often not accounted for in ordinary consumer surveys and this is one reason for adopting conjoint analysis in consumer research and, in particular, this study on papaya. Conjoint analysis can provide a better understanding of the real value consumers attach to specific attributes, including their relative importance (by attribute levels). As it is not possible to achieve 100% of what consumers want in a perishable biological product, conjoint analysis provides a realistic basis for developing value chain improvement initiatives to which consumers will respond positively. It is also useful in product concept identification, pricing and market segmentation.

There were four attributes considered in the conjoint analysis, each broken down into three levels. Although, as noted above, price is not an attribute of quality it is a determinant of purchasing behaviour, therefore it was included in the analysis. Initially, the full profile of product attribute combinations (18 profiles on one card) was used. To ascertain the reliability of the full profile presentation (which is prone to information overload), a partial product presentation using three profiles per card at a time was also conducted.

Based on these results, similar trends were observed. The papaya attributes that consumers preferred in order of importance were the presence/absence of decay/damage, sweetness, peel colour and price.

Conjoint results are also useful for market segmentation as a strategy for product positioning and thus another survey was performed. Using cluster analysis two market segments were identified and named as the aesthetic-conscious group and the taste-sensitive group. The former gave higher importance to presence/absence of decay and damage (44.29%) and the latter attached a premium to fruit sweetness (37.03%).

Clustering also showed sensitivity of these two market segments to price, unlike the results of the overall analysis which did not indicate or define preference to price (all utility values for the different price levels were negative). The taste-sensitive group were willing to pay for good quality papaya fruits up to PhP 40 per kg and the aesthetic-conscious group will pay up to PhP 30 per kg.

Establishing the objective value of sweetness described by consumers through sensory evaluation

Sweetness was one of the quality attributes desired by all consumers of papaya fruit. There is a need to establish an objective value for sweetness to serve as a basis for interventions during production and harvesting. A total of 88 fruits at the table ripe stage were sampled. Sliced fruits were presented to trained panellists for sensory evaluation and the corresponding Brix level of the pulp extracts were determined. The schedule of sensory evaluation, mean total soluble solids (TSS) content and sweetness rating are presented in Table 7 of Appendix 2. Based on the outcome of the sensory evaluation, fruits with TSS content of 9°Brix and below are less sweet and those with 10–12°Brix are sweet. At present, no fruit with greater than 12°Brix has been evaluated to provide data for a very sweet rating.

Correlation between peel and pulp colour and total soluble solids content

Both consumers and merchandisers of *The Company* associate peel and pulp colour with sweetness. According to them if the peel colour is yellow-orange and pulp colour yellow-orange to orange the fruit is sweet. Thus, correlation analysis between peel colour and total soluble solids content as well as pulp colour and total soluble solids content was done to determine whether peel and pulp colour can be used as indicators of sweetness. Importantly, results on 246 fruits showed no relationship between peel or pulp colour and sweetness.

Baseline performance analysis

Following the benchmark data gathering in April 2009 in *The Company* packinghouse with regard to the extent of papaya rejection, a follow-up baseline data gathering was conducted in 2011–12. The quality of 'Solo' papaya delivered by three papaya suppliers to the Paranaque packinghouse was monitored to determine changes or improvements in quality over time. The period under study included both peak and lean months of production and supply, that is October 2011 and March 2012 respectively. Key informants in the area reported that there is an excess supply of fruits in October and November while a production gap occurs during the summer months from February until May.

The original and the major suppliers (A and B) both had shipments during the period. Supplier A was *The Company*'s original and main supplier of six years, while Supplier B was currently the biggest source, supplying fruits from South Cotabato twice weekly for over a year. On the other hand the third and newest source (Supplier C), of barely eight months, had started deliveries only in March 2012.

Supplier B had a delivery (3.7 tons), which was more than double that of Supplier A. Interestingly he had a lower percent 'bad order' (BO) than Supplier A after three days of holding and evaluation, even though his shipment was delayed and was unloaded much later than the other supplier's lot.

Based on the benchmark data of 14.4% rejection or BO in April 2009, rejection or BOs were reduced considerably during the evaluation period of October 2011 and March 2012. Reduction in BOs ranged from 37% to 73%, which can be translated as a significant reduction in losses to the suppliers since BOs are returned to them and are not paid by *The Company*. Since Shipper 1 does not have local outlets in Metro Manila, where BOs that are still marketable can be forwarded and sold even at a lower price, he shoulders all the rejects reported at *The Company* packinghouse. The reduction in BOs therefore translates to increased revenue for the shipper, which could be shared by him with the growers in terms of higher farm price. Information on this aspect has not been gathered nor validated with the grower-shipper. This still needs to be examined.

Supplier B, on the other hand, still recovers part of his BO rejects since *The Company* brings BOs from his deliveries to his outlet in Balintawak market where the lower quality produce can be sold at a lower price. This fallback position could also be the reason why, despite *The Company*'s specific quota requirement, the Purchasing Manager reports that Supplier B always delivers more than the ordered quantity. Supplier C, on the other hand, has consistently lower BOs according to the Purchasing Manager and he also has outlets in Divisoria where BOs are sold at a lower price.

For all suppliers mechanical damage and disease were the primary reasons for rejection. These observations were fed back to the suppliers and possible solutions to these problems discussed with them, such as reducing the size of the wooden crate to reduce mechanical damage, and hot water treatment for disease control. However, these recommendations have not been adopted. The size of the wooden crate (60 kg capacity) cannot be reduced since the transport fee is on a container and not on a weight basis. In the case of hot water treatment there are no facilities in the area and they are not keen to invest in a facility, except for Supplier C since he is also targeting the export market. The local government of Tupi, through the mayor, had expressed interest in funding the fabrication of a hot water tank for use by papaya growers and traders. Instead of the local government providing assistance the GEM program of USAID provided the hot water tank and the plastic crates. One grower-supplier invested in a modest packinghouse with a hot water tank facility, plastic crates and sorting tables.

It is worth noting that the causes of rejection due to immaturity were not recorded during the three day evaluation. It cannot be concluded yet whether this was a result of the training conducted in July 2011, wherein the importance of maturity in relation to sweetness valued by the consumer was stressed.

During the conduct of experiments on maturity validation and during the training grower-suppliers were given an overview on how to improve the quality of their fruits. A simple comparison was performed to determine if there would be some changes in fruit sweetness even in a short period of time. Comparison was based on the total soluble solids content of fruit as well as its perceived sweetness during the sensory evaluation.

The first sampling for Suppliers A and B was done in April 2011 and in June 2011 for Supplier C. The second sampling for all growers was done in October 2011. Over this short period of time a slight increase in total soluble solids content was observed, thus improving the sensory sweetness rating for all fruit samples from the different grower-suppliers (Appendix 2, Figure 26). Since sweetness and TSS content of papaya fruits are good indicators of the growing condition and maturity of fruit at harvest, results of this comparison support that knowing and following proper preharvest practices and harvest maturity can greatly affect the overall quality of the fruit. Further samplings need to be done to continuously monitor the performance of grower-suppliers.

