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project

Developing markets and products for the Pacific Island and PNG canarium nut industry

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2 Executive summary

Canarium indicum is an indigenous timber tree that grows throughout the south Pacific and produces edible nuts. The processed canarium nut industry is in its infancy in Pacific Island countries and has great potential to improve livelihoods. Processed nuts are an ideal product for these countries to trade in as they can be transported easily, stored for long periods of time, and do not have the cold chain challenges of other produce.

This project investigates value-adding and processing opportunities for both domestic and export markets for canarium nuts in Vanuatu and Solomon Islands. There are differences in quantity and quality of supply, processing techniques, and types of products and markets in each country. In Vanuatu there is evidence of unfulfilled domestic demand, and significant potential to tap into the increasing tourist market coming by air and ship. In Solomon Islands there are more market opportunities in the domestic food service, hotel trade and retail sectors. In PNG there is potential to first maximise the domestic market with a view to canarium developing as an important export market crop.

This project addressed the key constraints in the supply chain:

1. Identifying and developing markets by understanding consumer preferences:
2. Primary and secondary processing techniques that are targeted to these specific consumer needs and the specific capabilities of each country's supply chains:
3. Understanding the drivers and barriers to stakeholder industry participation and to attend to these emerging obstacles to further industry development and capacity:

The major achievements of this project are:

- We have learnt more about the different market segments, consumer preferences and product development opportunities as we have conducted multiple surveys and interviews in all countries. Tourists were most interested in raw, roasted/salted and chocolate coated products and were willing to pay between $500 - $1000 Vt for a packet of snack nuts.
- An Australian nut enterprise survey on canarium consumer preferences showed that 67% of companies believed canarium nuts have commercial appeal in the Australian market. The most suitable market segments suggested were health stores, gourmet food, boutique stores, bakery and confectionary. Best value adding was thought to be roasted and salted kernel to bring out the flavour.
- Other export market opportunities for PNG, Vanuatu and Solomon Islands have been identified, with whole nut samples provided to chocolate makers and canarium oil to cosmetic manufacturers as an active ingredient in their skin care range
- A pilot factory has been developed in PNG and is producing around 80 % whole kernels using modifed crackers imported from China. Equipment and protocols for processing were developed by this project.
- A canarium nut marketing strategy for the direct business-to-consumer market has been prepared and presented to the proprietors of Lapita Café
- "Best bet" trees have been identified with large nuts and kernels in a controlled progeny trial in Solomon Islands. Large gains in production and processing efficiency can be made by selecting and planting the best performing trees.
- New processing systems such as kernel drying and solar drying have been developed. Some of these protocols are being used in the pilot factory in PNG.
- Shelf life tests have found that commercially dried kernel can be stored for 6-9 months, although initial moisture content of the kernel is critical for effective storage.
- Microbial testing highlighted the need for improved food safety standards during processing in all countries.

- Protocols for salt roasted and sugar coated kernels have been developed in PNG and information shared between countries.
- A series of modules has been prepared to 'train the trainer' on canarium nut protocols, including " Best practices for canarium Harvest and Post-harvest care", "Guidelines for Farmers and Village Collectors " and these have been tested in PNG
- Extensive analysis of stakeholders and changes since the start of the project has shown that there have been clear economic increases in cash, labour and indirect economic growth benefits to individual processors and farmers in Vanuatu from the growing canarium industry.

This project has improved market access for farmers, as processors have been sourcing more raw material and value adding to supply higher value product into markets. As a result there has been substantial growth of the canarium nut industry in Vanuatu. The industry has grown from one processor at the start of the project to five processors and value adders at the end of the project. For example:

- During the project, one processor increased the volume of dried kernel sold from 18 kg in 2010 to 1 tonne in 2014 with parallel increases in prices to farmers, number of suppliers and retail price of their products. More than 100 farmers are now supplying canarium nut to this processor.
- Another processor increased the price to farmers as some are now value adding on-farm. In 2011 the proprietor purchased nut in shell for approx. 200vatu/kg kernel. In 2014 the proprietor was encouraging his suppliers to add value on farm using solar driers and paying 1,000vatu/500g kernel.

At the time of project completion, NARI in PNG had just commenced commercial sales of processed Canarium nuts in formal markets in East New Britian. Nuts were selling for 50 Kina per kg of packaged product and around 200kg of products had been sold.

The project has built capacity through:

- Providing equipment such as oil presses, crackers and data loggers. Ovens, balances and other scientific equipment were supplied to the Department of Forests Vanuatu and oil presses were supplied to NARI in PNG.
- Developing competency and experience in product development, promotion, brand development and marketing with NARI personell in PNG.
- Providing assistance with processing, nutritional analysis, and packaging for processors (Jedom, Lapita, ACTIV) and helping to develop and implement processing techniques at the NARI pilot factory in PNG.
- Training provided to Solomon Islands Ministry of Forests on tree assessment, early fruiting and flowering and timber volume. They were also trained in weighing and measuring fruit and how replication influences the experimental design.
- Vanuatu Bureau of Statistics have collaborated and shared techniques with our project partners for both the canarium and cocoa PARDI projects.
- Helping to develop business and marketing plans for the private processors.
- Sharing information. In particular, information sharing networks were established between the Vanuatu department of Forests and Solomon Islands Ministry of Forests, and processors from the two countries.
- Student training. Students from the University of Adelaide and University of the Sunshine Coast built their capacity while contributing to the project.

3 Background

Canarium indicum is an indigenous tree that grows throughout the south Pacific and produces edible nuts and timber. The canarium nut industry is in its infancy in the Pacific and the nut industry has great potential to improve the livelihoods of smallholders and business operators in Solomon Islands and Vanuatu. Processed nuts are an ideal product for Pacific island countries to trade in as they can be transported easily, stored for long periods of time, and do not have the cold chain challenges of other produce.

The world trade in tree nuts is in excess of $US 2 billion and just four species, walnuts, hazelnuts, pistachios, and almonds, make up more than 80 % of this trade (USDA, 2008). The nut industry worldwide has enjoyed strong growth over the past decade, with some nut industries such as almonds and walnuts forecast to grow by over 10 % annually (USDA 2010). While canarium nut is not well known in international markets, there is evidence of strong domestic demand in each partner country.

Traditionally in South Pacific countries canarium nuts are mostly traded fresh in roadside and village markets, either as nut-in-shell or as dried kernels. Women conduct the majority of farming and trading activity in the South Pacific, and many women simply sell the raw product in coconut shells at markets. The trade in canarium nuts is predominantly based on wild and garden tree populations amounting to around 2.4 million trees across Vanuatu (0.3m), Solomon Islands (0.9m) and Papua New Guinea (1.2m) (Evans, 1996a). In a recent agricultural census in Vanuatu (2007) the number of planted, permanent canarium trees was 145,317 with Malampa and Penama provinces displaying the largest number of trees, 45,472 and 43,421 respectively. Processing and value adding to canarium nuts would open up world nut markets to Pacific Island countries, however at present processing and value-adding are in their infancy in the Pacific.

This project builds on domestic markets while investigating value-adding and processing opportunities for both domestic and export markets. At present there are differences in quantity and quality of supply, processing techniques, and types of products and markets in each country. In Vanuatu there is evidence of unfulfilled domestic demand**,** estimated at 50T of kernel for the snack market. Current estimates of value are A$17,000 per tonne with only a limited amount of value-adding (Bond, 2006). There is also significant potential to tap into the increasing tourist market coming by air and ship however secondary processing and value adding is more advanced here than other parts of the Pacific. Alternative processing methods and alternative products are needed to create opportunities to grow the industry.

In Solomon Islands there seems to be more market opportunities in the domestic food service, hotel trade and retail sectors. Their primary processing of the nut through existing village systems seems to work quite well, although it results in a lot of broken pieces so the most potential for improvement is in the secondary value adding and processing of the nut to meet specific market and consumer requirements.

In PNG NARI has distributed 250,000 elite Canarium seedlings most of which have been planted in East New Britain. Thus there are extensive plantings but no commercial processing of canarium.

In all countries, the key constraints in the supply chain are:

1. Identifying and developing markets by understanding consumer preferences: Market research is crucial to understand what consumers want and what customers require. Market research needs to drive the processing and product development research. Failure to address market needs in the research would result in ineffective interventions and poor outcomes for the industry at the supply end of the chain.
2. Primary and secondary processing techniques that are targeted to these specific consumer needs and the specific capabilities of each country's supply chains:

Processing techniques are an obvious key constraint across all three countries. The nut spoils unless it is dried or frozen so primary stabilisation is required. Both primary and secondary processing and value adding need to be tailored to the market for the quality to be acceptable to the end consumer.

3. Understanding the drivers and barriers to stakeholder industry participation and to attend to these emerging obstacles to further industry development and capacity: Stakeholder analysis is needed to understand the constraints facing stakeholders about the research findings and the broader social and cultural constraints to the industry. An adaptive approach is needed to ensure that the research findings will be fine-tuned with appropriate stakeholder participation strategies.

This report presents the results of research to address each of these three constraints outlined above. The collaborators on this research are Maraghoto holdings in Solomon Islands, and Vanuatu Department of Forests, Lapita Café in Vanuaut and NARI in PNG. Vanuatu and Solomon Islands have a small resource base, and more opportunity to diversify *canarium* products in tourist markets and create a suitcase export industry, while PNG has excellent infrastructure and large scale plantings of improved material.

4 Objectives

This aim of this project was to identify and develop market led opportunities to improve and build the capacity of the canarium nut industries. The specific objectives and major activities of each objective were:

Objective 1) *Conduct consumer and customer research to understand the markets and the market segments*

- *Continue to refine the canarium nut industry chain maps for Solomon Islands and Vanuatu*).
- *Verify the best market opportunities for each country*.
- *Understand more about those markets and market segment opportunities by conducting consumer and customer research*.

Objective 2) *Develop processing techniques tailored to each countries market, consumer and supply chain circumstances with capacity for expansion**.***

- *Work with chain champions to develop and test a number of nut products in chain in each country.*
- *Examine processing methods to improve percentage of whole kernel and prevent kernel breakage.*
- *Examine processing methods for by-product broken pieces, oil, nutmeal for biscuits*
- *Examine processing methods to improve shelf life.*
- *Examine microbial load and risks of contamination in the processing chain**.***
- *Develop industry quality standards and product specifications for Canarium indicum, including any appropriate certifications.*
- *Develop food safety and product testing protocols.*

Objective 3) *Analyse drivers and barriers to stakeholder industry participation and capacity*

- *Analyse positive and negative impacts of market opportunities and product development experienced or anticipated by stakeholders.*
- *Develop alternatives or strategies that might address the barriers to engagement experienced or anticipated by stakeholders.*
- *Training and capacity exchange.*
- *Quantitative benchmarking.*

5 Methodology

The methodology adopted in the canarium project was a continuous integrated approach. The early stakeholder engagement helped to understand the industry structure, identify broad market opportunities, identify 'chain champions' and direct the whole of chain research activities.

This project emerged from a supply chain analysis conducted by the University of Adelaide (UoA) on the canarium supply chain in Vanuatu and Solomon Islands and the recommendations and advances of past ACIAR funded research that identified these gaps in the knowledge and development of the canarium nut industry.

This imbedded approach results in a much more whole-of-chain and market-led understanding of the opportunities, researchable issues and lessons learnt. A summary of the approach used across PARDI, including the strategic framework, selection criteria and general process is included in the UoA PARDI Objective 1 Summary Report in Appendix 11.1.

This project continued the partnership with the macadamia industry developed in the previous project (FST/2006/048). Experts from the macadamia industry were used to empower champions in the emerging canarium industry, by giving them access to techniques, methods and industry strategies that may be appropriate for marketing and product development.

Objective 1: Conduct consumer and customer research to understand the markets and the market segments and the capacity to supply new markets. This included:

- refining the canarium industry map for Solomon Islands and Vanuatu,
- verifying the best market opportunities for each country,
- conducting consumer and customer research, and
- working with chain champions.

Rather than just providing initial direction for project partners and a rapid analysis of the industry, UoA dedicated resources and funding to play an ongoing role throughout the duration of the project.

Targeted consumer research was conducted to understand consumer perceptions and behaviour in key target markets and to get specific feedback on canarium nuts and important attributes of value added products.

In PNG marketing research was undertaken firstly by desk-top research and analysis and utilising market segmentation principles.

Objective 2: Develop processing techniques tailored to each country's current circumstance. This included: kernel drying methods, roasting, use of by-products, shelf life of kernels, microbial testing, and assessment of a progeny trial.

Kernel drying

Oven drying at different temperatures

Moisture loss from *Canarium indicum* kernels was investigated during drying for 6 hours at each temperature (80°C, 60°C, 50°C and 40°C) in electric ovens. The initial moisture content of the kernels and the moisture content at the conclusion of the drying process were determined by weighing the kernels and drying kernels at 105°C for 15 hours (overnight) at the completion of the drying process.

Commercial Drying

Temperatures inside a commercial drying system was recorded hourly as well as being monitored with Tinytag temperature and humidity data loggers.The initial moisture content of the kernels and the moisture content at the conclusion of the drying process were determined by drying at 105°C for 15 hours (overnight) at the completion of the drying process.

Commercial roasting

Using commercial equipment in Vanuatu, canarium kernels were:

1) air roasted for 10 minutes at temperatures of 110°C, 120°C and 150°C;
2) after immersion in a saturated brine solution kernels were air roasted for 10 minutes at temperatures of 120°C and 150°C;
3) to achieve sugar coating, the kernels were immersed in a sugar solution (1/2 cup water; 1 cup sugar) and air roasted for 20 or 30 mins at 150°C.

Processing by-product

Commercial operators were surveyed to ascertain current practices to utilise by-product. It was found that broken pieces were used for manufacturing into biscuits, and oil for cooking and cosmetic purposes.

Shelf life

Two experiments have been undertaken on shelf life with kernels from Vanuatu and Solomon Islands. Samples from two commercial processors were stored and at three monthly intervals assessed for Peroxide Values and Free Fatty Acids to determine rancidity. Peroxide Values measures the production of hydroperoxides during lipid oxidation while Free Fatty Acid values measures hydrolytic rather than oxidative rancidity. These values are commonly considered indicators of shelf-life.

Processed nuts were compared to fresh nuts as the control. Data were analysed with Kruskal-Wallis and Mann-Whitney U tests and a Bonferroni correction was applied to determine the appropriate level of significance.

Microbial testing

Canarium indicum samples were taken from different methods of processing and different phases in the processing chain in Papua New Guinea, Solomon Islands and Vanuatu. Samples of nuts examined were fresh nuts, nuts dried in villages over hot stones heated in wood fired ovens, nuts dried using solar driers and nuts dried from two different commercial processors.

Three samples of nuts from each processing method were assessed by a registered food laboratory in Australia for microbial contamination and known pathogens. The results were compared to guideline levels for microorganism contamination from the NSW Food Authority (Food Authority NSW 2009).

Satisfactory results in these guidelines indicate good microbial quality, marginal results are within acceptable limits of microbial quality but may indicate possible hygiene problems during food preparation, while unsatisfactory results have unacceptable microbial contamination. Results for the microbial tests were classified as (1) satisfactory, (2) marginal or (3) unsatisfactory when used as a ready to eat food and analysed using SPSS.

Variability in fruiting and nut size of Canarium indicum

A *Canarium indicum* progeny trial on Kolumbungara Island in Solomon Islands was measured for three years to determine early fruiting and desirable nut characteristics. One thousand seedlings from 50 known parent trees were planted in 2006 (20 per parent).