7.2.2 Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Results of the improvement projects included:

Improvement projects	**Key Results and Discussion**
Improving product quality through fruit maturity Value addressed—sweetness	There was a wide variation in the maturity of fruit at harvest. For fruits classified as M1, which is more mature (although yellow streak on the skin is not prominent), the yellow-orange pulp coloration was not yet apparent in some fruits. Fruits classified as M2 and M3, which growers consider mature, were immature based on pulp colour and low total soluble solids (TSS) content. That the M2 and M3 fruits were still immature was validated at the ripe stage, where their TSS content was very low. Thus, this maturity index used by the growers is not appropriate as it invariably leads to fruit that fails to meet consumers' needs in terms of sweetness (> 10°Brix). Papaya has a low starch content at harvest (about 0.1%), hence it will not be a sufficient carbon source for the increase in sucrose responsible for postharvest sweetening (Gomez *et al.* 2002). The dramatic increase in sugar content occurs when the seed and the pulp show colour (Chen *et al.* 2007). These are the reasons for the recommendation to harvest when yellow skin colour becomes prominent. Ethephon enhanced the ripening of papayas regardless of the stage of maturity but did not affect the physico-chemical properties of the fruit. (The 6–7% weight loss of the fruit at the ripe stage did not result in shrivelling. When not ripened with ethephon the rate of ripening was slow and not uniform within the lot. Most of the M3 fruits were still green even on the seventh day, indicating immaturity. Based on these results immaturity of fruit is one of the main causes of rejection at *The Company* packinghouse. These rejects are deducted from the total volume delivered by the grower-shipper, representing a significant economic cost.
Regulation of ripening: 1-Methylcyclopropene (1-MCP) treatment to retard ripening Value addressed—ripeness (peel and pulp colour)	Treatment of papaya fruits with 1-MCP at PCI 1 and 2 retarded ripening during the three day sea shipment from General Santos City to Manila. This is in contrast to the advanced stage of ripeness (more than 60% yellow) of control fruits. Treatment with ethephon (2000 ppm) five days after 1-MCP treatment hastened the peel colour change, particularly of colour-break fruits, attaining the full yellow colour on the eighth day. In the case of fruits treated with 1-MCP at PCI 1 and induced to ripen, although peel colour change was slow the rate

Improvement projects	**Key Results and Discussion**
	of colour change was comparable to the control. Fruit treated only with 1-MCP and not induced to ripen with ethephon failed to attain full yellow peel colouration. In this study, regardless of the papaya maturity, 1-MCP dramatically retarded fruit softening. Firmness values of the fruits ranged from 6.1–6.9 kg.cm^{-1} force compared to only about 2 kg force in the control fruit. Even with application of ethephon the fruit did not soften although peel and pulp colour were already yellow orange. The same results have been observed in ‘Gold’ and ‘Rainbow’ papaya in which the negative effect of 1-MCP on softening could not be reversed (Manenoi and Paull 2007). There was no treatment imposed to control disease prior to 1-MCP treatment to determine its effect on disease development. As the fruit ripens, stem end rot occurred in all treatments. The onset of disease occurred later in fruit treated with 1-MCP at PCI 1 than those fruit treated at PCI 2 but the severity was significantly lower compared to other treatments. The occurrence of disease is the primary reason for shelf life termination.
Modified atmosphere packaging (MAP) during sea shipment Value addressed—ripeness (peel and pulp colour)	The control crates (no ethylene adsorbent (EA)) with fruit harvested at S1 (green stage), both from Farmers 1 (Nimes) and 2 (Concepcion), were of mixed ripeness although the majority were at colour break stage. When harvested at a more advanced S2 stage (colour break), fruits from Nimes were already nearing ripeness (PCI 4.4) upon arrival in Manila, validating the claim of the shippers that more mature fruits are not fit for long distant shipment. The use of EA in retarding ripening worked best in a sealed package such as in PEB lined wooden crates. However, in the case of S2 fruits from another grower-shipper (Concepcion), ripening was also retarded when EA was used in wooden crates with used cartons as liners. When polyethylene (PE) bags were used as liners and 30 EA were used ripening was completely retarded in both S1 and S2 fruits. This was attributed to the modification of the atmosphere inside the PE bag resulting in the retardation of ripening. However, the use of PE bags led to a high incidence of decay due to high relative humidity inside the bag. When the fruits from PE bags were ripened at ambient temperature (28–30°C), simulating the holding condition at *The Company* warehouse in Manila, S1 and S2 fruits did not attain the full yellow peel colour even with the application of ethephon. On the other hand, fruits packed in crates with and without EA ripened normally, although S1 fruits exhibited a slower rate of ripening compared with S2 fruits in the case of those sourced from Nimes. Differences were likewise observed on the ripening rate of S2 fruits from the two grower-suppliers. While S2 fruits from Nimes ripened fast S2 fruits from Concepcion ripened at a slower rate, with the fruit attaining PCI 5 (yellow with green tips) on the seventh day when allowed to ripen naturally. When treated with ethephon fruits were almost ripe on the third day. At the ripe stage S1 and S2 fruits from the control treatment were subjected to sensory evaluation to determine if there are differences in sensory attributes. As shown in Appendix 2, Figure 18, there were no marked differences in sensory attributes of S1 and S2 fruits from the two suppliers although hedonic (overall acceptability) rating for S1 fruits coming from Nimes was higher than that of Concepcion. Peel and pulp colour at the ripe stage were rated high (3.2–3.5; yellow-orange) and almost the same rating was given for S1 and S2 fruits. However, when it comes to sweetness S2 fruits received higher sensory ratings than the S1 fruits, although the total soluble solids content at the ripe stage did not vary markedly with S1 fruit having 8.8°Brix and 9.2°Brix for S2 fruits at the ripe stage. From the results of these trials it appeared that S2 fruits would meet the requirement of the consumer with regard to sweetness. However, the three day shipment at high temperatures led to premature ripening and, in some fruits, over ripening upon arrival in Manila. Follow-up handling trials were planned to be conducted on the method of EA application and modification in the use of PE bags. Unfortunately, the follow up did not occur. This technique should be combined with field application of hot water treatment for disease control.
Reducing heat treatment time with different temperature-time combinations Value addressed—freedom from rots	Marketability and shelf life of papaya fruit are limited by diseases particularly anthracnose caused by *Colletotrichum gloeosporioides* (Penz) and stem (end) rot caused by *Phoma caricae-papayae* (Tarr.) (Martins *et al.* 2010). These diseases become a problem when fruits have more than 40% skin yellowing. Heat treatments have been used in papaya to control decay (Couey *et al.* 1984). Previous Australian funded projects at PHTRC-UPLB had optimised the temperature-time combination for HWT of Philippine-grown ‘Solo’ papayas and this served as the basis of this experiment.

Improvement projects	Key Results and Discussion
	High HWT temperature (57°C) and long dipping time (5 minutes) resulted in poor colour development with fruits not attaining full yellow peel colour after nine days under ambient conditions. The lowest incidence and severity of anthracnose among the different treatments done immediately after harvest was observed in fruits treated at 57°C for 5 minutes. However, this treatment combination was not recommended due to abnormal peel colour development brought about by the high temperature. Treating fruits at 53°C for 5 minutes gave better peel colour development and good disease control. In these treatments anthracnose incidence and severity was very low and almost comparable with the usual 50°C, 10 minute dip treatment. Moreover, incidence of stem end rot was also lower compared with the usual 50°C, 10 minute dip. The other temperature-time combinations, particularly those at higher temperatures, did not give adequate disease control. Sweetness of ripe papaya fruits as estimated by Brix was not affected by the different treatments but the highest rating was observed from fruits treated at 57°C for 5 minutes with average total soluble solids content of 11.5°Brix (data not shown).
Effect of delayed hot water treatment (dHWT) on degree of disease control Value addressed—freedom from diseases	This trial demonstrated the effectiveness of HWT (50°C, 10 minute dip) in reducing or controlling the incidence of decay of the different varieties of papaya even with the delays in the application of HWT. For 'PPY' and 'Sunrise' anthracnose apparently is not the problem but stem end rot (SER) is. On the other hand, 'Red Bonita' is susceptible to anthracnose and HWT only reduced the incidence, although severity of anthracnose infection was only slight. Anthracnose is initiated in developing fruit in the field and symptoms show up later after harvest (Alvarez and Nishijima 1987), hence the need for timely preharvest fungicide sprays. HWT can only reduce, but rarely eliminate, infection once established (Couey *et al.* 1984). Even with delayed application of HWT reduction in disease incidence ranged from 33–100% depending on the variety and source of fruit.
Comparison between on-farm HWT and delayed HWT Value addressed—Freedom from diseases	The results of the preliminary trial of on-farm versus delayed application of HWT showed the incidence of both stem end rot and anthracnose was reduced by hot water treatment. Unexpectedly, delayed application of HWT (done four days after harvest when peel colour was still at colour break stage) resulted in a better disease control than on-farm HWT which was done on the day of harvest. The incidence of 'choco' spot was also reduced by HWT. Another trial needs to be conducted to validate the results obtained. In this batch of fruits stem end rot was more of a problem than anthracnose since the onset of the latter disease was observed only when fruits were already at advanced stages of ripeness, that is at PCI 4–5, while that of stem end rot occurred when fruits were still at PCI 3 (more green than yellow). Moreover, severity of stem end rot infection was higher than that of anthracnose.

7.2.3 Develop training resources to be used to improve supply chain performance

Enhancing awareness of improved production and postharvest handling techniques can be made possible through training activities.

Training on papaya production and postharvest handling

Since a total systems approach was envisioned in project implementation the C1 project component (supply chain) linked with the C3 papaya component in the conduct of a two day training course on 'Papaya Production and Postharvest Handling', which was held on 24–25 May 2011 at the Training Hall of the MAO of Tupi, South Cotabato. Participants included 52 growers, grower-shippers and traders of papaya whose markets are mainly Metro Manila, Iloilo and Cagayan de Oro City. There were also three representatives of an exporting firm, Diamond Star Agro-Products Inc.

Five modular PowerPoint presentations were developed and used during the training. In all the topics the results of the consumer survey, the value chain analysis conducted in the papaya chain, and the improvement opportunities aimed at delivering the attributes in papaya valued by the consumer were discussed with the participants.

Training of papaya grower-suppliers and labourers

Building the capacities of the different stakeholders in the value chain was an integral component of the project. Having identified and technically addressed the chain improvement opportunities that will deliver what consumers value in 'Solo' papaya, two separate half-day trainings on the proper postharvest handling of the fruit were conducted on 18 May 2012 in the production areas in Tupi, South Cotabato. The idea was to provide feedback to the growers and suppliers of the results from both consumer and postharvest studies, for them to have a better understanding and appreciation of why improvements are needed, and to encourage them to do their part in ensuring improved product quality in order to maximise value creation and management along the chain.

Six harvesters and labourers of Supplier 1 attended the morning session in Brgy Poblacion, while 18 regular growers of Supplier 2 in Brgy Cebuano participated in the afternoon schedule. The activities were practical free-wheeling forum-discussions anchored on a PowerPoint presentation that highlighted the results of the consumer survey, particularly those attributes that buyer's value in 'Solo' papaya, and the findings of the value chain analysis which mapped the farm-to-market product flow, the nature and extent of losses along the chain, and the improvement opportunities to reduce losses, maintain produce quality and deliver consumer-defined value.

Training of The Company personnel

Training of *The Company* personnel (26 participants) involved in papaya procurement, receival, quality control, sorting and merchandising was conducted on 29 July 2011 in the conference room of *The Company* in Parañaque City. The training was held only for half a day since all participants needed to be back working in the afternoon. The training was aimed at familiarising staff with different postharvest handling techniques to maintain quality and minimise damage and losses during sorting, packaging, distribution and retail display.

Training of stakeholders of papaya for export to Singapore

As an off-shoot of the feedback from the importer in Singapore and the Davao-based exporter regarding erratic volume of shipments due to quality problems (failure to ripen and decay), training on improved harvesting and postharvest handling was conducted in Tupi, South Cotabato on 30 November 2013. There were 24 participants, consisting of grower-suppliers, harvesters, packinghouse personnel (classifiers, HWT operators, packers) and quality control staff of the Davao-based exporter to Singapore. The training was primarily aimed at analysing the causes of rejection in Singapore, identifying where in the chain did problems occur, and what needs to be done to correct the problems.

Comparison of the performance of different papaya grower-suppliers of The Company based on sensory evaluation

The Company has three papaya suppliers from Tupi. To determine if there are improvements in the quality of fruits they supply, sensory evaluation scores of 'Solo' papaya comparing the different papaya growers from South Cotabato were presented in a spider web or radar chart (Appendix 2, Figure 26). A spider web or radar chart shows the gaps among the different treatments tested, displays the important categories, and makes visible concentrations of strengths and weaknesses. The different sensory parameters evaluated for comparison of fruits from the different growers were the following: peel colour, pulp colour, sweetness, flavour, firmness and Hedonic rating.

Viewing the differences among the growers, sensory profile of Concepcion (Supplier A) and Nimes (Supplier B) were similar having points near each other. Manansala received the highest ratings for pulp colour, sweetness, flavour and Hedonic rating, which did not overlap with the other suppliers. This indicates that among the grower-suppliers of *The Company* Manansala produced a better fruit than Concepcion and Nimes. The chart also shows that increased ratings for pulp colour, sweetness and papaya flavour corresponds to an increased Hedonic rating. This implies that these sensory attributes of papaya need to be maintained to ensure that the fruit will be consistently liked or preferred.

7.3 Objective 3. To enhance profitability and competitiveness through supply chain improvement for Philippines pPapaya

7.3.1 Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Market	Key Results
Domestic consumer response to quality improvements	Two shipment trials, in collaboration with *The Company* and two Metro Manila supermarkets to which it supplies fruits, were conducted to determine market response to quality improvements in papaya. The interventions included harvesting at the recommended maturity and hot water treatment to control disease. The first trial involving an upscale supermarket. Only *The Company*'s daily store inventories of treated papayas and the usual harvest were monitored since an actual consumer survey was not allowed. Results showed that treated fruits sold better and faster than the usual untreated harvest. In the store where a consumer survey was allowed the majority of the 69 respondents were female (86%), mothers (83%), married (82%), belonging to the 40–59 years age bracket (48%) and employed (59%). Some 24% were housewives and 13% were retirees. Respondents commonly had a household size of less than five (58%) or five to seven members (36%). Twenty eight per cent of the consumers valued colour as an important quality attribute, 23% valued ripeness, 17% sweetness, 10% eating convenience (ready-to-eat) and 6% overall quality. The first three characteristics are essentially addressed by the technical improvements in this trial. Price and firmness were also considered (9%). Interviews indicated that consumers were willing to pay (74%) and buy more (77%) and purchase more often (66%) those papayas of improved quality. Respondents were willing to pay extra or a premium price ranging from PhP 1 to PhP 10 per kg for guaranteed quality fruit. In terms of volume they expressed willingness to double their purchases, and frequency of buying ranging from once to 2–3 times weekly, or from monthly or twice monthly to weekly. These initial results indicate that there is a measurable response to consumer value created through technological innovations in product quality which should motivate growers and other chain members to invest in and implement improvements.
Simulation Middle East sea shipments	Papaya fruits that underwent combinations of postharvest treatments like HWT, hydrocooling in fungicide and MAP were observed after two weeks of storage at 13°C. Upon withdrawal from low temperature storage papayas from all treatments had relatively similar peel colour index from full green to breaker. Fruits from each treatment combination were then divided into two lots upon transfer to 23°C. One lot was allowed to ripen naturally and the other induced to ripen using 2000 ppm ethephon. The ripening behaviour was monitored and fruits had relatively the same rate of ripening. On the fifth day fruits were at PCI 4 (more yellow than green stage) and 5 (yellow with tinge of green) and disease development was observed. Papayas subjected to HWT and hydrocooled in 125 ppm azoxystrobin (both ethephon and non-ethephon treated) were free from disease while other fruits were slightly infected (severity rating = 2) with stem-end rot (SER), with the highest incidence of 55.6% for fruits subjected to HWT but no azoxystrobin after HWT, and the control (no HWT, no azoxystrobin). Disease incidence and severity progressed with ripening. However, low SER incidence was observed in fruits treated with HWT+ hydro-cooling (125 ppm azoxystrobin) with or without ethephon treatment throughout the monitoring period. The external appearance and pulp colour of fruits were evaluated for their physico-chemical properties and sensory acceptability. The different treatments did not affect the TSS content and firmness of the fruit samples. The majority of the papayas had TSS content above 8°Brix and most were rated to have 'just right' sweetness during the sensory evaluation. As the