Tree height and diameter at breast height were measured in 2011. Each year (2011-2013) we counted the number of flowers and fruit bunches on all surviving trees and estimated

the number of flowers and fruit in each bunch on all surviving trees. Trees were assessed halfway through the fruiting season, when most flowers had set fruit and very few ripe fruit had abscised. Of 693 surviving trees in 2011 155 trees bore fruit, in 2012 137 trees bore fruit, and in 2013 135 trees bore fruit.

We collected 20-30 ripe fruit from each of 25 trees (2011), 33 trees (2012) and 34 trees (2013) to determine nut-in-shell and kernel characteristics. The pulp was removed and the nut-in-shell were individually weighed at field moisture content (approx 30 %). Nut-in-shell were cracked, the testa removed and each kernel was weighed. The kernel recovery ratio (weight of kernel / weight of wet nut-in-shell) x 100) was calculated.

Objective 3: **Analyse drivers and barriers to stakeholder industry participation and capacity.**

The 'researchable' questions were:

- What drivers, benefits and barriers are experienced by smallholders that are related to the results of the marketing, product development and processing findings in this research?
- What drivers, benefits and barriers are experienced by commercial producers that are related to the results of the marketing, product development and processing findings in this research?
- What drivers, benefits and barriers are experienced by processors that are related to the results of the marketing, product development and processing findings in this research?
- What drivers, benefits and barriers are experienced by distributors and marketers that are related to the results of the marketing, product development and processing findings in this research?
- What changes in capacity and capability of each of the above stakeholder groups can be measured in this project in terms of their understanding of production and processing (e.g. growth, harvesting and anticipated profit returns) of canarium nut?

The research for this objective followed a two-stage process, commencing with a stakeholder analysis comprised of 76 semi-structured interviews conducted in situ (in a government office, local village or farm) to qualitatively record the key drivers and barriers to Canarium industry development in each country (Table 1). Interviews were followed by 4 workshops that involved round table discussions following expert presentations, and non-participant observation. Data were pooled and analysed to identify six key themes, and devise potential strategies or recommendations that were adaptively implemented during the project where possible. These were supplemented with two desk-top case studies of similar industries to identify further recommendations (Appendix A and B).

Stage 2 involved using the stakeholder analysis themes as indicators for pre-project and post-project benchmarking. The semi-structured interviews and discussions detailed above additionally sought quantitative data, where available, against which to benchmark the project at its inception (year 1) and again at completion (year 4). Differences attributable to the project and industry development were compared across countries and stakeholder groups, noting changes in indicators of supply, production, processing, capacity or capability of different stakeholder groups, and growth in numbers of growers and profit returns.

Table 1: Interview participants included in the stakeholder analysis and workshops held in each country.

Number of people	PNG	Vanuatu	Solomon Islands
Government	NARI n = 4 PPAP	Department of Forestry n = 2 Santo Agricultural College, n=1	Commodity Export Marketing Authority (CEMA), Ministry of Agriculture and Livestock (MAL), Kastom Gardens Association (KGA), Ministry of Commerce, Industry, Labour and Immigration (MCILI),
Smallholders and commercial growers	n=5 One on one interviews	n= approx. 20. A combination of one on one interviews and groups of farmers and or villagers	n= approx. 30. A combination of one on one interviews and groups of farmers and or villagers
Processors/marketers	n=3: Agmark, ENBDC, Paradise Foods Ltd	n=3: Kava Store, Lapita Café, Summit Cafe	n=4: Maragota Holdings, Jedom Organic Foods, Global Vision, Tetepare Descendents Association (TDA)
Workshops	Sept 2014	April 2012	April 2010 Oct 2013
TOTAL	12 interviews (4 government, 5 growers, 3 processors) 1 workshop	26 interviews (3 gov, 20 growers, 3 processors) 1 workshop	38 interviews (4 gov/NGO, 30 growers, 4 processors) 2 workshops

6 Achievements against activities and outputs/milestones

Objective 1: To conduct consumer and customer research to understand the markets and the market segments

PC = partner country, A = Australia

No.	Activity	Outputs/ milestones	Due	Comments
1.1	Continue to refine the canarium nut industry maps for Solomon Islands, Vanuatu (product flow, key players, main markets, broad issues and opportunities).	Verified supply chain maps and their constituent elements	Yr 1, m6	Completed in close collaboration with the Vanuatu Dept. of Trade and Industry. Value chain industry maps have also been updated as new processors have been enticed into the industry in both countries and are included in the key results section below. In both countries the key opportunities identified early in the project were; • Unfulfilled domestic demand • Need to identify nut growing and primary processing systems suitable for these countries and the market requirements • Need to understand more about consumer demand in priority markets • Work with chain and industry 'champions' for the benefit of the wider industry and its future development
1.2	Verify the best market opportunities for each country (Vanuatu and Solomon Islands)	Recommendations for product testing in markets	Yr 1, m12	Market opportunities were initially identified as the tourism market in Vanuatu and the food service sector in Solomon Islands with a longer term goal of export once industry capability and capacity increases. A comprehensive canarium Nut Marketing Strategy is provided (see Appendix 11.4) which provides research into market opportunities and recommendations in Vanuatu.

1.3	Understand more about those markets and market segment opportunities by conducting consumer and customer research	Analysis of consumer preferences	Yr 2, m6	We have learnt more about the different market segments, consumer preferences and product development opportunities as we have conducted multiple surveys and interviews in all countries. Some broad insights from the Vanuatu tourists were; • tourists were most interested in raw, roasted/salted and chocolate coated products • tourists are willing to pay between $500 - $1000 Vt for a packet of snack nuts. • tourists are willing to pay more for locally produced product • tourists either consumed the nuts while on holidays or bought them as a gift to take back home. Another survey of locals and tourists in Solomon's uncovered the following key insights; • tourists are reluctant to purchase edible gifts to take home • tourists were mainly unaware of local nuts and availability was mostly as raw nuts in the local market • tourists were interested in canarium as a nut snack, roasted or salted • locals purchased canarium mainly as a raw product in season from the local market but are interested in value added products all year round A comprehensive canarium Nut Marketing Strategy is provided (see Appendix 11.4) which provides research into the tourist industry in Vanuatu and tourists nut consumption preferences. Tourist market information and consumption preferences form the basis of the recommendations for the marketing strategy, branding strategy, product hierarchy and packaging strategy provided in document.
1.4	Pick 'chain champions' to work with along the chain	Results of market trials by industry champions	Yr 2, m12	Chain champions were selected in Vanuatu and Solomon Islands and worked closely with the project team to utilise market insights and develop new products to meet consumer preferences and market requirements. NARI is a key player in PNG in terms of industry development and attracting private sector investment, with some other organisations showing interest.

1.5	Identify and quantify viable export market opportunities for commercially manufactured canarium products	Report detailing potential export markets and quality requirements for retail and food service market segments, competitor analyses and expectations of producers, distributors and marketers regarding supply and sales volumes, and financial returns and margins.	Yr 3, m6	Australian Nut enterprises were given canarium nut samples, nutritional and background information and then surveyed to assess their interest in the nuts, buyer requirements and general consumer preferences. The results indicated; • 67% of companies believed canarium nuts have commercial appeal in the Australian market • The most suitable market segments suggested were health stores, gourmet food, boutique stores, bakery and confectionary • Best value adding was thought to be roasted and salted to bring out the flavour Opportunites for the tourism markets in both Vanuatu and Solomon Islands and outcomes of the Australian nut enterprise surveys are detailed in Appendices 11.20-11.22 **PNG:** Canarium produced at the NARI Pilot Factory was successfully promoted and sold at the Melanesian Spearhead Group Investment Roadshow and Trade Fair, held in Port Moresby on the 28th to 30th November 2014. Trade Fair attendees from throughout the South Pacific, Australia, New Zealand, the EU and South East Asia were unanimously positive as to the look and taste of the product and there was no price resistance to the premium prices charged from either Papua New Guineans or visitors to PNG. A report on developing markets and products for the canarium nut industry in PNG (Appendix 11.5) identified long term opportunites for export to China, Japan and Australia for both food and cosmetic products.
1.6	Identify specific value-added market chain opportunities in focused export markets for a range of identified products	Value added market opportunities identified and ranked for a range of products.	Yr 3, m6	In addition to assessing snack nut opportunities with the Australian nut company survey, nut samples have also been provided to Haigh's chocolates and also canarium oil to Jurlique for possible inclusion as an active ingredient in their skin care range. **PNG:** There is unmet demand for Canarium within PNG and throughout Melanesia where it is not widely available commercially. Preferential market access arrangements also exist between Melanesian countries that favour inter-regional trade. The NARI Canarium Conference and Fair held in September 2014 identified domestic and regional market development to be a critical 'first step' for the embryonic Canarium industry in PNG to be followed by development of suitable high value export markets. Domestic and Melanesian markets will be important in regards to establishing commercial harvesting, processing, distribution and marketing systems, generating income and cash flows for growers and processors and providing a mechanism for product development and new market testing (Appendix 11.5).
1.7	Analyse macadamia industry product range and market development as a case study for galip marketing potential	Strategies and risks from the macadamia industry that could be considered for galip marketing.	Yr 3, m6	See Appendix 11.2 for macadamia industry case study

1.8	Develop an Industry Strategic Marketing Plan	Document detailing Industry strategic marketing plan (also incorporating domestic market analysis from FST/2004/055)	Yr 3, m6	See Appendix 11.5 for Industry Strategic Marketing Plan

Objective 2: To develop processing techniques tailored to each country's circumstances

No.	Activity	Outputs/ milestones	Due	Comments
2.1	Develop and test a number of nut products in chain in each country (e.g. roasted, salted, honey coated). Repeat after consumer feedback	A range of potential products for testing	Van Yr 1, m9. SI Yr 2, m6. SI Yr, 3 m6. Van Yr 3, m9. PNG Yr 1, m9 PNG Yr 3, m9	Information on the protocols for salt roasted and sugar coated were developed at the National Agricultural Research Institute in Keravat PNG. The best product for salt roasted was found from roasting at 150^{o}C for10 minutes and Sugar coated nuts were roasted for 150^{o}C for 30 minutes. Feedback from customers indicated that; roasting for 10 minutes produced a more acceptable product as this gave a more flavoured product; salt roasted using the 15% salt solution was salty, but not too salty; sugar coating using one cup sugar just dissolved in half a cup hot water (not boiled) for either 30 and 40 minutes at 150oC gave a shiny coating without the sugar crystals. (Appendix 11.6).
2.2	PNG Examine processing methods to improve percentage of whole kernel	Protocols to produce high value product for export market	PNG Yr 2,m6 Yr3, m12	Modified TJ were trialled and macadamia crackers were imported from China. The Chinese crackers produced greater than 80% whole kernels and have been used successfully in the NARI factory at Kerevat, PNG.

2.3	Examine processing methods for by product broken pieces, oil, nutmeal for biscuits)	A range of potential products for consumer testing	Van Yr 2, m9 SI Yr 2, m9 PNG Yr 2, m9	For an overview of the processing methods see Appendix 11.7 Early in the project processors identified the need for kernel drying methods rather than nut in shell methods. Moisture loss and quality of *Canarium indicum* kernels were measured during drying at a range of oven temperatures (80°C, 60°C, 50°C and 40°C). These experiments showed that temperatures of above 60°C will reduce kernel moisture content to below 5 % in only 1 hour but may have a detrimental effect on colour and storage potential. Temperatures of 50°C, even after 6 hours of drying, produced a whiter coloured kernel that may have longer storage potential. However temperatures of 50°C only reduced moisture content to around 10% even after 6 hours. This is insufficient for long term storage and further drying is needed to reduce moisture content to 3%. (Appendix 11.8). Broken pieces of canarium are being processed and value added. Lapita Café in Vanuatu is using broken pieces of canarium nuts in biscuits and oil production, Maraghoto Holdings Ltd in Solomon Islands is producing oil for cooking and cosmetics, Jedom Organic Foods in Solomon Islands is using broken pieces of canarium nuts in muesli; ACTIVE in Vanuatu use canarium oil in cosmetics and candle production and The Summit Café in Vanuatu also has a small scale hydraulic press that they use in their product development laboratory for small batch processing to produce cosmetics and candle production. Oil presses using a screw to compress canarium kernels and extract the cold pressed oil have been used but found to be difficult to use. Oil presses using a hydraulic ram to press the broken kernels have been found to be more effective and have been provided to project partners (NARI in PNG) (Appendix 11.9).

2.4	Examine processing methods to improve shelf life. This would involve research on handling protocols (drying, storage, packaging) and the consequences for product quality in terms of rancidity and shelf life. It would also include chemical analysis of the products	Protocols for improved shelf life to meet export market requirements	Van Yr 3, m12 SI Yr 3, m12 PNG Yr 4, m6	Shelf life experiments on canarium nut-in-shell and kernel have been undertaken. Using a domestic vacuum-packaging system dried kernels have been stored with little oxidation for six months at 30°C and for nine months at 25°C. Increases in free fatty acids while stored at ambient temperature may limit further storage potential. Two shelf life experiments with nuts from Vanuatu and Solomon Islands have been undertaken. In the first experiment, initial moisture content at 3.12% was too high and the peroxide values after 3 months was greater than 3.0 meq/g oil (milliequivelants/g oil), indicating that at this initial moisture content, although free fatty acid levels were acceptable, shelf life was restricted to only 3 months. In the second experiment with an initial moisture content of 2.5%, the free fatty acid levels was greater than 0.5%, indicating that although peroxide values were acceptable, shelf life was restricted to 9 months. Information supplied to processors about the kernel shelf life trials is contained in Appendix 11.10. Shelf life experiments on commercially prepared canarium oil commenced in November 2014 and are expected to continue for a further six months. A series of modules has been prepared to 'train the trainer' on canarium nut protocols. See Appendix 11.11-13 for the first three presentations in the series. These were trialled in PNG.
2.5	Examine microbial load and risks of contamination in the processing chain	Recommendations on best practice for growers handling to meet export food safety requirements	Van Yr 2, m9 SI Yr 1, m9 PNG Yr 2, m9	Microbial testing results for samples from Solomon Islands and Vanuatu taken through the processing chain were tested. Standard plate count results for fresh & solar dried samples indicate that they are unsatisfactory as a ready to eat product, but satisfactory if used for further processing. Village dried & commercially prepared nuts were mostly satisfactory for immediate consumption. Results for many of the other indicators were marginal by Australian food standards. Although within acceptable limits, this may indicate hygiene problems during food preparation (Appendix 11.15). This highlights the need for improved food safety standards during processing. A series of modules has been prepared to 'train the trainer' about food safety, see Appendix 11.14, and the risk of aflatoxin in canarium nuts.
2.6	Develop industry quality standards and product specifications for *canarium indicum*.	Finalised industry standards and protocols	Yr 3, m12	Prior to the start of the season, old and immature nut-in-shell should be removed and the ground under the trees cleared of undergrowth and leaves to make collection of nuts easy and reduce the risk of mould and exposure to pathogens such as *Salmonella* and *E. coli*. Nuts need to be collected regularly. The fleshy mesocarp (flesh) should be removed and the nut-in-shell dried as quickly as possible (See Appendix 11.16 for best practice guidelines for farmers and village collectors; see Appendix 11.13 for a presentation for farmers on good practices).