	sensory tests showed 9–10°Brix as the break point for sweetness, the acceptance of levels less than this is difficult to explain. On the other hand, firmness of fruits allowed to ripen naturally ranged from 2.7–7 kg-force while ethephon-treated fruits were 3.6–5.9 kg-force. There was no difference in peel colour, pulp colour, fruit firmness, and hedonic rating for the different treatment combinations. No strong off-flavour was observed. Sweetness ratings did not vary for most treatments. Using the papaya growers' harvest maturity index, which is mature green to colour break, 'Sunrise' papaya fruits free from mechanical damage and insect infestation can be shipped to the Middle East using a reefer container set at 13°C. Based on the results of the experiment the postharvest handling guidelines for long distance refrigerated sea shipment of papaya are as follows: • Harvest 'Sunrise' papaya fruits at the green mature to colour break stage (ensuring that fruits are free from mechanical damage and insect infestation). • Use a hot water treatment at 50°C for 10 minutes. • Then hydrocool fruits in 125 ppm azoxystrobin after HWT. • Dry, cool and wrap fruits individually in polystyrene socks and pack in cartons (5 kg net). • Use a transit temperature of 13°C for 14 days. • Ripen at 25°C. Fruit can then be allowed to ripen naturally or if fast ripening is desired, fruit can be treated with 2000 ppm ethephon. A second experiment was conducted to determine if the hot water treatment time can be reduced and also to determine the quality of papaya fruits transported for 18 and 21 days at 13°C. Results of our preliminary trial showed that papayas remained at the green to colour break stage after 18 and 21 days at 13°C and will ripen normally when transferred at 23°C. The incidence of stem end rot and anthracnose was reduced both in the usual 50°C, 10 minute dip and at 53°C with adipping time of three or five minutes. Hydrocooling in fungicide is necessary to ensure greater disease control during and after cold storage.
Actual Middle East sea shipments	Actual export to the Middle East was made possible through the market linkage established by the GEM program of USAID with a Davao-based exporter. The sea shipments to Dubai and Abu Dhabi followed the recommended harvesting and postharvest handling guidelines developed by the project. Favourable feedback regarding papaya quality upon arrival in the Middle East was obtained from the exporter. However, due to the problem of payment terms the shipments were not sustained. The exporter now focuses on Singapore shipments.
Simulation Singapore sea shipment	'Sunrise' papaya fruits used in the experiment were obtained from a grower with a reputation for good cultural management in papaya production and fruit were of good quality. The importer wanted the fruit to arrive in Singapore at near ripe stage and ready for distribution. Fruit were harvested at colour stages 2 and 4. The shipping temperatures that were tested were higher, that is 15°C and 18°C, rather than the recommended 13°C. Results showed that papayas at colour 4 will meet the desired stage of ripeness after the seven day sea shipment to Singapore (near ripe stage) and this will still allow distribution to supermarkets/retail outlets with a shelf life of three to five days (Appendix 2, Figure 32). Moreover, fruits at this stage were sweeter compared to fruits at colour 2. Papayas at colour 2 were not yet ready for distribution after the seven day sea shipment, regardless of shipping temperature and whether they were treated with ethephon or not (Appendix 2, Figure 33). Only upon transfer to high temperature (23°C) will ripening be fast and it took about three days at 23°C for fruits to attain the desired ripeness stage for retail (Appendix 2, Figure 34). In this experiment we compared disease incidence in fruit treated with azoxystrobin (125 ppm) after HWT. Since the fruits used in this experiment came from a farm with good management and low disease pressure we obtained the same results, that is very low to almost no disease incidence after seven days at low temperature and even after five days at 23°C (total of 12 days from harvest to retail display). Thus, dipping in a fungicide like azoxystrobin could be omitted in this case. This is significant because Singapore is very strict when it comes to pesticide residues. In this trial disease incidence due to anthracnose and stem end rot was very low after seven days at 15°C or 18°C ,and even after three days at 23°C which simulated retail conditions. This reflects the good production management of

	the farm where papayas were obtained. However, since during the actual commercial shipment fruits will come from different farms where management practices vary, hot water treatment is recommended. During HWT papayas were placed in fruit caps, since in previous experiments papayas not placed in fruit caps during HWT were prone to mechanical damage resulting in poor appearance. In this experiment when papayas were placed in fruit caps (starting at the farm, after field sorting and transport to the packinghouse) fruits were free from damage. If this can be followed high quality fruit outturns will result. Ethephon treatment is necessary prior to transport if the shipping temperature is 15°C. At 18°C ethephon treatment may be omitted although there will be some fruits not yet at near ripe stage after seven days. Upon display of fruits in retail shelves, and if the temperature is high (23°C), papayas will ripen fast. Results of these experiments were translated into a simplified harvesting and postharvest handling guide for papayas intended for sea shipment to Singapore. This was provided to the members of MATROFA through the MAO of Tupi and GEM. However, the planned export to Singapore did not materialise in 2012 since the GEM project has ended.
Actual Singapore sea shipment	Together with a progressive grower the project co-operator was able to establish market linkage with a Davao-based exporter to Singapore. Shipment started in February 2012 until November 2012 and followed the harvesting and postharvest handling guidelines developed by the project. Since other fruits are in peak season during the months of December to February shipments stopped. It resumed in March 2013 and has been going on up to now. The progressive farmer who sent his fruit to Singapore through the trial shipment received a 7% higher farm gate price. The customer's were successfully met up to shipments of 200 cartons of 5 kg per carton. Quality problems like failure of fruits to ripen and incidence of decay were encountered when the import demand increased, resulting in erratic volume of shipments. The main reason for the quality drop when sending more than 200 boxes was because the 200 boxes were more than 60% of this progressive farmer's fruit. When the exporter ordered more the farmer had to send immature fruit and fruit with defects. Apparently other farmers nearby did not send or grow papaya as they were watching the result before taking any new actions. In response to these problems the project team conducted a training of the stakeholders involved in Singapore shipment.

7.4 Objective 4. To enhance profitability and competitiveness through supply chain improvement for Australian papaya

7.4.1 Identify and mobilise commercial partners who can champion improvements in papaya chains and where benefits and cost savings are shared by all members of the chain

Two target supply chains were identified in consultation with industry, with a focus on access to selected domestic markets and those who are able to drive supply chain improvement and motivate their supply chain partners to work with them. The supply chain represented the two major growing regions of 'Tableland' and 'Coast' north Queensland. A third supply chain from coastal north Queensland was engaged in the third year of the project as a result of the initial studies. This third business represented an innovative company that was prepared to make large investments in supply chain improvement.

The engagement of these commercial partners was an important achievement of the project. Together they represent over 50% of commercial papaya production and the three common production systems for papaya from the wet tropical coast and the drier elevated Tablelands. Importantly they represent the part of the industry that is innovative and continuing to make investments in the supply chain. The engagement of the three industry collaborators also allowed the project team access to the major papaya handlers in the Australian capital cities.

7.4.2 Identify strategies to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

Two consignments for each supply chain and season of activity were monitored for quality and handling practices and conditions. Results were reviewed, and analysed to determine areas for improvement.

A typical supply chain process for each of the sample loads is shown in Figure 3 on the following page.

Each of the three collaborators had slightly different handling systems but the process of picking at early colour development, treatment with postharvest fungicides, grading for colour development, ripening at high temperatures using Ethepon/Ethylene and packing and pre cooling to transport temperature is common. Cooling systems, packaging materials and methods of application of postharvest fungicides did vary between collaborators.

Findings from the sampling and monitoring process analysis included:

Temperature management

The fruit in all the supply chains were held under normal industry practice but in each sampling there was considerable temperature variation, both between pallets and within pallets. This was expected with the use of room cooling rather than forced air cooling—for instance fruit heated over 24 hours to 31°C and ethylene treated after packing, then room cooled to 13°C with the room set to 12°C over 20 hours. For example, in one shipment the top cartons cooled to 16°C while the centre and outside cartons on layer four only cooled to 18°C. Cooling continued during truck transport (13°C) and at arrival. Fruit at the top of the pallet were at 14–15°C with fruit on the inside pallet positions being up to 4°C warmer.