2.7	Develop food safety and product testing protocols.	Finalised food safety and product testing protocols for processors	Van and SI Yr 3, m12 PNG Yr4, m12	Factory hygiene protocols with appropriate training to ensure principals of food hygiene are observed need to be implemented. Critical control points (e.g. blanching kernels) need to ensure the temperature is sufficient to achieve sanitising the kernel. Moisture content, microbial and aflatoxin levels need to be monitored to ensure the nuts are safe for human consumption. Kernel should be packaged in moisture proof sealed bags. (See Appendix 11.17 for recommended industry standards).
2.8	Measure SPRIG germplasm trials in Solomon Islands for early yield and processing characters	Selection of best bet germplasm for distribution to smallholders	SI Yr 1, m11 SI Yr 2, m11	Early fruit yield of the progeny trial and morphological variation in nut size during 2011, 2012 and 2013 was measured. Our results indicated that there was no significant difference in total fruit yield between families. There were large differences in nut size between individual trees. Kernels from *C. indicum* trees that produced the largest kernels weighed nearly twice as those from the trees that produced the smallest kernels. These results highlight the benefits of early evaluation programs to identify superior selections that will increase yield and quality of *Canarium indicum* kernels in Pacific Island countries. Using the results from 2001, a paper on “Selection of the Tropical Tree Nut canarium indicum for early flowering, Nut and Kernel size” was presented at the IHC Brisbane 2014. (Appendix 11.18). Data from 2011-13 has been analysed and a journal articles on early fruiting and flowering and kernel size are attached (Appendix 11.19). To optimise yield, trees need to be planted at least 10m x 10 m apart to allow light interception. This research also showed differences in yield, nut size and kernel size between individual trees, providing a basis for clonal propagation.

PC = partner country, A = Australia

Objective 3: To analyse drivers and barriers to stakeholder industry participation and capacity

No.	Activity	Outputs/ milestones	Due	Comments

3.1a	*Analyse positive and negative impacts of market opportunities and product development* experienced or anticipated *by smallholders, commercial growers, processors, marketers in Papua New Guinea, and in particular, from export arrangements*	Analysis of the key drivers and barriers for different stakeholder groups in market and product development for each of the three countries.	Yr 3, m1	Key positive impacts are: *An evident resource base for supply* • 27,000 trees planted by ENBDC and 19,000 by Agmark • 30,000 trees planted by small-scale farmers and around 120,000 planted by cocoa farmers. • Nursery to continue to supply seedlings to PPAP *Maturation of processing and capacity* • Hand crackers have doubled the cracking rate • Refinement of on-farm processing guidelines and processed products for market and SME demonstration • Good handling practices, train the trainer and HACCP extension materials. *An evident interest in partnership for regional infrastructure to support supply* • Large cocoa exporters and companies such as ENBDC keen to streamline commodities through buying network • Interest from one large company in establishing plantation, constructing a factory and further market penetration with increased volumes. Key negative impacts are: *Further equipment and research needed to continue large-scale supply* • Although supply lines of cocoa industry can be used, large-scale equipment is needed. • Further product development and marketing needed

3.1b	*Analyse positive and negative impacts of market opportunities and product development* experienced or anticipated *by smallholders, processors, marketers in Vanuatu in the suitcase industry and domestic industry.*	Analysis of benefit sharing along the value chain and impacts on livelihoods from expanded value added markets for each of the three countries.	Yr 3, m1	Key positive impacts are: *An evident developing capacity* • There is a nut industry association established in six provinces for information, planting support, collaboration and industry development. • Lapita Café are proactive with village collectors and have expanded their supply base from family farmers on Marlo Island in 2010 to over 100 farmers spread across four districts in 2014. Key negative impacts are: *Further capacity needed* • Arrangements and motivation needed for farmers to supply processors, possibly based on coffee and sandalwood training models, sustained informal training and formal training. Training to include understanding of quantity as well as quality so that farmer expectations for returns on effort are managed. • Trees but not human or physical capacity to harvest and process (e.g. the Summit/South Pacific Sandalwood) *Supply challenges* • Primary processing methodology needs to be developed and implemented in remote districts to ensure food hygiene and quality is maintained. • Cracking continues to be perceived as labour intensive and returns not worth effort. Further research is required on mechanical crackers. • Cost of driers or methods for on-farm drying *Product specifications and standards* *Still require development* • An increase in supply is required before international marketing

3.1c	*Analyse positive and negative impacts of market opportunities and product development* experienced or anticipated *by smallholders, processors, marketers in Solomon Islands in terms of the domestic industry and/or linkages with the other two countries industries .This includes analysis of social acceptability by honours student*	Cross-country comparisons of drivers, benefits and barriers for the different stakeholder groups		Key positive impacts are: *An evident developing capacity* • At least one community has a solar drier and there is an industry association. • Some initial testing of samples in restaurants has occurred. • One processor is looking to expand capacity and is seeking to obtain a Chinese hand cracker to improve productivity. Key negative impacts are: *Further capacity needed* • More industry associations are needed to coordinate and network and promote markets once product specifications are known • Policy options remain under discussion for increasing tree plantings. • More processors need to be encouraged • Supply and buying networks need to be established from outer islands (as it is expensive transporting in small volumes) *Lack of consistent supply* • Subsistence value of Canarium is perceived to be higher than its market value. • Processors require larger quantities than are being supplied. • Cracking continues to be perceived as labour intensive and returns not worth effort. • Lack of market structure and advice e.g. returns to farmers *Product specifications and standards* • Still require development. *Infrastructure* • Limited and expensive

3.2a	*Research case studies or successful models from elsewhere that might mitigate against or further enable the drivers, benefits and barriers articulated by each of the stakeholder groups in Activity 3.1 above.*	A list of recommendations for each of the countries will help governments, the private sector and growers to expand the industry and facilitate industry development in ways that are unique to each of the countries and their stage of industry development, as well as unique public sector arrangements and other influencing factors.	Yr 3, m6	The case study of Macadamia industry development suggests that: Further effort should be made to achieve a cost effective method of producing large numbers of clones and eliminate natural variability of seedlings for large scale commercial orchards. Mechanical cracking needs further investigation. Hand cracking may have a place in high end niche markets, but the larger commodity market will require more kernel than can be supplied by existing technology. The single most important ingredient currently missing is capital investment by a company who is serious in taking the industry forward. Government initiatives in research, extension, subsidies and other policy incentives are needed, as well as formal structures or institutions for devolving participation or negotiating on behalf of membership. The Nutmeg industry development case study suggests that: Food safety and quality is critical and requires principles for farmers and regular testing and regulation. Drying and storage facilities need to be high quality. Whole of chain education is needed, especially if exporters and processors train their suppliers in food safety.
3.2b	Develop alternatives or strategies that might address the barriers to engagement experienced or anticipated by stakeholders for PNG, especially in the export industry.		Yr 3, m6	Promotion of Canarium as a timber and shade tree as a risk mitigation strategy during seedling distribution Possible nursery or grafting opportunities in the future to continue supply. Regional rather than centralised processing, based on existing buying networks. Need for equipment that suits a larger-scale of operation, joint venture with business partner needed. Use of existing extension networks through allied projects.
3.2c	Develop alternatives or strategies that might address the barriers to engagement experienced or anticipated by stakeholders for Vanuatu, especially the suitcase industry.		Yr 3, m6	DoF propagate and distribute seedlings; policy needed for public-private involvement. Processor-led training provided to suppliers, with processor-developed standards that vary according to their end uses. Easier, efficient cracker needed. Farmer organisations in each province. Stablise nuts on-farm with on-farm solar driers.

3.2d	Develop alternatives or strategies that might address the barriers to engagement experienced or anticipated by stakeholders for Solomon Islands, especially the domestic industry.		Yr 3, m6	MoF distribute seedlings, policy adoption Processor-led training provided to suppliers, with processor-developed standards that vary according to end uses. Re-establish buying network. Easier, efficient cracker needed. Stablise nuts on-farm with on-farm solar driers.
3.3	Written documentation and on-farm, applied demonstration, in PNG, Vanuatu and Solomon Islands.	Educative materials in different formats/training packages that includes information on growth, harvesting, expected returns from domestic and export markets.	Yr 3, m6	Written training documentation and on-farm demonstration delivered in Vanuatu and to be forwarded to Solomon Islands. Written training documentation and on-farm demonstration delivered in PNG on good harvest and post-harvest handling practices, train-the-trainer and HACCP.
3.4	Quantitative benchmarking of changes in capacity and capability of each stakeholder group in terms of understanding aspects of the industry including growth, harvesting and anticipated profit returns in the value chain for each of the three countries.	A set of indicators by which quantitative data can be collected and used to measure change for each of the three countries. Data gathered and analysed against these indicators to demonstrate capacity and capability changes for each of the three countries.	Yr 1, m12 Yr 3, m 12	Initial and final data against the following indicators were collected; and the differences compared: • Economic returns and willingness to sell – steady processor-led increases in Vanuatu; decreases in Solomon Islands • Infrastructure and equipment – steady processor-led increases in Vanuatu • Cracking NIS – Chinese hand crackers introduced have doubled the capacity for cracking over traditional methods in PNG • Changes in available resource – small increases • Knowledge and coordination – steady processor-led increases in Vanuatu • Product specifications and standards – processor-led increases in Vanuatu, draft standards produced in PNG that will be extended across all three countries

7 Key results and discussion

7.1 Objective 1: Canarium Markets and Consumer Insights

7.1.1 Canarium Industry Structure

As a result of this project we now have a much clearer understanding of the structure of the canarium industry, the process flow and the different market channels linking supply to consumer markets in Vanuatu and Solomon Islands (Fig. 1 & 2).

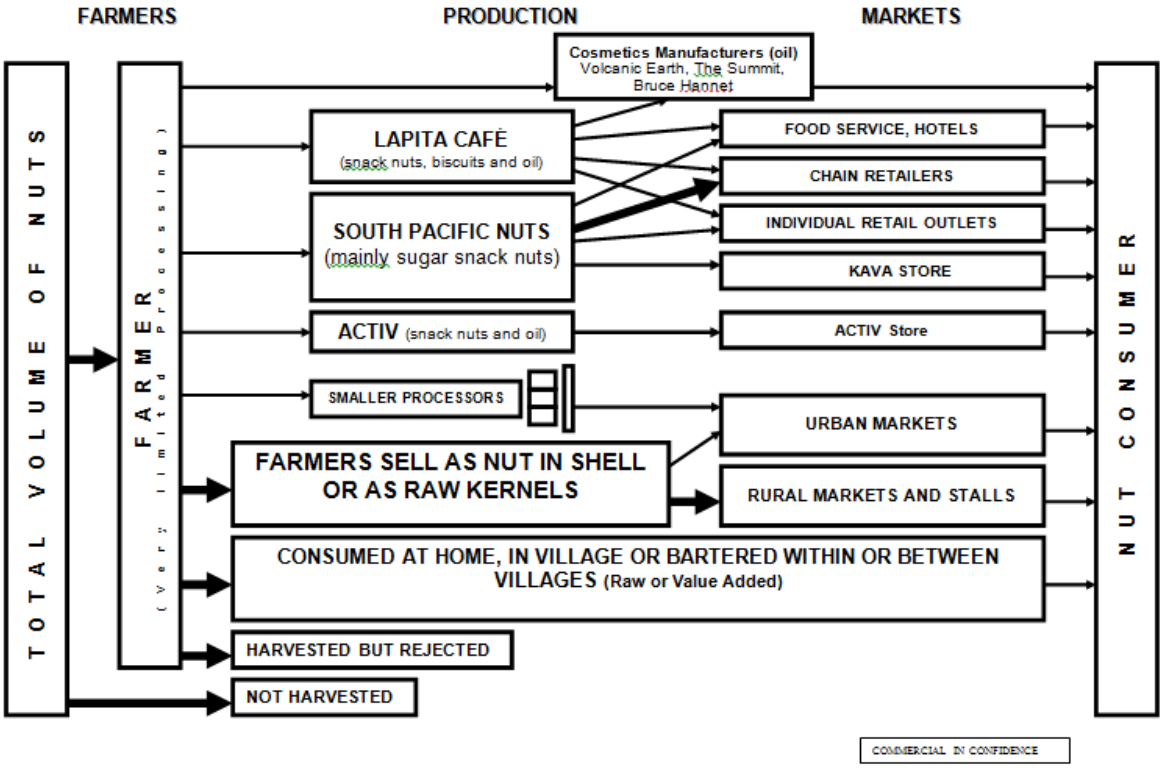

Figure 1. Vanuatu canarium Industry Chain Map

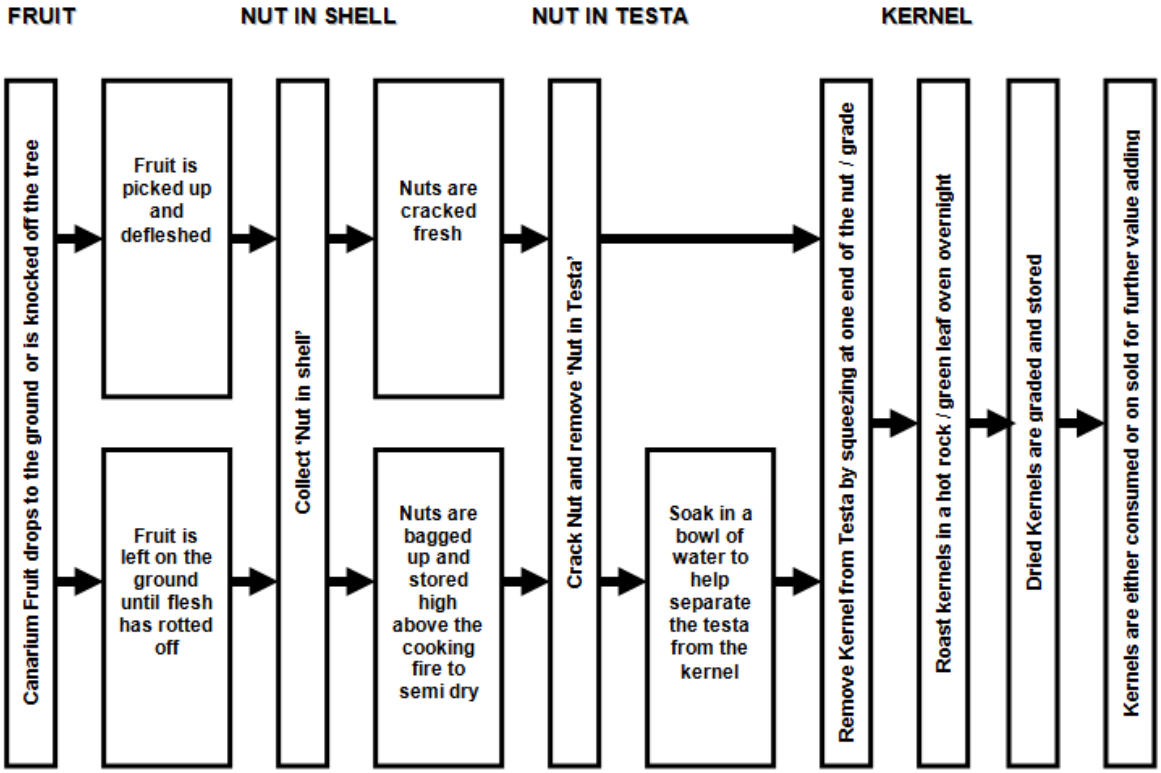

Figure 2. Solomon Islands Nut Process Flow Map

In both countries the key opportunities identified early in the project were;

- Unfulfilled domestic demand
- Need to identify nut growing and primary processing systems suitable for these countries and the market requirements
- Understand more about consumer demand in priority markets
- Work with chain and industry 'champions' for the benefit of the wider industry and its future development
-

In Vanuatu there is evidence of significant unfulfilled domestic demand, particularly with the high volume of tourists that arrive by either air or ship. In 2013 there were 352,755 visitors to Vanuatu with 69% of these arrivals by cruise ship. The cruise ship figures have driven the growth in recent years with the average number cruise ship arrivals jumping from 154,939 in 2011 to 242,646 in 2013 (an increase of 57%). Australians are the largest nationality of visitors in Vanuatu followed by New Zealand and New Caledonia. By far, holidays is the main purpose of visit for the people going to Vanuatu, followed by business and visiting friends and relatives (The Vanuatu National Statistics Office, 2014).

Supply of nuts has been a problem in the past with stringent processing requirements to freeze all raw product within 24 hours, limiting access to market for wild harvested nuts and nuts from remote islands. In more recent times, new raw material requirements and processing techniques have been developed and adopted which has led to an expansion in the number of processors and products, including some processing of canarium oil for cosmetic uses.

In Solomon Islands there are market opportunities in the domestic food service and retail sectors. The primary processing of the nut through existing village systems seems to work

quite well and in addition to snack nuts, the kernels are also being incorporated into small quantities of value added products like ice cream, muesli and oil.

Export markets like Australia, New Zealand and potentially even New Caledonia need to be explored as industry capability increases and product quality improves.

Once the broad target markets and potential private sector partners were identified the next step was to gain more information on consumers in these target markets. This research aimed to understand consumer behaviour, valued attributes and willingness to pay for a range of new value added canarium products.

This was achieved through multiple surveys and interviews across both countries;

- In August 2011, 355 surveys were conducted in Vanuatu on tourists and locals (for canarium and Cocoa projects)
- In July 2012 a follow up survey was conducted in Vanuatu which narrowed the questions asked and the targeted consumer to adult nut consuming tourists who were leaving Vanuatu (105 surveys collected, 61 analysed after screening questions)
- In October 2011, preliminary surveys and interviews were conducted in Solomon Islands with locals, tourists, restaurants and hotels.
- In Feb 2014 a follow up survey of locals and tourists was conducted in Solomon's targeting adults who buy or consume nuts (200 locals in Honiara, 100 locals in Auki, 100 locals in Gizo and 50 tourists in Honiara)
- In Dec 2012 a survey of 50 Australian nut processing companies was conducted targeting the key decision makers like CEO's, Purchasing and R&D Managers.

Detailed reports are available for these research activities in Appendix 11.20 and 11.21 Key insights are summarised below.

7.1.2 Vanuatu Tourists

Of the tourists surveyed in 2011

- 76% arrived by plane, 75% were Australian or New Zealand, 70% plan to purchase souvenirs or gifts while in Vanuatu
- 91% of respondents who had never heard of canarium were interested in trying them
- The most appealing products to respondents were 1) plain nuts 2) chocolate coated nuts 3) salted nuts
- Key influencing factors when purchasing canarium nuts were 1) Price 2) Being locally produced with local ingredients 3) Local ownership
- Tourists were willing to spend between 500-1000Vatu (AUD $5-$10) on packs of snack canarium nuts

For the follow up survey in 2012

- 50% of tourists were purchasing local food at least once per day. 80% purchased local food at some time during their visit which suggests tourists are willing to engage with local food
- 92% bought a souvenir during their stay, 65% of these were food products
- Interestingly, their nut purchasing increased slightly while on holidays
- The consumption of nuts by tourists was predominantly done as a snack (79%) or as a gift to take back home (69%)
- Cafés (87%) and fine dining restaurants (84%) are the venues visited most by tourists but the retail outlets used most to purchase canarium nuts were supermarkets (83%) followed by the central market (72%). This no doubt says more about the availability of canarium nuts than the preferences of tourists, which

highlights the opportunity to expand into new market channels as industry capacity increases.

- The survey also showed that the majority of respondents would be willing to pay 10-30 % more for nuts that were clearly branded as being local to Vanuatu which is encouraging for all links of the chain including retailers, processors and farmers.
- The nut attributes consumers valued the most were based on being healthy, fresh, organic, nutritious, local and an ability to pass through quarantine (Fig. 3).

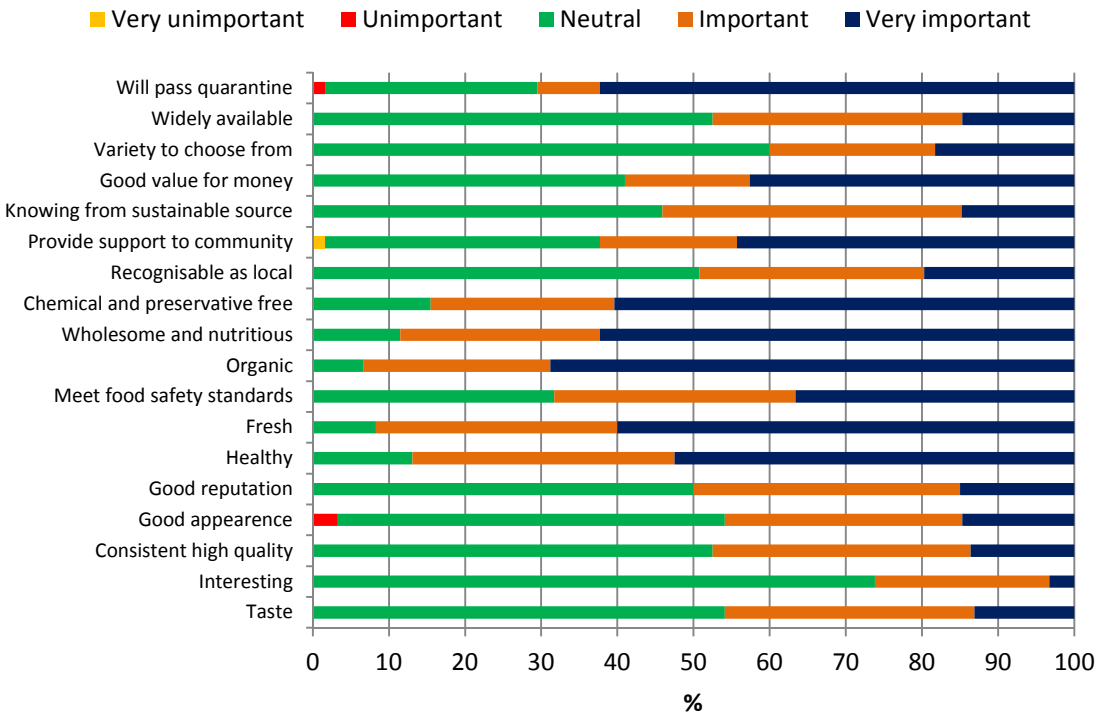

Figure 3. Vanuatu tourist nut attribute values

7.1.3 Solomon Island Locals and Tourists

In an effort to understand the experience of locals and tourists in Solomon Islands with canarium nuts, we instigated two surveys, one targeting local consumers and another targeting tourists leaving Solomon Islands. At present, with relatively low tourist numbers of around 20,000 visitors each year, the tourist market is small, and as such should not be the sole focus of product development and market efforts but rather 'top up' domestic sales.

While the tourist market is currently relatively small, the results from the tourist survey can shed light into international market preferences and help bridge the gap between domestic suppliers and international markets. The survey was designed to understand canarium and local food consumption and purchasing behaviour. The local consumer survey had a similar goal from a domestic perspective and both sets of data were used to provide recommendations and insight into the development of the canarium industry in Solomon Islands.

For the tourists we found that;

- The majority of tourists visiting Solomon Islands were on business (56%), with others attending a conference (16%) or visiting friends or relatives (14%). All respondents were on their first trip to the region, with most staying for more than 14 days

- Tourists are interested in purchasing souvenirs (55%) but unlike Vanuatu only 8 per cent were interested in purchasing edible gifts to take home which may be due to quarantine concerns and the relative lack of value added products in Solomon's. Since packaged canarium nuts are able to pass through Australian customs, any future efforts targeted at tourists should clearly advertise this fact.
- During their stay in Solomon Islands, nuts were purchased infrequently if at all, with 47 per cent not purchasing any, compared with 44 per cent who eat nuts at least once a week when at home. This indicates the underdeveloped local nut market in Solomon's and lack of awareness of local nuts by tourists. When asked why they didn't purchase nuts, most respondents stated that they were not aware of local nuts or did not see them where they shopped.
- Similar to Vanuatu, nuts were purchased mainly from the central market (76%) and supermarket (24%) even though tourists are more likely to shop at cafes (78%) and restaurants (51%).
- Unlike Vanuatu where the majority of nuts are value added, in Solomon Islands the majority of nuts were purchased as fresh kernels (64%), in shell (48%), or as dried kernel (32%)
- In contrast to the types of canarium nut available, the greatest interest from tourists was for canarium as a nut snack (67%) or roasted & salted (61%)
- The survey also showed that the majority of respondents (70%) would be willing to pay 5-30 % more for nuts that were clearly branded as being local to Solomon Islands which is also a similar result to the observation in Vanuatu.
- The nut attributes tourist consumers valued the most were based on taste, being chemical free, nutritional and fresh (Fig. 4).

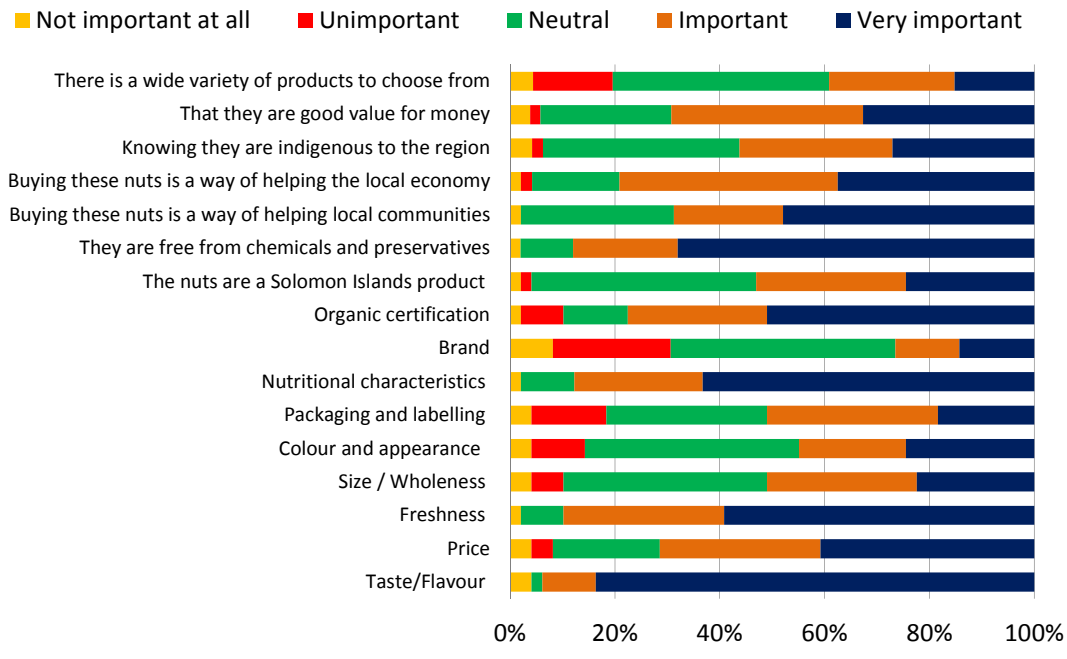

Figure 4. Solomon Island tourist nut attribute values

The local survey of Solomon Islanders showed very similar results to the tourists in that;

- Most canarium nuts are purchased in season from the wet market (89%).
- Approximately 60% of respondents stated they would buy more canarium nuts if they were available all year round.
- 80% of nuts are purchased as a fresh kernel, yet 51% of respondents would prefer canarium nuts to be value added in some way
- Most households consume canarium nuts raw (93%), followed by in traditional recipes (68%), roasted (46%) and then mixed with other nuts and food (41%)
- The nut attributes consumers valued the most were based on taste, freshness, price and nutrition (Fig. 5).

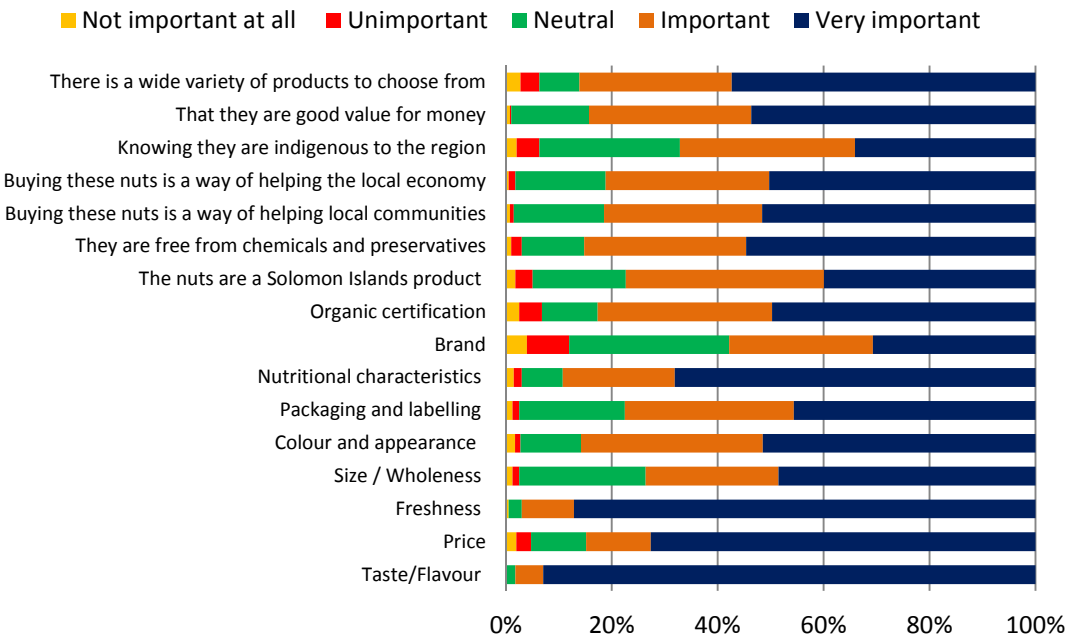

Figure 5. Solomon Island local nut attribute values

7.1.4 Nut Companies in Australia

In 2012, the CEOs of 50 Australian nut processing companies were approached and invited to take part in research on the potential for canarium nuts in the Australian marketplace (Appendix 11.21). Fresh samples of new season dried canarium nuts were supplied to the companies along with background information on the nuts, nutritional analysis and four questionnaires to capture the thoughts of the key decision makers in each company.

Of the 50 companies, 16 companies returned a total of 25 surveys which were completed by the CEOs, Purchasing Managers and Research and Development Managers. In one of the questions, the companies were asked an open ended question about their first impression of canarium nuts. To summarise these comments and highlight the words that were used the most, a word cloud was constructed. The biggest word in the cloud was 'Roasted' which reflects the common value adding suggestion given by the respondents that roasting is very effective in bringing out an improved flavour and texture in the nuts (Fig. 6).

Figure 6. Word Cloud

Other key insights from the Australian nut company survey were;

- The most significant nut attributes stated by the companies were flavour, price and freshness
- It was encouraging to note that 67% of respondents believed canarium nut would have commercial appeal in the Australian Market and 58% stated they would consider using canarium nuts as part of their product mix
- The market segments suggested as the best opportunity in Australia included health stores, gourmet food and boutique stores, bakery and confectionary products and as a cooking ingredient
- We also asked the processors how they would prefer to buy the nuts. Some respondents replied raw so they could control the value adding step themselves but other companies that specialise more in packaging and distribution were more interested in obtaining the nuts already value added. This offers an interesting differentiation in the types of Australian companies that could be targeted by Pacific exporters.

7.1.5 Summary of the canarium Nut Marketing Strategy Report

Summary of canarium Nut Marketing Strategy Report (Appendix 11.4)

- This canarium Nut Marketing Strategy is concerned principally with the Vanuatu tourist market. Stimulating demand for the local nut among the many tourists that visit is vital to the success of the emerging nut-based agri-industry. Related marketing literature conveys that pro-social food motivations are important with today's consumers concerned about the social and ethical circumstances of the origin of the food they consume.
- The tourism industry in Vanuatu is of significant size and has experienced rapid growth and development that is projected to continue for some time. Vanuatu hosted more than 230 cruise ship calls in 2014, mostly comprising Australian tourists who have an interest in food-focused travel.
- Short- and long-term food trends are favourable for the development of canarium nut products, with a focus on ethical awareness, healthy options, and growing demand for exotic, foreign foods.
- Transferrable strategies from the Australian macadamia nut industry indicate that social media marketing and ecommerce may be considered to supplement traditional supply chains once these have been established.