Fruit quality

The use of pre transport ripening did reduce the variability of colour development, with all market fruit attaining colour at the required stage 4 (colour 80% of fruit surface) by day five. Ripening fruit improves uniformity of colour development, which is desired by the market. Some variability was demonstrated due to variability of temperature within the pallet. Fruit from the warmer, inside pallet positions were more advanced. This fruit had a more limited shelf life as the fruit was more advanced and higher ripening temperature promotes greater disease development.

The major quality issue during the wet season sampling was the development of fruit diseases. During fruit sampling times the market handlers were reporting losses of up to 30% due to fruit rots. The samples taken at markets showed that at first point of sale (day six) over 25% of fruit had disease severity of over 10% of the fruit surface. By day nine 63% of fruit sampled from the market were rejected due to disease. Effectively, during the wet season papaya fruit had little saleable life due to disease development. Fruit wastage of 30% is very high and results in considerable costs to all parts of the supply chain, with increased handling costs and loss of confidence in the product.

An indication that fruit temperature was a major influence on disease development was apparent in the sampling. Fruit sampled post ripening and held at 22°C coloured quicker and had higher disease incidence and severity than market fruit which had been pre cooled and held at lower temperatures during transport. As a result of this data ripening temperature was implicated in increased disease particularly in the wet season. This is similar to work in mangoes where postharvest diseases are favoured by warm ripening temperatures.

The effect of disease in the dry season sampling and monitoring was much less than expected. Saleable life was extended from less than one day to seven days. At day seven less than 10% of fruit had disease development on more than 10% of the fruit surface. In the absence of fruit diseases issues of bruising, winter spot and black spot were apparent but were not influenced by supply chain handling systems.

Typical supply chain process flow

Date/Time	Process	Conditions/comments
Day 1	HARVEST	Harvest fruit at colour break all year Pickers grade for obvious defects Fruit placed in single layer on roll-off trailer top (poly pipe + padding)
	TRANSPORT TO SHED	Picking trailer drawn by tractor Trailer top removed onto rail system shed
	FRUIT WASH	Wiped with damp sponge (foam rubber) over end of fruit while on trailer top to remove dust/spray residue
	POSTHARVEST FUNGICIDE TREATMENT	Trailer top with fruit treated with prochloraz as flood spray for 1 minute (less time during dry season) Prochloraz solution is run to waste Trailer top moved under cover and left to dry Fruit held at ambient temp for 24 hours
Day 2	SORTING/ GRADING/ PACKING	Fruit graded/sorted based on colour (mostly green vs mostly yellow), size and defect Poly socks fitted Mostly yellow fruit sent same day to Bne and is not cooled prior to dispatch Mostly green fruit (picked Mon/Tues/Wed) consolidated Wed and heated (28–33°C) overnight to develop colour. The fruit are heated using external heat; Ethylene (as Ripegas) applied at 12 hour intervals, using the shot systems. Thurs pm cooled to 12°C (variable depending on stage of ripeness). During wet season top layer of pallets inspected for phytophthora infection of fruit Dispatch Friday day 3 to market in refrigerated truck @ 12–13°C? Fruit harvested Thur/Fri in same process—coloured fruit dispatched with Fri truck; green fruit consolidated and ripened over Fri/Sat, cooled Sun and dispatched Mon
	PACKAGING	Fruit pattern—packed according to fruit size Cardboard cartons and returnable plastic crates with cardboard inserts Palletised—strapping/gluing for cartons
Day 3–7	TRANSPORT	Collected by pick-up truck or bigger Sometimes loads consolidated at transport depot Shipped at 12–13°C? Approx transport times—Bne 2 days, Syd 3 days, Melb 4 days
Day 5–7	ARRIVAL	Pre sort into sizes and quality check/resort Fruit held at ambient temperature

Figure 3. Typical supply chain flow proces

Based on the results of monitoring the commercial consignments a number of interventions were discussed with the collaborators to improve supply chain performance. These included improvements in cooling systems to reduce temperature variability, handling systems to reduce bruising, and improved grading to reduce the impact of disease.

A number of interventions required additional trials to quantify the effects the supply chain handling conditions. This work was focussed on ripe fruit disease development as this was the major impediment to supply chain performance. Trials were focussed on the effect of pre- and postharvest fungicides and temperatures used during ripening.

Improvement projects	Key results (for Methodology refer to Section 5)
Two papaya hybrids, ethrel vs no ethrel, four ripening temperatures in wet season (see Appendix 3) Value addressed—disease	The results demonstrated that ripening fruit at 18°C with ethrel as well as postharvest chemicals produced the optimal results in terms of fruit with more even skin colour development, less fruit softening and fewer rots. Ripening temperature and, to a lesser extent, the location from which papaya fruit were sourced had an effect on ripening behaviour and propensity for disease expression. Higher ripening temperatures (>18°C) were associated with increased softening and generally higher incidence of disease. Higher temperatures are therefore likely to result in significantly higher fruit losses throughout the supply chain and at retail. Ripening of fruit at 18°C would likely provide the best trade-off in terms of achieving optimum colour development whilst minimising softening and the development of rots. Additionally, applying ethrel prior to ripening would also be effective at reducing skin colour patchiness or uneven skin ripening and reducing rots, particularly in hybrid RB1. ***Implication*** That the current practice of using Ethrel or ethylene to improve uniformity of ripening be continued as should the use of Sportak® to reduce postharvest diseases. That the temperature of ripening be lowered to 18°C to reduce disease development.
Experiment—location, two papaya hybrids, three ripening temperatures in dry season (see Appendix 4) Value addressed—disease, peel colour	Ripening temperature applied to fruit sourced from two distinct locations over the dry season had little to no impact on pathogen development in hybrids RB1 and 1B. Instead, differences in the incidence and severity of rots and other diseases/disorders were primarily site dependent. Appropriate pre- and postharvest fungicide applications would likely curb the higher incidence and severity of diseases as recorded primarily in the coastal site. ***Implication*** That the ripening temperatures are less critical for fruit with low disease potential. This is the case for fruit harvested in the dry season and sites which have low disease incidence. Fungicide applications and tree age were implicated in the site differences observed.
Six fungicide sprays, coastal location, wet season (see Appendix 5) Value addressed—disease	Applications of either Aero or Bravo WeatherStik were most effective at reducing the severity of all diseases. In this case chlorothalonil, the active ingredient in Aero, and pyraclostrobin (a strobilurin) in Bravo WeatherStik were more effective at controlling the severity of diseases compared with the traditional copper-based fungicides tested in this trial. ***Implication*** That fungicides applied to the fruit column for Phytophthora control are also effective in reducing postharvest diseases. Future improvements in the efficacy of these fungicidal products for controlling disease severity might be achieved by further optimisation of application times and rates.
Treatments with hot water, fungicides, chitosan early in wet season (see Appendix 6) Value addressed—disease	The effectiveness of the various disease control treatments could not be fully evaluated due to the negligible severity of disease as fruit were harvested early in the wet season. The work is being repeated as part of ACIAR Fiji Papaya Project PC/2008/003.
Papaya harvested from trees 15, 17, 19, 24 and 29 months of age (see Appendix 7) Value addressed – disease	Postharvest disease severity on 1B papaya fruit was strongly influenced by tree age (logarithmic R^2=0.98) with older trees incurring a higher incidence and severity of disease expression, and with the most harvestable fruit from trees less than 24 months of age. The most prominent disease type was associated with a *Colletotrichum* species. ***Implication*** That older papaya orchards are more susceptible to postharvest disease and that orchard life may be limited. Supply chain effectiveness could be improved, for instance where orchards are not harvested in the wet season.