PNG: The analysis of markets and market segments for PNG found there is unmet demand for canarium within Papua New Guinea where it is very well known but not available commercially beyond traditional markets. The analysis recommended maximizing domestic market potential as a critical starting point for the PNG canarium industry, with initial exports to focus on Melanesian countries due to preferential market access arrangements. Ultimately however canarium is viewed as being a very important export market crop. Three export markets that provide a good fit for canarium products were identified as China, Japan and Australia, with opportunites for both food products and cosmetic oil. A full report is provided in appendix 11.5.

7.2 Objective 2: To develop processing techniques tailored to each country's circumstances

7.2.1 Drying

Effective drying is the most important part of the value adding process for *Canarium indicum* and effective drying results in excellent storage potential of processed products. Processors have indicated a preference to crack canarium nuts fresh and dry and process kernels, rather than drying and storing nut in shell.

These results show that consistent temperatures of above 60°C will reduce kernel moisture content to below 5 % in only 1 hour but may have a detrimental effect on colour and storage potential (Fig 7). Temperatures of 50°C, even after 6 hours of drying, produced a whiter coloured kernel that may have longer storage potential.

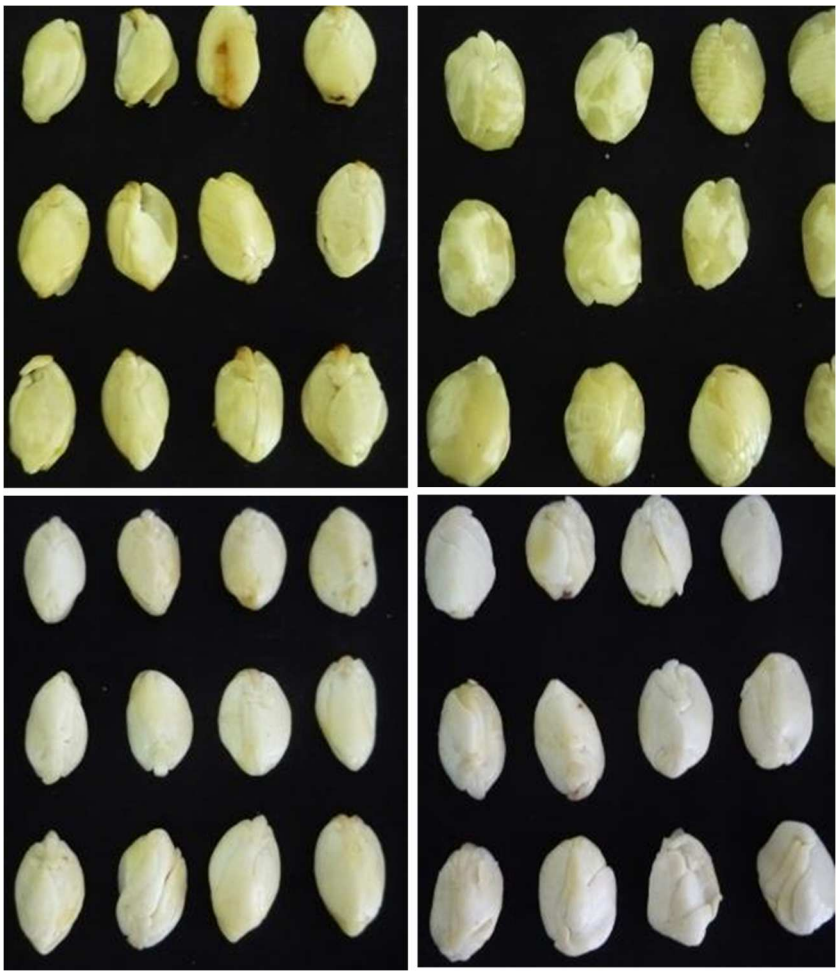

Figure 7. Colour of Canarium kernel dried for 6 hours at 80°C (top left), 60°C, 50°C and 40°C (bottom right).

However temperatures of 50°C only reduced moisture content to around 10% even after 6 hours (Fig 8). This is insufficient for long term storage and further drying is needed to reduce moisture content to 3-5%. Temperatures of between 50°C and 60° C would be the most appropriate for high quality canarium kernel.

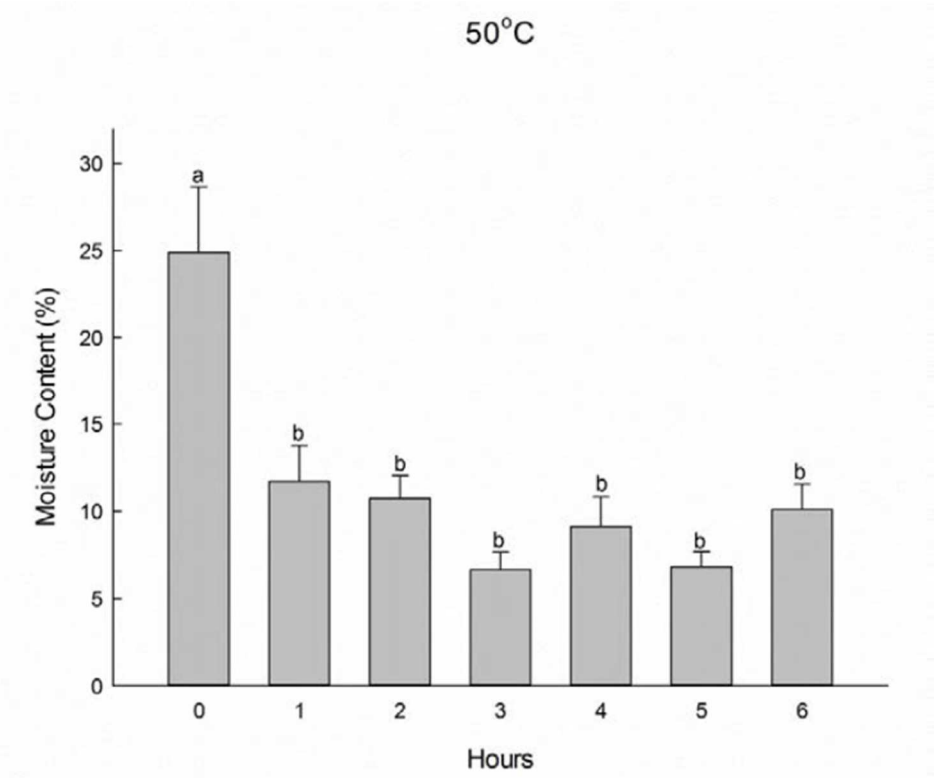

Figure 8. Hourly moisture content on *Canarium indicum* kernel during drying for 6 hours at 50°C.

7.2.2 Roasting and use of by products

Information on the roasting experiments undertaken at the National Agricultural Research Institute in Kerevat Papua New Guinea was shared processors in Solomon Islands and Vanuatu. This data has since been presented as a poster at the International Horticultural Congress in Brisbane in August 2014. The journal article “A roasting study for the tropical nut *Canarium indicum* (Burseraceae)” has been submitted for inclusion in an Acta Horticulturae publication.

Trials were also undertaken in Vanuatu at Lapita Café with roasting, salt roasted, sugar and honey coated canarium products. Feedback from customers indicated that: roasting for 10 minutes produced a more acceptable product as this gave a more flavoured product; salt roasted nuts using a 15% salt solution was salty, but not too salty; sugar coating using one cup sugar just dissolved in half a cup hot water (not boiled) for either 30 and 40 minutes at 150ºC gave a shiny coating without the sugar crystals and the honey products were all still sticky. Those dried in the desiccator for 18 hours were the least sticky (Appendix 11.6)

Canarium indicum has a mild flavour that can be substituted into value added products and contains a healthy nutritious source of fats. Commercial operations are using broken pieces of *Canarium indicum* for biscuits and producing oil for cooking and cosmetics. Equipment to more effectively produce oil has been sourced and provided to NARI in PNG (Fig. 9). Information about uses of by-products to minimise waste have been shared between current processors (Appendix 11.9).

Figure 9. Coconut oil press from Axis Industrial Ltd (New Zealand) holds 15 litres meal per pressing.

7.2.3 Shelf life

Two experiments have been undertaken on shelf life with nuts from commercial processors in Vanuatu and Solomon Islands. They were assessed for peroxide values and free fatty acids, which are industry standard methods for analysing deterioration of foods over time. Reports containing the specific results have been submitted to the respective industry partners.

The canarium nuts from commercial operator A at three months had peroxide values 3.06 meq/g and free fatty acid values 0.26%. Peroxide values at 9 months were 3.62 meq/g and free fatty acid values 0.38%.

The canarium nuts from commercial operator B at three months had peroxide values 0.81 meq/g and free fatty acid values 0.37%. Peroxide values at 9 months were 1.6 meq/g and free fatty acid values 1.1%

Recommendations from the Australian Macadamia industry are that the moisture content should be less than 1.5%; Recommendations from the Australian Macadamia industry for peroxide values have recently been amended from 6.0 meq/g oil (milliequivelants/g oil) to peroxide values less than 3.0 meq/g oil (milliequivelants/g oil) and free fatty acids less than 0.5% (Appendix 11.10).

The initial moisture content was higher from Commercial A than Commercial B with the higher peroxide values from Commercial A indicating shorter storage potential. For commercial A, initial moisture content at 3.12% was too high and the peroxide values after 3 months was greater than 3.0 meq/g oil (milliequivelants/g oil), indicating that at this initial moisture content, although free fatty acid levels were acceptable, shelf life was restricted to only 3 months.

For Commercial B with an initial moisture content of 2.5%, the free fatty acid levels was greater than 0.5%, indicating that although peroxide values were acceptable, shelf life was restricted to 9 months.

7.2.4 Microbial testing of canarium samples

Canarium indicum nut samples from different processing method (fresh nuts, nuts dried in villages over hot stones heated in wood fired ovens, nuts dried using solar driers and nuts dried from two different commercial processors) were assessed by a registered food laboratory in Australia for microbial contamination and known pathogens. The results were compared to guideline levels for microorganism contamination from the NSW FoodAuthority (Food Authority NSW 2009).

Satisfactory results in these guidelines indicate good microbial quality, marginal results are within acceptable limits of microbial quality but may indicate possible hygiene problems during food preparation, while unsatisfactory results have unacceptable microbial contamination.

Fresh nuts were higher in all forms of microbial contamination levels (Table 2). Marginal coliform results from all samples (except commercial B) indicate bacterial pollution, which may result from harvesting methods or contamination after cracking from the shells. Low coliforms levels from commercial B indicate a higher standard of hygiene. Satisfactory levels of *Escherichia coli* in the processed samples demonstrates acceptable hygiene levels during processing, while the marginal and unsatisfactory *Escherichia coli* levels in the fresh and solar dried samples demonstrates unacceptable hygiene during processing.

Processed nuts contained significantly lower standard plate count and *E.coli* contamination compared to fresh nuts. Yeast Count and Mould Count were generally higher in the fresh samples than the more processed treatments. Yeasts and Moulds, particularly in nut products are of concern because they can produce mycotoxins that are not destroyed during processing and may be harmful to human health.

Table 2. Microbial contamination of *Canarium indicum* samples collected from different processing methods. Standard Plate Count rated as satisfactory or unsatisfactory as a ready to eat (level 1) food; (number of samples each level).

	Fresh	Village	Solar	Commercial A	Commercial B
Standard Plate Count	Unsatisfactory (3)	Satisfactory (2) Marginal (1)	Unsatisfactory (3)	Marginal (3)	Satisfactory (2) Marginal (1)
Coliforms	Marginal (3)	Marginal (3)	Marginal (3)	Marginal (3)	Satisfactory (3)
E. Coli	Marginal (2) Unsatisfactory (1)	Satisfactory (3)	Marginal (2) Unsatisfactory (1)	Satisfactory (3)	Satisfactory (3)

These microbial results shows the need for a Hazard Analysis Critical Control Points (HACCP) program and detailed procedures to improve food safety standards during processing (Appendix 11.15).

7.2.5 Variability in fruiting and nut size of *Canarium indicum*

A *Canarium indicum* progeny trial on Kolumbungara Island in Solomon Islands was measured for three years to determine which families or trees showed early fruiting and good nut characteristics. Some trees flowered and fruited in multiple years (Tables 3 & 4). There were significant differences in mean C*anarium indicum* kernel and nut-in-shell weights between trees. Kernel weight from selected trees each year demonstrated a large range (Fig. 10-12). Kernel weights and nut-in-shell weights from the best trees were nearly twice the weight as for the poorest trees. The best tree selections for nut weight were not the same as the best selections for kernel weight, highlighting the importance of assessing a range of nut characteristics. These results highlight the benefits of early evaluation programs to identify superior tree selections that will increase yield and quality of *Canarium indicum* kernels in Pacific Island countries. A clonal propagation program is also highly desirable to capture the best germplasm for nut production and a clonal propagation program could result in large gains in nut production and kernel size.

Data from 2011 has been analysed and reported at the International Horticultural Congress in Brisbane in August 2014 and the journal article “Selection of the tropical nut *Canarium indicum* for early fruiting, nut-in-shell size and kernel size” has been submitted for inclusion in the Acta Horticulturae publication (Appendix 11.18).

Data for the period 2011 to 2013 has been analysed and an initial draft journal article” three year study on early fruiting and nut size of the tropical nut C*anarium indicum*” (Appendix 11.19) is attached.

Table 3. Early-flowering families with more than 13 individual trees flowering between 2011 and 2013

Provenance	Family	Number Surviving Trees	Number of. individual trees (%) flowering			Number of. individual trees flowering in multiple years		
			2011	2012	2013	1 year	2 years	3 years
Ranogga	4	15	4 (27)	5 (33)	4 (27)	5	1	2
Marovo	11	13	8 (62)	7 (54)	3 (23)	5	2	3
Marovo	12	14	3 (21)	7 (50)	4 (29)	4	2	2
Marovo	14	14	6 (43)	6 (43)	6 (43)	3	3	3
Marovo	18	14	4 (29)	4 (29)	5 (36)	3	2	2
North New Georgia	20	13	5 (39)	5 (39)	3 (23)	4	3	1
North New Georgia	21	14	4 (29)	7 (50)	4 (29)	2	2	3
North New Georgia	22	16	6 (38)	5 (31)	2 (13)	4	3	1
North New Georgia	23	12	3 (25)	6 (50)	4 (33)	3	2	2
North New Georgia	26	15	4 (27)	8 (53)	4 (27)	2	4	2
Vona Vona	29	14	7 (50)	7 (50)	5 (36)	4	6	1
Vona Vona	31	16	3 (19)	5 (31)	5 (31)	2	4	1
Vona Vona	35	18	5 (28)	5 (28)	7 (39)	2	3	3
Vona Vona	36	14	7 (50)	6 (43)	5 (36)	4	4	2
Vona Vona	37	16	6 (38)	6 (38)	2 (13)	5	3	1
Vona Vona	38	16	8 (50)	7 (44)	8 (50)	4	2	5
Renadova	44	15	6 (40)	6 (40)	4 (27)	2	4	2
Rendova	45	16	2 (13)	6 (38)	5 (31)	4	3	1
Rendova	49	14	6 (43)	7 (50)	6 (43)	2	1	5

Table 4. Early-fruiting families with more than 13 individual trees fruiting between 2011 and 2013

Provenance	Family	Number Surviving Trees	Number of. individual trees (%) fruiting			Number of. individual trees fruiting in multiple years		
			2011	2012	2013	1 year	2 years	3 years
Ranogga	10	14	3 (21)	6 (43)	4 (29)	4	3	1
Marovo	11	13	7 (54)	4 (31)	6 (46)	2	3	3
Marovo	12	14	4 (29)	6 (43)	3 (21)	1	3	2
Marovo	13	15	5 (33)	3 (20)	5 (33)	4	3	1
North New Georgia	26	15	7 (47)	5 (33)	7 (47)	0	5	3
Vona Vona	29	14	7 (50)	4 (29)	5 (36)	3	2	3
Rendova	40	15	5 (33)	4 (27)	5 (33)	2	3	2

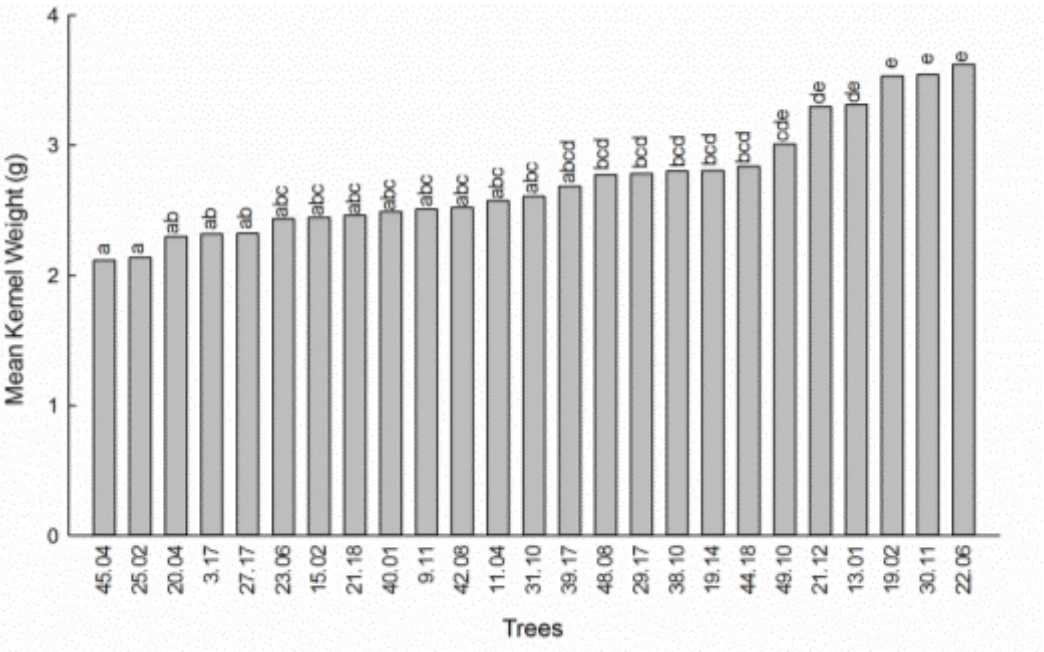

Figure 10. Kernel weight (g) of *Canarium indicum* from early flowering trees in 2011 from Solomon Islands

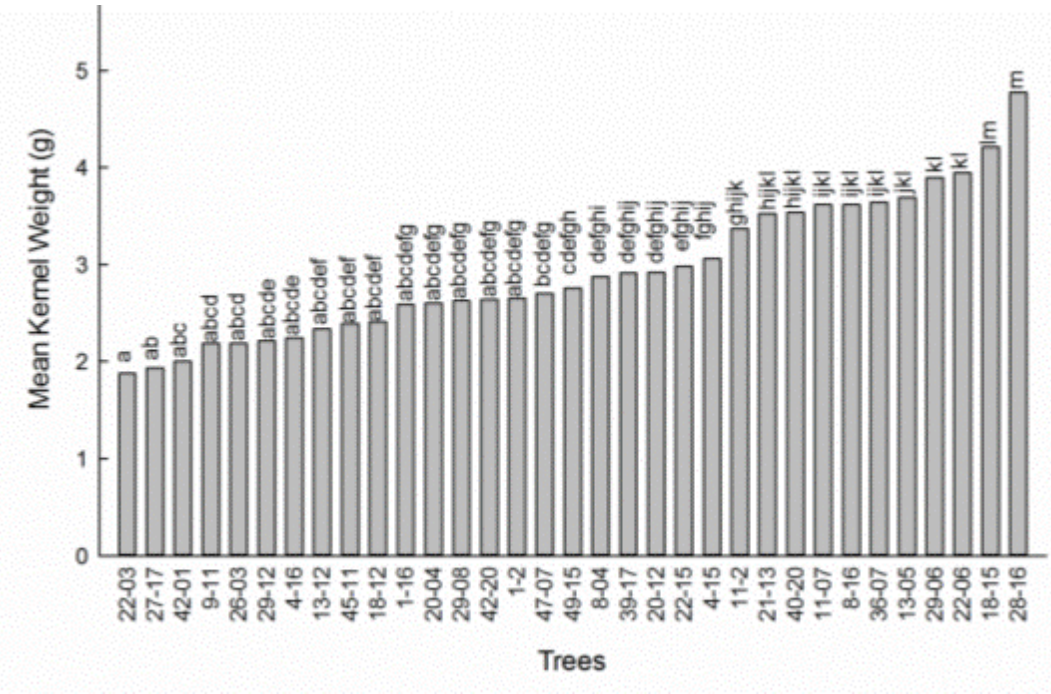

Figure 11. Kernel weight (g) of *Canarium indicum* from early flowering trees in 2012 from Solomon Islands

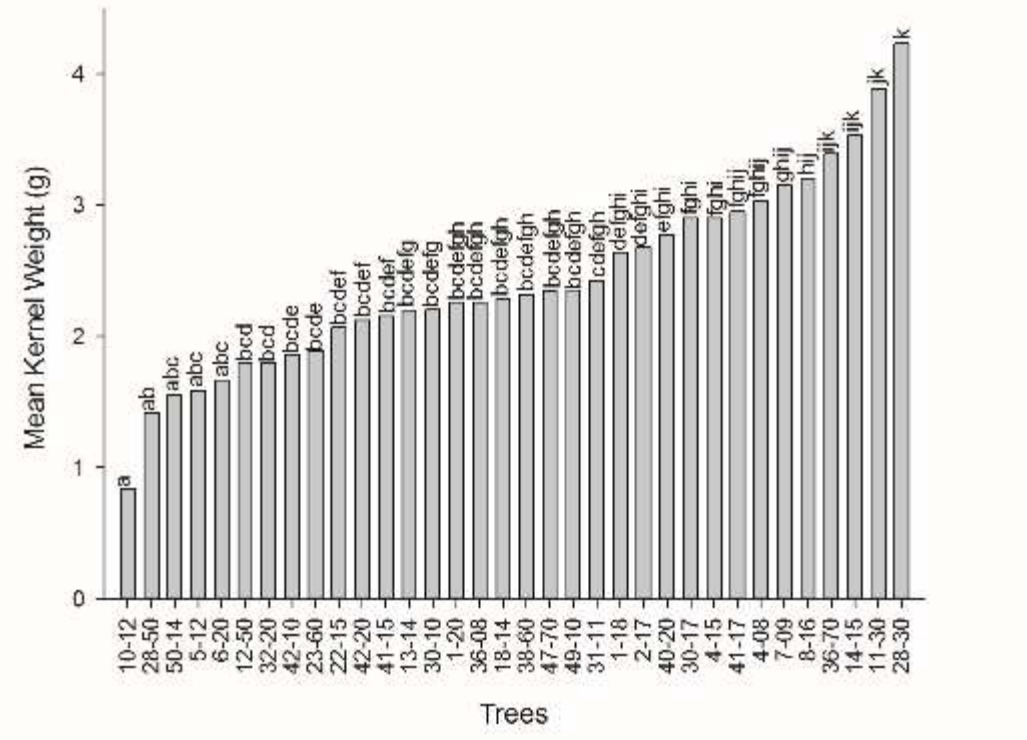

Figure 12. Kernel weight (g) of *Canarium indicum* from early flowering trees in 2013 from Solomon Islands.

7.3 Objective 3: To analyse drivers and barriers to stakeholder industry participation and capacity

7.3.1 Benchmarking stakeholder themes

From the stakeholder analysis six key themes were established as indicators for further canarium industry development (Table 5). These are discussed below in terms of benchmarking their progress over the life of the project, that is. The analysis firstly presents the situation at project inception (year 1) and at its completion (year 4) for each indicator and for the different countries.

1. *Available resource:*

At project commencement, participants in Vanuatu noted that a national canarium planting program was needed because of the lack of available resource. Despite the Forestry Department propagating and distributing high kernel recovery varieties to growers, especially in plantations, during this project, most production remained from wild harvest and the seedlings distributed during the project have not yet reached maturity. It is unclear whether the national planting program will increase the supply of nuts to industry, as wild trees provide high quality nuts suitable for the commercial industry, but only about 30% of the crop is harvested, with the rest left to rot in the forest. One plantation - The Summit – had over 2500 trees prior to the project commencement, but no mains power for processing on site, and thus there was little incentive to increase plantings. At the end of the project there is no stand-alone canarium or nut industry policy in Vanuatu, which would be important in building the resource for supply.

The Ministry of Forestry in Solomon Islands established a small-scale propagation program and distributed elite cultivars to farmers for commercial planting. Seedlings are mainly from seeds with high kernel recovery nuts, but most nuts are still wild harvested. There remains excess nut production from wild trees that could be utilised if there were improved distribution lines and market opportunities. A draft policy for Indigenous fruits and nuts has been written in Solomon Islands to support the development of the canarium nut industry, but is yet to be adopted by government. A key section of the draft policy is the identification of opportunities for donors and foreign investors. Once a policy has been adopted more resources can be directed towards the canarium industry (government interviewee, 2014).

NARI staff at PNG noted a similar need to increase the available resource of commercial quality Canarium seedlings and had established a planting and seedling distribution scheme at project commencement. Through the life of the project, 27,000 trees were planted by the East New Britain Development Corporation (ENBDC) and around 19,000 by Agmark, both of whom are commercial companies. Another 150,000 seedlings were distributed to smallholders, valuing their timber, shade and minimal maintenance qualities as risk-mitigation strategies during farm business planning. Around 30,000 of these 150,000 seedlings were distributed to small-scale farmers with small garden plots (average planting of 3 or 4 trees), and the remainder were planted by cocoa farmers (averaging 10-20 trees each). The NARI nursery aims to produce another 600,000 seedlings over the next four years and has a ready market in the Productive Partnership in Agriculture Project (PPAP) who has funding to purchase 300-400,000 of these trees. The conclusion of the PPAP project may see lack of international aid funding to purchase NARI seedlings, however it is expected that by this time the commercial potential of Canarium will be well acknowledged and there may be an opportunity for a private nursery to establish itself as a supplier, driven by supply and demand. NARI have also been successfully producing clones by marcotting, however the labour-intensive nature of this method is not feasible for the scale needed to produce clones in the numbers required by the emergent industry. Grafting is a better option and follow up on some successful grafting trials by MAL is needed in the future.

Clearly both Vanuatu and Solomon Islands have sufficient available resource to commercialise activity and there is clear growth of the available resource across all scales of production in PNG, which has been an important indicator of activity. All countries could benefit from an enabling policy environment to help industry development and there are some interesting opportunities for development of industries in allied areas such as private nursery establishment.

2. Infrastructure and equipment:

At the start of the project, participants in Vanuatu stated that centralised industry development was needed in a major urban area such as Luganville, Espiritu Santo, with access to a good airport, port and mains power. Transport costs from outer islands in both countries is high, which affects cost-effectiveness of nut processing and marketing.

Further, processors in both countries have limited capital and storage and therefore cannot buy and process more nuts. They buy direct from growers and pay cash upon receipt of nuts, but in turn their lack of capital and storage restricts the quantities they can buy from growers (processor, 2013). Some Solomon Islanders sell roasted kernel in 20 litre buckets to markets in Munda or Honiara but farmers have limited numbers of buckets, which restricts the quantity of nuts they can process and sell. An alternative industry arrangement would be for buyers to travel to these islands and purchase kernel directly from the villagers (e.g. based on the canarium regional buying points infrastructure set up by Solomon Islands Commodities and Export Marketing Authority (CEMA) in Makira during the 1990s under USAid). A change in government policy prohibits CEMA from participating in commercial activities meaning that commercial stakeholders will need to re-establish the regional buying points and distribution network. Currently the lack of buyers (markets) and the organised supply chain restricts the volumes being harvested by the villagers. It is now a commercial decision of processors in Solomon Islands as to whether to become more proactive with sourcing product from outer islands.

At the start of the project in PNG, participants also raised their concerns over the costs of transporting nuts from the farm to a central processing hub, particularly given the lack of transport of most smallholders and poor condition of roads. Transporting small volumes is very costly and inefficient. The NARI factory opened for operation in 2014 and a recommended supply strategy was that of using existing cocoa distribution networks to regionalise rather than centralise post-harvest handling. Regionalisation would counter the lack of on-farm or district facilities for drying and receiving large volumes of Canarium nuts. This regional scale of purchase is viewed as critical for buying nuts through the purchasing points in growing districts that already exist. Cocoa farmers are already familiar with drying product on-farm as each cocoa farmer over a certain size owns a cocoa fermenter to dry the cocoa to the required moisture content for delivery to the buyers. Cocoa farmers are required to be licenced to hold a cocoa fermenter and use a moisture probe to measure the moisture content at delivery. However, the project found that while use of extant buying networks is possible, the infrastructure (fermenters/driers, holding bins etc) of cocoa cannot be used as this may result in cross contamination. The Canarium industry in PNG will be driven by the large cocoa exporters who control the supply and distribution networks, for example, ENBDC is keen to streamline copra and Canarium processing. The entry of a large potential joint business partner to the industry has seen principal attitudinal changes towards the emergent Canarium industry from large-scale business which will be critical to further development. Further equipment needs for larger-scale activity are for dedicated driers and holding bins, a post-harvest de-pulping machine and drying facility, mechanised nut cracking machines for processing, suitably sized steam cabinets, ovens/driers, hydraulic presses, oil filters, packing and bottling machines, as well as further product development and marketing.

Whilst there has been strong interest from the private sector in PNG, the scale of the industry requires different improvements from those of the smaller, SME driven activity of

Vanuatu and Solomon Islands. In particular, more momentum is needed at the larger scale in order to achieve organisational change and appropriate operations and processes than is required for SMEs.

3. *Cracking Nut-in-Shell:*

This is a major limiting factor in both Vanuatu and Solomon Islands as manual cracking is seen as labour intensive and a deterrent to processing, which has remained from project inception. The strict timeframes that require cracking within 24 hours prior to shipment are a further deterrent to cracking nut in shell.

In PNG Chinese hand crackers have been sourced through this project and are being used in the NARI factory. These crackers have doubled the cracking rate over the traditional hand cracking methods.

Whilst NARI in PNG successfully uses the cracking machines in their factory, growers in Vanuatu and Solomon Islands still rely on the traditional cracking methods. They would prefer to sell NIS to a processor however the cost of transporting nut in shell between the islands is prohibitive. One processor in Vanuatu has implemented farmer training and rigid quality guidelines to ensure that nuts are cracked within 24 hours of delivery to the buyer.