Papaya treated with fungicides (Diczbalis *et al*. 2011) Value addressed—disease	Sportak®, when applied at the recommended label rate of 0.55 ml/L, resulted in the highest number of fruit that were saleable. The efficacy of Scholar® followed by Amistar® was low, particularly when compared to the recommended rate currently prescribed with the use of Sportak®. ***Implication*** That Sportak® remains the most effective postharvest chemical but unless the chemical is applied correctly this effectiveness is reduced.
Assessment of commercial Sportak® use patterns and evaluation of sample dips and sprays for prochloraz concentrations (Diczbalis *et al*. 2011) Value addressed—disease	Sportak® use in the packing shed varied with recycled and stored solutions, and showed a depletion of the active ingredient. Measured prochloraz in solution was highly pH dependent. ***Implication*** That the effectiveness of Sportak® is very dependant on its application method, storage and maintenance of correct pH in the spray solution.
Optimum maturity harvest date new papaya hybrid (see Appendix 8) Value addressed—sweetness	Harvesting of fruit at 20–49% colour break produced the optimum trade-off in terms of postharvest shelf life and internal quality. ***Implication*** That the current maturity index used for harvesting papaya is currently correct and represents the compromise of flavour development and susceptibility to disease.

7.5 Trial supply chain interventions with commercial partners to improve product flows/handling, information systems, supply chain relationships and value adding to all participants in the supply chain

The interventions tested showed the potential for impact on the supply chain of improved handling practices. Some of the interventions—such as improved fungicide treatments pre- and postharvest, and harvesting from younger orchards in the wet season—are effective for the whole supply chain and there will be little impact on other postharvest characteristics of the fruit.

The use of lower ripening temperatures will have an impact, with handlers requiring fruit to arrive at the market predictably ripe with low variability in ripeness.

The effect of lower ripening temperatures, particularly for wet season harvested fruit, was identified as an intervention for trial with three industry collaborators. Commercial shipments were monitored for changed handling practices, handling conditions and supply chain performance.

Monitoring of three papaya shipments from north Queensland to the Melbourne and Sydney wholesale domestic market was undertaken to analyse improvements in supply chain performance and implementation of improved quality systems.

The fruit sampled was commercial quality harvested and handled under industry best practice with all collaborators adopting lower ripening temperatures.

Fruit quality and handling conditions were monitored from the packhouse to the wholesalers stand in Sydney and Melbourne. Data recorded included supply chain process flow, temperature profiles through the supply chain, quality assessments at different points in the supply chain, and observations at some papaya retail outlets.

Findings from the sampling and monitoring process analysis included:

- Fruit in this supply chain were held under revised industry practice but there was significant variation from intended ripening and transport temperatures.

- Fruit ripening temperatures were warmer that the intended treatment, in the range of 22–24°C rather than the intended 18–22°C. While the intention was to cool fruit to the desired temperature range of 14–16°C prior to transport all the monitored fruit were approximately 22°C when they started the transport phase.
- Cooling continued during the transport phase but there was a large variation (+6°C) from the desired transport temperatures within the pallets depending on carton position. Fruit in the box on the top layer of the pallet reached 16°0C after 15 hours while fruit in the middle layer/inside position spent approximately 50 of the 60 hours in the transport phase above 16°C.
- The fruit ripeness at the lower temperature regime still met handler's expectations and there was less incidence of over ripe fruit. All but 4% of fruit reached saleable colour on arrival and the variability of ripening at packing had evened out by the time of arrival into Melbourne. Saleable life in the monitored loads was good. At market arrival disease level was low; about 8% of fruit had some disease.
- The variable temperature after cooling in the pallet in at least one consignment contributed to the problem of variable ripening within the pallet.
- Where there was even cooling of the pallets in some consignments fruit ripening was uniform.

8 Impacts

8.1 Scientific impacts – now and in 5 years

This project was predominantly using accepted knowledge and adapting the concepts to commercial environments.

The value chain analysis approach should form the basis for value chain analysis and subsequent science-based interventions in other fruit and vegetable supply chains.

8.2 Capacity impacts – now and in 5 years

The UQ, Q DAFF and UPLB teams all developed their capacity in value chain analysis, including consumer research and postharvest techniques. Professor Ray Collins conducted a training session on VCA research methodology for five UPLB staff in 2010, focusing on the main themes of consumer value and innovation, and the process of mapping and evaluating a chain's material and information flows and relationships. In the Philippines new insights were provided on identifying quality improvement opportunities in a value chain. Dr Sun provided in-market value chain research training to two UPLB researchers who accompanied the trial shipment to Singapore in late 2013.

The four Philippine training programs involved 52 papaya growers, grower-cum-shippers and traders; 26 *The Company* personnel who were involved from papaya procurement to merchandising in retail outlets; six harvester-labourers; and 18 growers who were sources of *The Company*'s supplies. They have all improved their capacity in postharvest handling. Creating awareness on the importance of postharvest handling will have a multiplier effect that will improve product quality and safety beyond the project's direct participants. Another training program, involving 24 stakeholders in the supply chain of papaya for export to Singapore, was conducted to meet the increasing demand of papayas in Singapore.

The Q DAFF team have noted that because of their efforts in this ACIAR project they have improved their relationships with the papaya industry and importantly Q DAFF have now been invited to join the papaya industry advisory committee.

Realising the benefits of improved handling systems one grower-shipper invested in a modest packing house with hot water treatment facility. He was the co-operator during the two Middle East sea shipments, although these were not sustained due to the problem of payments. He was also the co-operator in the current Singapore shipments.

8.3 Community impacts – now and in 5 years

Good working relationships were established with the MAO of Tupi, South Cotabato who was highly involved in the project, thus ensuring sustainability past the life of this project.

USAID through the GEM program facilitated the market linkages and also provided support to the association through trainings and provision of plastic crates and hopefully this support will continue.

Relationships were improved with a commercial papaya exporter, grower-suppliers, shippers and *The Company* personnel involved in handling papayas to be supplied to various for supermarkets.

8.3.1 Economic impacts

The following economic impacts are envisioned: a reduction in rejection at *The Company* packing house (from baseline data, about 37–73% reduction in rejection) which should translate to reduced losses on the part of the shipper/supplier due to increased volume of marketable fruits. There will also be increased *The Company* sales and reduced 'bad orders' from supermarket/retail stores due to increased supply of better quality fruits. In general consumers are willing to pay and buy more and purchase more often papayas of improved quality. More specifically, the fact that there are two segments of papaya consumers with differing responses to product value attributes suggests that segmentation based marketing strategies can increase the total value created in the market. This increased value should be shared back down the chain so as to motivate growers and other chain members to invest in and implement and sustain improvement initiatives.

Interviews in the Philippines indicated that consumers were willing to pay (74%) and buy more (77%), and purchase more often (66%) those papayas of improved quality. The surveys showed that consumers are willing to pay for better quality papaya but only to a certain limit where the upper limit is PhP 35 per kg.

Respondents were willing to pay extra or a premium price ranging from PhP 1 to PhP 10 for guaranteed quality fruit. More specifically 'the taste-sensitive' group are willing to pay for good quality papaya fruits up to PhP 40 per kg. On the other hand, the aesthetic-conscious group will pay up to PhP 30 per kg.

These initial results indicate that, in domestic markets at least, there is a measurable response and greater consumer value created from technological innovations in product quality in this value chain that could apply more widely to the papaya industry.

The increased access of the papaya growers' association to export markets such as the Middle East and Singapore, the development of harvesting and postharvest guides for sea shipment of papayas through this project's adaptive research, and the adoption of consumer-focused value chain strategies in developing export markets provides a platform for industry development that can increase farmers' skills and networks, ultimately providing them with increased incomes and more secure livelihoods.

In Australia the interventions evaluated showed that postharvest losses could be reduced by 25%. This should translate through to economic benefits. However, no economic analysis was possible to determine which part of the value chain would benefit from these potential reductions in loss.

8.3.2 Social impacts

The work will improve equity of returns within the papaya industry through enhanced bargaining power of grower-shippers as a result of better quality fruits, and more knowledgeable and skilled growers and produce handlers as a result of the training activities conducted.