4. Knowledge and coordination:

The main barriers to industry participation in Vanuatu at project commencement were around knowledge of processing techniques and the supply chain. The Department of Forests considered establishing farmer organisations for training and market activity in each of the six provinces. However, at project finalization, training was led by the private sector because the most appropriate training depends on the end market and the subsequent products developed and marketed by processors. There are currently two main processors in Vanuatu – Lapita Café and the Kava Store/Pacific Nuts, with the Summit plantation undertaking their own product trials. Similarly the two processors in Solomon Islands – Maraghoto Holdings and Jedom Organic Fruits Ltd, but their commercial activity has decreased since the start of the project because the Australian RAMSI mission left and the restaurant trade declined. These two processors have attended project workshops and Jedom Organic Fruits Ltd has acquired a TJ nutcracker in an attempt to improve cracking efficiency, and will also trial the Chinese crackers. Jedom Organic Fruits Ltd has designed new labels for commercial packs based on advice from the project team with information about nutrition panel on the pack.

An industry group or association was suggested at the start of the project in PNG as a strategy to coordinate supply and promote universal quality standards. Coordinated supply will be achieved through the use of existing networks in the cocoa industry. The PPAP project in PNG is an ideal vehicle for technology transfer to the Canarium industry, as the PPAP project directly promotes the planting of galip trees as mixed farming enterprises and their extension network has direct access to about 20,000 farmers with galip trees. It is anticipated that significant quantities of nuts will be produced from 2016 onwards.

There will be need to share knowledge across all three countries as there are different ‘push and pull’ factors involved in the industry establishment at different scales – with small-scale activity ‘pushing’ industry development in Solomon Islands and Vanuatu, and larger-scale commercial organisations ‘puling’ the industry in PNG. These push and pull factors should be synthesised to reconcile and the different approaches, needs, and outcomes; and ultimately coordinate the industry across Melanesia.

Table 5: Stakeholder analysis. Note: VG = Vanuatu growers, including smallholders and larger companies; VPM = Vanuatu processors and marketers, SIG = Solomon Islands growers, including smallholders and larger companies; SIPM = Solomon Islands processors and marketers, PNGG = PNG growers, including smallholders and larger companies; PNGPM = PNG processors and marketers

Theme	Barrier/Driver	VG	VPM	SIG	SIPM	PNGG	PNGPM	Recommended strategy
Lack of available resource	Seedlings of high kernel recovery needed	x		x		x		DoF to propagate and distribute; MoF is distributing some seedlings, policy needed for public-private involvement; NARI has distributed to all scales
Infrastructure and equipment	Limited storage, electricity and capital Cost of transport from outer islands	x x	x x	x x	x	x x	x x	Centralised processors replaced by regional systems Processors in Vanuatu developed their own strategies and places from which they source product. Re-establish buying network in the Solomon Islands. Dried and properly stablisied KIT can make shipping more flexible and affordable.
Cracking NIS	Labour intensive and need for strict timelines and quality standards	x		x		x	x	Growers in Vanuatu and the Solomon Islands prefer to sell NIS, more efficient and easier cracker needed to turn it into a commercial product
Continued lack of capacity	Need for long-term mentoring and end-user based training.	x		x		x	x	Farmer organisations in each of six provinces in Vanuatu (DOF) initial strategy; final strategy is processor-led training. Extension to occur through PPAP in the first instance in PNG, and may be processor-led beyond that. Need for cross-country sharing.
Product specifications and standards	No uniform quality standards for product nor product descriptions of styles and uses.		x		x	x	x	Processors are also marketers so tailor their produce (PNG will develop wholesale export standards). Processors need/have involvement in the industry standards.
Economic returns and willingness to sell	Local markets are flooded during the season	x		x			x	Selling NIS is only a livelihood surplus income activity as it has a limited return compared with value-adding and selling KIT. Knowledge and willingness to stabilize NIS at village level through on-farm solar drying demonstrations.

5. Product specifications and standards:

Lack of uniform quality standards for product and product descriptions based on the various kernel styles and their potential uses was stated as a barrier at project commencement. This is no longer a barrier for Vanuatu and Solomon Islands as each processor is also a marketer and produces product appropriate to their individual markets, showing the private-led nature of Canarium industry development in Vanuatu and Solomon Islands. A wholesale export market is someway off and by then the PNG industry will have established standards and descriptors.

In PNG product stabilisation at the farm level was desirable at the project outset. This strategy was supported by discussions with ENBDC who suggested on-farm drying of NIP to reduce bulk and costs of nut supply. The NARI factory is now conducting research to refine the processing guidelines and developing processed products for demonstration to the market and potential SMEs. Good handling practices for harvest and post harvest care have been written (Appendix 11.13) as well as a 'train the trainer' course power point package for training extension officers and commercial operators in imparting knowledge and skill to farmers and village collectors, including Hazard Analysis and Critical Control Point HACCP plan for food safety (Appendix 11.11-16). All three countries have received training and/or training documentation in these standards.

6. Economic returns and willingness to sell:

Since project commencement, there has been far more product available than is utilized in both Vanuatu and Solomon Islands. In Vanuatu the domestic and suitcase markets are undersupplied due to the capacity of the processors. Canarium remains a surplus-income commodity, and local markets are flooded during the Canarium season so that most product is wasted. Due to the labour intensive nature of hand cracking, farmers prefer to sell NIS rather than KIT. The commercial price for NIS in Solomon Islands would need to be lower for buyers, giving a lower return to growers but possibly better alignment with their other livelihood activities. Knowledge on stabilising the kernel at village level through drying commenced in Vanuatu, and currently one processor is training growers in the use of solar driers for drying Canarium which may increase returns to growers. However, not all farmers will be able to afford solar driers (processor, 2013).

PNG has no commercial harvesting or processing activity to date, although domestic activity at village markets remains. The lack of any market prevents meaningful analyses of economic returns at this stage. There is a keen interest in a partnership from certain well-established businesses in ENBP to start a galip nut company involved in production, processing and marketing which will involve establishing one or more large galip plantations for regular, secure supply of large volumes, construction of a galip processing factory in Kokopo and marketing galip products. This business vision proposition of supplying product to contracted markets has serious financial commitment and may be a reality within months, aiming for larger nut market penetration with increased product volumes. It is envisaged that galip will be sourced by the new company from smallholders for the initial 6 years and will then be augmented by production from the plantations.

Again, there will be need to share knowledge between countries if the private-sector led, larger-scale development activity in PNG is successful. Whilst processor-led training in on-farm drying is occurring, it has yet to be widely adopted in Vanuatu and Solomon Islands possibly because of cost which may mean a cost-benefit analysis would help growers with their decision to enter the industry and a commercial decision of processors as to whether to become more proactive with sourcing product. Regionalisation of the industry through private sector partnering with the existing SMEs in those countries would also offer different opportunities and pricing structures.

7.3.2 Summary

Following Ubels et al (2010) capabilities are considered to be the technical skills and competencies required to participate in the industry; whereas capacity development is used to refer to the interconnected system by which human capacities (individually, in groups, in sectors and institutions) grow, sustain and adapt their activities. Capability development in this research is represented by the indicators of available resources, infrastructure and equipment, crackers, standards and specifications, whilst capacity development is indicated by the indicators of knowledge and coordination, and willingness to sell).

PNG capability development is demonstrated by the increase in the available resource of around 200,000 trees distributed to smallholders and commercial growers. The establishment of a nursery and pilot factory (now employing 1 full-time NARI staff and additional intermittent workers) increases the physical resources available for processing, and further equipment can be purchased from factory profits. NARI staff have scientific equipment including oil presses to expand capability. Human competencies in knowledge of factory processing operations and in using mechanical crackers and other equipment are demonstrated and will increase with nut supply. Training modules and train-the-trainer packages position staff to rapidly spread knowledge to others. Standards and specifications for various products are available. Solomon Islands and Vanuatu have sufficient resource to commence an industry, but are also increasing the availability of selected varieties. Traditional cracking continues in both countries. The Vanuatu Department of Forests has some scientific equipment such as ovens and balances for expanding capability. The Ministry of Forests in Solomon Islands has increased knowledge on resource assessment. Processors in Vanuatu have purchased equipment, and innovated the standards and specifications to develop their own requirements and train growers to supply to these standards. Limited cash and storage prevents them from scaling up their operations. Solomon Islander growers are restricted in supply by equipment, mostly relying on buckets. Processor-led standards are available to growers, as well as labelling and packaging designs, and the industry is positioned for developing human capital for nut collection.

In terms of capacity development, PNG already has a regionalised collection ‘system’ that connects growers, processors and collectors; alongside a system for knowledge dissemination and training through donors and researchers, and extension programs and partners. As such, human capital for Canarium nut processing is high, and the transition from the NARI-factory processing to commercial demand will be market driven. The system is well-positioned for addressing any continued lack of capacity in knowledge of the supply chain and processing. An enabling policy environment for industry development, including private-sector extension will promote the further learning and innovation that is needed to develop industry at this scale. At the moment, willingness to sell remains less known. The NARI staff have purchased some nuts from growers, but many continue to sell at domestic markets. Knowledge about costs and benefits of supply to the different markets (roadside stalls, urban marketplaces, the NARI factory) may increase awareness about the role of a factory within the supply chain. Private-sector led knowledge and training is occurring in Solomon Islands and Vanuatu through a shorter supply chain. The development of a collector system, particularly in Solomon Islands, may develop further capacity to supply nuts, and additionally, this collector ‘system’ would also disseminate knowledge and training to processor-specific standards in Solomon Islands. This would utilise the shared knowledge that has grown between the respective government forestry staff of both countries. Again willingness to sell may require increased awareness of the costs and benefits, in supplying NIS to processors versus elsewhere or supply of other commodities. It also might involve increasing knowledge of the product amongst potential end-users such as the hotel or restaurant trade, which would increase supply chain connections and thus industry capacity.

In upgrading value-added products, Giuliani et al. (2005) suggest that it is not just the decisions and efforts at the level of the firm, and their operating environment, but the degree

of joint action between producers and all other actors (input suppliers, government, research, extension providers, etc). In particular, as the role of the State diminishes, Hall (2005) recommends innovation capacity where networks of actors in the supply chain together develop the management, strategic directions and organisations needed for new products and processes to be socially and economically used. This will allow for capacity as a system to develop and adapt to change, including market change.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Early flowering and fruiting of canarium trees from the SPRIG trial on Kolumbungara Island, Solomon Islands was assessed for three years in conjunction with staff from Solomon Islands Ministry of Forests (Fig. 13). This project has generated scientific data on tree growth, early flowering, early fruiting and nut quality characteristics for canarium in the plantation. As a result we now have a comprehensive and rigorous data set in a replicated trial that can be used as the basis of tree selection. Results from the first year was presented as a paper, with pacific stakeholders as authors, at the International Horticultural Congress in Brisbane in 2014 (Appendix 11.17). A draft of the results from the three year's study on early fruiting and also nut size has been prepared and when completed will be submitted to an appropriate journal (Appendix 11.18).

Our results show that the best trees of canarium produce kernels that weigh twice as much as the poorest trees (Fig 14). Selecting the right trees could lead to double the production of kernels by weight. Kernel recovery and total nut weight was also much higher in the best selections compared to the worst selections. This highlights the importance of a clonal propagation program to capture best tree selections to improve the efficiency of production and processing.

Figure 13. a) Progeny trial on Kolumbungara Is, Solomon Is. b) Measuring and weighing canarium nuts

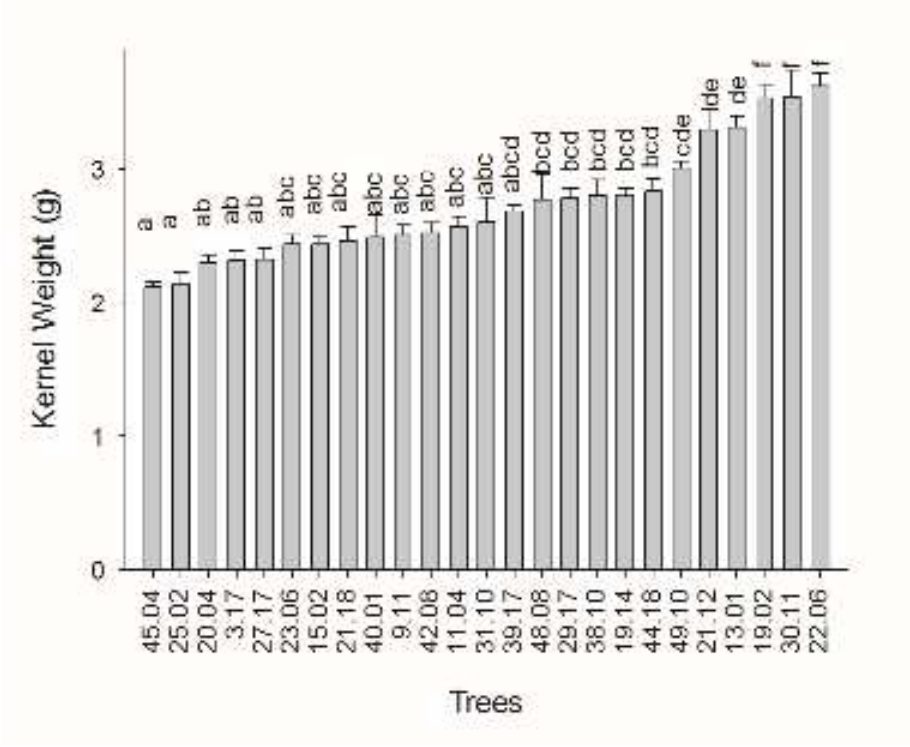

Figure 15. Differences in kernel weight from 5 year old *Canarium indicum* trees in Kolumbungara Island, Solomon Islands. Trees indicates the identity of individual trees sampled. N=25-30 nuts per tree.

USC staff, conducted shelf life storage experiments for Lapita Café Vanuatu and Jedom Organic Food Ltd in Honiara, Solomon Islands. Nuts were tested for peroxide values and free fatty acids (rancidity). Results from a storage experiment of Lapita Café and Jedom Organic Food Ltd products have been discussed with the processor (Appendix 11.10). Shelf life experiments on *Canarium indicum* nut-in-shell and kernel have shown that kernels can be stored successfully for six months at 30°C and for nine months at 25°C using a vacuum packer. Increases in free fatty acids of nuts while stored at ambient temperature may limit further storage potential. A draft journal article of these storage experiments is underway.

Our experiments have shown that the risk of pre-harvest microbial contamination is low. There is a risk of contamination where cracking is done in the village. Nut-in-testa is supplied to processors in Vanuatu which affords some protection from contamination. There is a risk that mycotoxins could developing during prolonged on farm storage. Safe moisture contents need to be achieved as soon as possible after harvest.

PNG: The USC processing team worked with Godfrey Hannett, Belinda Yawanies and Dulci Hannett to develop experiments for depulping, drying, product development, timber production and tree yield for Canarium. The team worked on research questions, experimental design, data entry and data analysis protocols. The team also developed protocols for roasted, salt roasted and sugar coated products.

The team has produced a processing protocol that results in a very high quality product. Canarium nuts are being purchased in-pulp when purple, depulped using boiling water, cracked using mechanical crackers sourced by the project, the testa is removed using boiling water and then kernel is dried using drying ovens. Dried kernel (< 5% MC) is of an extremely high standard with a white undamaged kernel and more than 80% nuts remaining whole (Fig 16). This is an excellent achievement by the project team as it methods have significantly improved quality of the product compared with previous methods.