A culture of quality was impressed upon the different stakeholders as a result of an appreciation and better understanding of the importance and effects of proper postharvest handling.

Value chain analysis also provides an opportunity for more effective and improved relationships among actors in the value chain.

8.3.3 Environmental impacts

In Australia, the recognition that Sportak® spray mixes were not delivering the planned active ingredient should mean more effective chemical applications resulting in less fungicide entering the environment. The project also identified a practical way of deactivating the chemical through the use of high pH additives.

8.4 Communication and dissemination activities

See also section 10.2.

Training materials developed

Five modular PowerPoint presentations on postharvest handling of papaya fruits.

Postharvest handling pictorial guide in cartoon form (adapted from the tomato postharvest handling developed by Dr OK Bautista of PHTRC-UPLB).

Reports submitted

Esguerra EB & Absulio WL (2011). *Harvesting and postharvest guides in preparing papayas for export to the Middle East.* Submitted to the Municipal Agricultural Office of Tupi, South Cotabato, Growth for Equity in Mindanao (GEM) and Tupi Papaya and Guava Growers' Association (TUPAGGA).

Esguerra EB & Absulio WL (2012). *Harvesting and handling guide for papaya fruits destined for Singapore.* Submitted to the Municipal Agricultural Office of Tupi, South Cotabato, Growth for Equity in Mindanao (GEM) for use by the Matutum Tropical Fruit Association (MATROFA).

Esguerra EB, Maunahan MV, del Carmen DR, Masilungan GD & Absulio WL (2010). *Analysis of the constraints to selected tropical (papaya) supply chains and implementation of improved quality systems for the Southern Philippines and Australia.* Progress report submitted to *The Company*.

Australian Project Reports

Rober Henriod & Daniel Sole. *Ripening temperature and saleable life of 1B Papaya fruit.* December 2010

Rober Henriod, Terry Campbell, Stewart Lindsay & Daniel Sole. *Effects of field applied fungicide sprays on postharvest diseases in papaya fruit.* May 2010

Rober Henriod, Terry Campbell, Stewart Lindsay & Daniel Sole. *Postharvest evaluation summary of hybrid 1845.* March 2010

Rober Henriod, Terry Campbell, Stewart Lindsay & Daniel Sole. *Ripening temperature effects on papaya fruit quality during the dry season.* April 2010

Rober Henriod, Terry Campbell, Stewart Lindsay & Daniel Sole. *Ripening temperature effects on papaya fruit quality during the wet season.* April 2010

Rober Henriod, Terry Campbell, Yan Diczbalis & Daniel Sole. *Effect of hot water treatments and Chitosan on postharvest disease.* June 2012

Rober Henriod, Terry Campbell, Yan Diczbalis & Daniel Sole. *Papaya postharvest fungicide trial—preliminary findings.* (Efficacy of postharvest fungicides on Papaya fruit quality). August 2011

Rober Henriod, Terry Campbell, Yan Diczbalis & Daniel Sole. *Papaya saleable life trial—preliminary findings.* May 2011

Rober Henriod, Yan Diczbalis, Daniel Sole & Terry Campbell. *Effect of tree age on postharvest diseases in papaya fruit.* June 2012

Collaborator reports

Papaya monitoring report, ACIAR project. Coastal Papaya to Brisbane. Terry Campbell, Stewart Lindsay, Rob Henriod and Daniel Sole. March 2009

Papaya monitoring report, ACIAR project. Coastal Papaya to Brisbane. Terry Campbell, Stewart Lindsay, Rob Henriod and Daniel Sole. August 2009

Papaya monitoring report, ACIAR project. Coastal Papaya to Sydney. Terry Campbell, Rob Henriod and Daniel Sole. April 2011

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Papaya monitoring report, ACIAR project. Tableland Papaya to Brisbane. Terry Campbell, Stewart Lindsay, Rob Henriod and Daniel Sole. August 2009

Papaya monitoring report, ACIAR project. Tableland Papaya to Sydney. Terry Campbell, Rob Henriod and Daniel Sole. April 2011

9 Conclusions and recommendations

9.1 Conclusions

Supply chains for fresh produce (fruit and vegetables) are rapidly changing throughout the world. A successful supply chain must deliver the right product, value and satisfaction to the end customer, and profitability for its participants. The growing competition for consumer expenditure requires a whole of supply chain approach to delivering value and satisfaction. Critical to getting the product right is identifying those points where quality and value can be lost and implementing practices that produce and maintain quality through the chain.

In this project two differing approaches were used and both have led to improvements in the papaya supply chain.

In the **Philippines** a value chain approach was adopted. Professor Ray Collins trained and supported the UPLB team to investigate the chain value for consumers and to target where value could be increased and shared within the chain. As the original intent of engaging with a papaya export chain did not materialise, this project focused on a domestic papaya supply chain.

Value chain analysis, which focuses on delivering consumer-defined value, began with focus group discussions followed by formal consumer surveys and conjoint analysis. Then the chain was mapped to establish the product, information and relationship dynamics from the farm to the retail outlets.

Performance measures derived from information flow, relationships and product mapping, when combined with consumer survey results, enabled the identification of improvement opportunities to reduce losses, maintain produce quality and deliver greater consumer-defined value. In VCA improvement activities focus on quality attributes valued by consumers. In this case, attributes consumers look for when buying papaya included colour (28%), ripeness (23%), sweetness (17%), eating convenience (ready-to-eat) (10%) and overall quality (6%). Fruit quality improvement technologies had been developed during previous Australian-funded projects, thus an adaptive research approach was implemented with the aim of improving sweetness by sourcing fruit of the correct maturity and using hot water treatment for disease control and regulation of ripening.

Lack of information on proper postharvest handling as well as poor consumer insights on attributes valued in papaya were validated during the two training activities conducted in Tupi with suppliers and a company representing the customer. The trainings, participatory research and feedback on consumer research appeared to have an impact on subsequent deliveries, as there was a 37–73% reduction in rejection of papaya fruits delivered from these grower-suppliers.

The shipment trials and the survey to determine market response to quality improvements in papaya indicated that consumers were willing to pay more, buy more, and purchase more often papayas of improved quality. This measurable response to consumer value created through technological innovations in product quality can be used to motivate growers and other chain members to invest in and implement improvements.

Enhanced access to domestic and export markets relies on an enabling environment that was partly demonstrated in this project. This was achieved through the collaborative efforts of : (1) members of the project research team who provided technical assistance in validating/modifying existing technologies, providing training, information dissemination and continual feedback on the outcomes of the research; (2) the local government of Tupi, South Cotabato through the MAO who were highly involved in the project, thus ensuring sustainability, and who provided an assurance of financial assistance for the establishment of a packinghouse with a hot water tank as a service facility; and (3) the GEM program of USAID who facilitated the market linkages and also provided support to the association through training and provision of plastic crates.

There is a need to determine the volume and extent of final rejects or 'bad orders' (BO) at the supermarket level as this will give an indication to the key commercial collaborator on the possibility of providing premiums or incentives should shippers be able to supply quality fruits. This is important as the cooperating firm targets both increased sales (15%) and reduced BO (minimum of 5%). In this connection the Operations Audit in-charge has started work on the relevant data from the various supermarket groups, but no update was available for the project team. There is also a need to see if growers benefit financially from reduced 'bad orders'.

A 'walking-the-chain' approach of bringing at least one key company representative as part of the training team or as a resource person on quality requirements and causes of rejection upon arrival at the commercial packinghouse is most appropriate for a better understanding and appreciation of why improvements are needed. At the same time, a parallel activity of having the shippers and/or farmer suppliers personally observe their deliveries at the other end of the chain up to the supermarket level complements the process of finding out where gaps occur and can be addressed in the value chain to maximise value creation activities.

In **Australia**, a product focused supply chain approach was followed to identify and improve the supply chain.

This process had seven steps:

1. Identify the key business in the supply chain that wants to champion improvement.
2. Work with this business and the other members of the supply chain to benchmark performance and identify the steps where quality is lost and processes where improvement is needed.
3. Conduct research where gaps in knowledge exist.
4. Develop, test and demonstrate improved practices.
5. Generate information products and communicate to all members of the chain to improve their knowledge.
6. Implement improved practices and monitor to evaluate improvements.
7. Communicate the generic knowledge gained to the wider industry.

It is believed the poor papaya performance during the wet season has affected the confidence in the product throughout the year and is a contributor to slow expansion of papaya in the domestic market, particularly into supermarket supply chains. Thus it is anticipated that the benefit of the studies, particularly on disease control, will extend beyond the wet season performance of the papaya supply chains.

While the approaches were different in **Australia and the Philippines** there were a number of similarities which have led to the successful outcomes.

The approaches of supply chain and value chain mapping did prove a useful technique to engage chain members, to identify improvement projects and to build trust between chain members and the project teams.

The engagement of new industry collaborators in Australia and the expansion of the approach to new markets in the Philippines is evidence of the success of these approaches.

Both countries used the skills of multidisciplinary teams to promote supply chain improvement. In Australia a range of logistics, postharvest and pathology specialists were engaged while in the Philippines these teams were expanded further to include marketing, consumer specialists, economists and social researchers.

The project also shared some important approaches on papaya from the improvement activities in each country. The use of hot water and its application in the supply chain worked well in the Philippines and was trialled in Australia. The Australian results of the effect of increasing tree age on reduced postharvest performance would also be expected to be relevant to the Philippine industry.

In both approaches there was considerable difficulty in engaging suitable supply chains which were prepared to engage with researchers and to champion improvements.

9.2 Recommendations

Recommendation 1: That project funds be sought to organise and train smallholder growers to together supply the Singapore market with the required quality. Singapore market trial shipments demonstrated that the market was under supplied and the progressive farmer who sent his fruit to Singapore through the trial shipment received a 7% higher farm gate price.

Recommendation 2: That encouragement be given for key Philippines supply chain staff at retail, shipping or farm levels to follow product through the chain.

Recommendation 3: That opportunities be sought to continue the Philippines work to determine if a leveraged relationship can be attained with key export oriented companies. This needs to include a quantitative assessment of the impact of changes in the value chain including on farm prices and on increased sales.

Recommendation 4: That an assessment be made in 2014 to see if the reduction in ‘bad orders’ has translated into increased revenue of the shipper and if so, has this been shared by him with the growers through higher farm prices. (See section ‘Baseline performance analysis’ under 7.2.1.)

Recommendation 5: That the ‘Postharvest handling pictorial guide’ developed in this project be made available to the new ACIAR/PCAARRD Bacterial Crown Rot project as supporting material for their extension activities and as another process to disseminate improved technology.

Recommendation 6: That the value chain model used in this project be extended to other crops in the Philippines including mango and major vegetables.

Recommendation 7: That supply chains within the Australian papaya industry consider utilising the value chain principles used by UPLB and UQ.

Recommendation 8: That further supply chain work in Australia incorporate a value chain approach, in particular consumer insight studies, to identify those features that consumers value and are prepared to pay for and with more emphasis on the transfer of value and information within the chain.

Recommendation 9: That work on non chemical postharvest disease control be incorporated into future research work in Papaya, replicating the work in the Philippines on hot water treatment of papaya and effect on postharvest diseases and ripening performance.

Recommendation 10: That ongoing liaison be encouraged between the UPLB and Australian papaya postharvest staff and value chain specialists to facilitate improvements in the papaya domestic and export industries.

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10.2 List of publications produced by project

Refereed papers

del Carmen DR, Esguerra EB, Absulio WL, Maunahan MV & Masilungan GD (2012). 'Understanding consumer's preference for table-ripe papaya', *Philippine Journal of Crop Science*, vol. 37-2, pp. 75–80.

del Carmen DR, Esguerra EB, Absulio WL, Maunahan MV, Masilungan GD, Collins R & Sun T (2012). 'Understanding consumers' preference for fresh table-ripe papaya using survey and conjoint methods of analysis', *Acta Hort.*, vol. 1012, pp. 1379–1385.

Esguerra EB, Marcaida MP III & Rosales RA (2010). 'Effects of 1-methylcyclopropene on ripening of two papaya (*Carica papaya* L.) cultivars', *Acta Hort.*, vol. 875, pp. 81–88.

Esguerra EB, Maunahan MV, del Carmen DR, Absulio WL, Masilungan GD, Collins R & Sun T (2013). 'Consumer-orientated quality systems improvement through value-chain analysis of 'Solo' papaya fruit' in Oakeshott J & Hall D (eds) 2013, *Smallholder HOPES—horticulture, people and soil. Proceedings of the ACIAR–PCAARRD Southern Philippines Fruits and Vegetables Program meeting*, 3 July 2012, Cebu, Philippines, pp. 12–30, *ACIAR Proceedings 139*, Australian Centre for International Agricultural Research, Canberra. **Best paper**

Papers presented in scientific conferences

Absulio WL, Esguerra EB & Amatorio EQ (2012). 'Optimisation of hot water treatment for domestic sea shipment of 'Sunrise' papaya fruits', poster paper, *7th International Postharvest Symposium (IPS2012)*, 24–29 June 2012, Malaysia.

Absulio WL, Esguerra EB, Maunahan MV & del Carmen DR (2013). 'Revisiting the hot water treatment protocol for 'Solo' papaya', *2nd Southeast Asia Symposium on Quality Management in Postharvest Systems*, 4–6 December 2013, Lao PDR.

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Esguerra EB, Marcaida MP III & Rosales RA (2009). 'Effects of 1-methylcyclopropene on ripening of two papaya (*Carica papaya* L.) cultivars', *Southeast Asia Symposium on Quality and Safety in Fresh and Fresh Cut Produce*, 3–5 August 2009, Bangkok, Thailand. [Organised by International Society for Horticultural Science (ISHS) and King Mongkut University of Technology Thonburi (KMUTT)]

Esguerra EB, Maunahan MV, Absulio WL, del Carmen DR & Masilungan GD (2011). 'Quality improvement opportunities in papaya through value chain analysis', *4th ACIAR-*

PCARRD Southern Philippines Fruits & Vegetables Programs Annual Meeting, 22 July 2011, Tagbilaran City, Bohol, Philippines. **Best Research Paper Award**

Esguerra EB, Maunahan MV, Absulio WL, del Carmen DR, Masilungan GD, Collins R & Sun T (2012). 'Quality improvement opportunities in papaya through value chain analysis', *Southeast Asia Symposium on Quality Management on Postharvest Systems*, 21–24 February 2012, Bangkok, Thailand.

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Feez T, Cook S, Leu H & Crocker N (2012). *Market Research Report on Philippine Papaya in Singapore*, Technical Report, The University of Queensland.

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Australia

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11 Appendixes

11.1 Appendix 1: Abbreviations

BAS	Bureau of Agricultural Statistics
BO	Bad order
BPI	Bureau of Plant Industry
dHWT	Delayed Hot water treatment
EA	Ethylene adsorbents
FGD	focus group discussion
GEM	Growth for Equity in Mindanao
HWT	Hot water treatment
LPG	Liquefied petroleum gas
MAO	Municipal Agricultural Office
MAP	Modified atmosphere packaging
MATROFA	Matutum Tropical Fruit Association
MCP	Methylcyclopropene
ME	Middle East
PCI	Peel colour index
PEB	Polyethylene bag
PHTRC	Postharvest Horticulture Training and Research Center
QC	Quality control
SER	Stem end rot
SPSS	Statistical Package for Social Sciences
SPV	Supervisor
TA	Titratable acidity
TSS	Total soluble solids
UPLB	University of the Philippines Los Baños
VCA	Value chain analysis

11.2 Appendix 2: Analysis of the constraints to selected tropical fruit (papaya) supply chains and implementation of improved quality systems for the Southern Philippines and Australia

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This report provides a detailed description of the Philippine activities of this project. A large number of portions of the report are included in this ACIAR final report