Figure 16. Cracked Canarium from the PNG factory showing a very high proportion of whole kernels

The following papers have arisen from this project:

- D.A. Walton, B.W. Randall, M. Poienou, J. Moxon and H.M. Wallace, 2016 '**Maturity indices of *Canarium indicum* (Burseraceae) nuts'**, Acta Hortic. 1109. ISHS 2016. XXIX IHC – Proc. Int. Symp. on Nut Crops. Ed.: M. Wirthensohn; pp. 17-21
- B.W. Randall, D.A. Walton, E.L. Grant, P. Zekele, B. Gua, R. Pauku and H.M. Wallace, 2016 '**Selection of the tropical nut *Canarium indicum* for early fruiting, nut-in-shell size and kernel size**', Acta Hortic. 1109. ISHS 2016. XXIX IHC – Proc. Int. Symp. on Nut Crops. Ed.: M. Wirthensohn; pp. 169-173.
- D.A. Walton, B.W. Randall, M. Poienou, J. Moxon and H.M. Wallace 2016, '**A roasting study for the tropical nut *Canarium indicum* (Burseraceae)**', Acta Hortic. 1109. ISHS 2016. XXIX IHC – Proc. Int. Symp. on Nut Crops. Ed.: M. Wirthensohn; pp. 43-47
- H.M. Wallace, B.W. Randall, E.L. Grant, K. Jones, D.A. Walton, M. Poienou, T. Nevenimo, J. Moxon, R. Pauku 2016, '**Processing Methods for Canarium Nuts in the Pacific**', Acta Hortic. In press.

8.2 Capacity impacts – now and in 5 years

The research under the PARDI project has aimed to help and empower people in the region to drive agribusiness development. The positive partnerships fostered right along the chain and with research, teaching, extension and policy staff has utilised a value chain framework to focus on the specific needs of each individual project.

This project has improved scientific capacity in Vanuatu and Solomon Islands via equipment, information and training. For example the following equipment was supplied:

Vanuatu and Solomon Islands

- Scientific Ovens plus freight plus shelves were supplied to the Department of Forests Vanuatu for scientific experiments (Fig. 17).
- Data loggers were supplied to Staff from Lapita Café and they were trained in operating and experimental design.
- Cacoa moisture meter
- Digital Balance x2, supplied to Department of Forests Vanuatu and Solomon Islands
- Camera, supplied to Department of Forests, Solomon Islands
- TJ nutcrackers

PNG

- 8 Chinese crackers + Freight to PNG, modification of blades
- Axis coconut oil press + freight (Fig. 9)
- Portable centrifugal fan (230 mm, 1.5 kw) + Freight
- Digital Balance
- 3 Data loggers
- Camera
- Water activity meter
- TJ nutcrackers

Information and training

- Information about shelf life experiments and microbial contamination has been supplied to processors in all partner countries.
- Training was provided to Solomon Islands Ministry of Forests on tree assessment, early fruiting and flowering and timber volume. They were also trained in weighing and measuring fruit and how replication influences the experimental design.
- Vanuatu Bureau of Statistics have collaborated and shared techniques with our project partners for both the canarium and cocoa PARDI projects.
- University of Adelaide and University of the Sunshine Coast students and staff building their capacity while supporting work on the canarium PRA include;
    - Stephanie Hajaj, UoA Master student
    - Yumeng Chen, UoA Master student
    - Sam Fargher, UoA Economics Graduate
    - Laura Bateman, UoA PhD student
    - Camilo Esparza, UoA PhD student
    - Xiaobo He, UoA Postdoctoral Research Fellow
    - Elektra Grant USC honours student
    - Bruce Randall USC PhD student
    - Dr David Walton, USC Research Fellow

Figure 17. Two scientific ovens used to dry canarium nuts that were donated by the project to the Vanuatu Department of Forests

This project provided expertise and advice to private sector processors in Vanuatu and Solomon Islands, with partners willing to share development and research results. Training on the solar drying by the Department of Industry in Vanuatu on the PARDI tamarind project has had an impact on canarium. Farmers who have been trained to dry tamarind have also been able to dry canarium and now are able to value add themselves and have access to new markets. The Kava Store conducted training for approx. 100 farmers in post-harvest care/drying and value adding using a solar drier and packaging in glass bottles (Fig. 18).

Figure 18. a) A solar dryer used for drying *Canarium indicum* kernel in Vanuatu and
b) This Farmer, Steven Atunesia from Nguna Island is now producing value added canarium using a solar drier and glass bottles, and selling directly into local markets

The results of the consumer and customer research have given project stakeholders a clearer picture of the market opportunity which in turn has given confidence to develop new products to meet the market demand. Throughout this process we have worked closely with both private and public sector partners and capacity building has occurred in a number of ways.

Private sector capacity building has been particularly successful with food processors but has also stretched back through the chain to canarium farmers to ensure they are able to meet the processor and market requirements. Canarium project stakeholder capacity impacts include Lapita Café and ACTIV (Vanuatu), Jedom and Maraghoto (Solomon Islands).

Lapita café:

- Over 90 women have been trained by Lapita Café to meet their specifications.
- They are producing a range of canarium products for sale aimed at the tourist market at outlets such as the new handicraft markets near the port (Fig.19).
- Representatives Lapita café received assistance to develop their processing facilities and marketing plan. They visited local retail outlets and nut processing facilities in Australia. Dr Maria Raciti also travelled to Port Vila to provide advice on marketing packaging, branding and product displays to Lapita café (Fig. 20).

Figure 19. a) Lapita café products in a supermarket in Port Vila and b) Sugar coated Lapita products for sale at the new handicraft market

Figure 20. Maria Raciti examines Lapita's local food tour display

Jedom

- Doni Keli at JEDOM Organic Fruits Ltd in Solomon Islands has recently expanded his business and developed new canarium products and packaging (Fig 21). Through the project Jedom obtained two TJ hand crackers and is seeking to purchase some of the Chinese hand crackers to try to improve productivity. A training presentation was delivered to Jedom Organic Foods on processing and a nutritional analysis of nuts was conducted that is being used on labels of Jedom products.

Figure 21. JEDOM Organic Fruits Ltd new canarium packing

ACTIV

- ACTIV is also trialing products including canarium nuts into chocolate made from local cocoa (Fig. 22)

Figure 22. Experimental chocolate produced by ACTIV in Vanuatu incorporating canarium

Maraghoto

- Richard Pauku at Maraghoto has been involved in the production of canarium nuts, the establishment of a national nut association and has also collaborated on the survey work conducted in Solomon Islands so he has been integral to the research project and has shared in the insights and knowledge gained. Project staff exchanged information with Richard and Doris Pauku on activities on canarium in Vanuatu and PNG and experimental sampling of canarium products for shelf life, nutritional and microbial analysis.

PNG: Capacity increases since the project include helping to develop protocols for the pilot canarium factory at NARI Kerevat, increased tree plantings and networks for collection of raw nuts, supplying equipment (see above). A critical advance was building capacity to commercial process canarium by modifying the blades of the Chinese crackers to suit canarium nuts (Fig 23a). The project has also assisted with drying, testa removal and roasting protocols for the pilot factory (Fig. 23b). The major need now is for business skills to make the canarium processing commercially profitable.

Figure 23. a) Cracking canarium nuts in the pilot factory. b) Inside the galip factory at the “clean” stage of processing

New products such as roasted, salt roasted and sugar coated canarium were developed, produced and packaged for distribution to visiting dignitaries at the official opening of the canarium processing factory at NARI (Fig 24). Production of dried kernel and value added products is of an extremely high standard.

Figure 24. Canarium sugar coated products produced by the NARI factory

NARI personnel are developing competency and experience in product development, promotion, brand development and marketing as a result of the project. Canarium produced at the NARI Pilot Factory was displayed at the canarium fair in September 2014 and promoted and sold at the Melanesian Spearhead Group Investment Roadshow and Trade

Fair, held in Port Moresby during November 2014 (Fig 25). NARI participants at the Trade Fair were Mr. Tio Nevevimo, Mr. Godfrey Hannet and Ms. Belinda Yawaries, assisted by support staff from the NARI Port Moresby office. Following on from observations made during the Trade Fair NARI is looking to create and register a Canarium trademark for use by the NARI Pilot Factory. NARI are currently liaising with relevant Government agencies on the process for this.

Figure 25. Pilot NARI canarium products on display at the canarium fair and workshop

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

There were strong increases in economic impact in Vanuatu. Lapita Café steadily increased the dried kernel sold to retailers and the prices to farmers, the number of suppliers and the retail price of their products (Table 7). Additionally, in 2012, Lapita Cafe sold approximately 16ltr of oil pressed from 40kgs dried kernel. The bulk raw oil was sold to a customer for 2500Vatu/ltr (including VAT) and the pressed kernel cake used by Lapita Café in biscuits. In 2013 Lapita Café sold 12lts of oil pressed from 20kgs of dried kernel, and plan to sell retail bottles on domestic market at 150-200Vatu/30ml (500Vt/ltr).

The Kava Store has decreased purchase of raw product but increased the price to farmers as some are now value adding on-farm. In 2011 the proprietor purchased NIS for 40vatu/kg (approx. 200vatu/kg kernel) and paid 1000vatu for dried KIT. In 2014 the proprietor was encouraging his suppliers to add value on farm and paying 1,000vatu/500g kernel solar dried in glass jars.

In Solomon Islands market has declined due to the withdrawal of RAMSI staff eating at restaurants. Maraghoto Holdings has traditionally purchased approximately 3 t kernel/yr of canarium kernel in flour buckets from TDA (flour buckets are never weighed so the exact price per KG can vary). In 2014 farmers supplying the TDA (in Munda) increased the price of kernel from SBD$25/kg to $30-$40/kg which was beyond the limit for Maraghoto Holdings. Consequently Maraghoto Holdings decreased kernel processing from 1500 kg in 2013 to 100 kg during 2014 (processor, 2014). The snack products of Maraghoto Holdings struggle to compete with the fresh market where 10-15 kernels on a string can sell for $SBD2.00. Additionally, oil is sold for SBD$20/125ml.

Jedom Organic Fruits Ltd buys kernel for 30$SBD/kg from farmers on Guadalcanal or when supply is short from the local markets at $2SBD/15kernels (approx SBD$100/kg). Jedom Organic Fruits Ltd used to sell 5t/yr when RAMSI was in SI to 10 restaurants, but now only

2 are buying kernel. Local people prefer fresh raw kernel during the season and only use the dried stored kernel for cooking. *Jedom Organic Fruits Ltd* see value adding nuts as the best opportunity, with sales of around 5kg/month of dried kernel and 10pkts/month of muesli to outlets at West Island Supermarket, Y Sato, and the Lime Lounge (50g packets dried kernel = SBD$10, Y Sato sells for SBD$13, muesli uses 25g dried kernel/500g pkt muesli).

Table 7: Production Statistics

Lapita Café:

Year	*Dried kernel sold to retailers (kg)*	*Farmer price (/Kg Kernel in testa)*	*Product Source*	*Retail Price (/Kg Kernel)*
2010	18	200Vt	Family only, Malo Island	
2011	95	200Vt	30 farmers Malo Island	2,500Vt
2012	223	220Vt	30 farmers, Malo Island	3,000Vt
2013	447	250Vt	61 farmers, Malo Island, 30 farmers Santo Plus some from South West Bay, Malekula Island.	3,000Vt
2014	1,000 (expected)	250Vt	More than 100 farmers, and will purchase from Malo Island, Santo, South West Bay, & East Santo	3,000Vt

Kava Store/ South Pacific Nuts:

Year	*Dried kernel (Kg)*	*Farmer price*	*Product Source*
2011	5,000 (20t NIS)	40Vt/kg NIS, 1000Vt/kg KIT	
2014	3,000	2000Vt/kg dried kernel packaged in glass jars.	Approx. 100 farmers Efate

Maraghoto Holdings:

Year	*Dried kernel (kg)*	*Farmer price*	*Product Source*
2011	3 t	SBD$25/kg NIS	
2014	100 kg	SBD$30-40/kg	

Jedom Organic Fruits Ltd.:

Year	*Dried kernel (kg)*	*Farmer price*	*Product Source*
2011	5 t		10 restaurants
2014	Limited		2 restaurants

PNG: At the time of project completion, NARI had just commenced commercial sales of processed Canarium nuts in formal markets in East New Britian. Nuts were selling for 50 Kina per kg of packaged product and around 200kg of products had been sold.

8.3.2 Social impacts

The increase in the industry in Vanuatu has increased the access to market for farmers resulting in more access to markets for products. The two main processors in Vanuatu have set their own standards and have specifically built relationships with their preferred providers. Lapita Café's supply base has increased from a small number on one district to over 100 farmers in four districts. The rotational basis on which family groups supply a specified amount on a particular day spreads the benefits amongst different groups.

Maraghoto Holdings and Jedom Organic Fruits Ltd in Solomon Islands rely on their suppliers with the type of nut drying according to traditional methods. They have yet to build training and preferred provider relationships that train them according to new standards but this will mean both a loss of their traditional agricultural knowledge and possible change to its current use in livelihood activities for cultural and ceremonial purposes.

PNG: The larger scale of production in PNG is likely to offer employment and infrastructure to improve livelihoods.

8.3.3 Environmental impacts

Canarium trees provide non-timber forest products in a sustainable integrated agricultural system. Retaining native species, increasing tree plantings and integration of trees as shade in farming systems provide environmental services such as soil stability and carbon offsets.

There were small increases in number of trees planted in Vanuatu, and limited increases in Solomon Islands, partly due to excess production from existing trees and lack of incentive for farmers to engage in this activity. A canarium trial and a small nursery on Espiritu Santo has been established by the Vanuatu Dept. of Forests (Fig. 26), and there are small increases in number of trees planted by farmers. In Solomon Islands, Maraghoto Holdings has a 15ha commercial orchard in the Western province to guarantee supply, with approximately 3ha planted with Cocoa as an inter-crop.

PNG: Around 200,000 trees were distributed in PNG and these are promoted as having other environmental values such as shade for cocoa and timber.

Figure 26. Joseph Tungon, Vanuatu Dept. of Forests, with the canarium trial on Efate Island

8.4 Communication and dissemination activities

The canarium project partners have been active in contributing to the overarching communication strategies for PARDI which have included a combination of scientific and technical reports, presentations at relevant conferences and workshops, and other communication methods that are listed below;

- Newsletter: PARDI produced a technical newsletter every 6 months which was uploaded onto the PARDI website, hosted by SPC (http://www.spc.int/) in the 'Focus Areas' section. Two-hundred printed copies of each issue were also distributed in the South Pacific.
- Website: The SPC site is being used to store and distribute PARDI publications, reports, newsletters and other PARDI material. A broad international and nation mailing list is maintained to link to the web space and regular website alerts are sent out when new material is made 'live'.
- YouTube clips: In an effort to expand into social media and to provide a strong visual representation of our work, a PARDI YouTube page was established in mid-September 2013. Two videos have been released. The first looks at solar drying canarium nuts and a village chief who has had considerable success with solar drying canarium and tamarind is interviewed. The solar dryer featured was donated through the Tamarind PARDI funded project. The second YouTube video features Lapita Café and the success that they have achieved as a consequence of PARDI funded projects. To view the YouTube clips visit: https://www.youtube.com/channel/UCElsoBmKSL6MnOLI_zsn6Wg/videos
- Capacity Building Booklet: PARDI produced a 32-page feature-style booklet in March 2014 to showcase the high capacity building impact of the project. The booklet was presented to ACIAR and the PARDI review team, and posted on the SPC web space. Printed copies have also been distributed in Australia and overseas. To view booklet online visit: http://www.spc.int/lrd/pardi-publications/annual-reports-a-capacity-building-booklet
- Information brochure: Information about the canarium project was disseminated through the Tetepare Descendants Association to villagers. The brochure was created to update the communities who had been visited by researchers in October 2011 about the projects progress (Appendix 11.24).

Workshops

- April 2012, Vanuatu – A Regional canarium Workshop was held in Port Vila at the Department of Forests, Agricultural Training Centre (Fig. 27). It was attended by representatives from Department of Forests, Lapita Café and The Kava Store (industry representatives), growers and other interested parties. The workshop was held as an information sharing exercise in light of the current canarium project on marketing and product development. Two processors operate in Vanuatu; Lapita Café and The Kava Store. The main theme that ran through the discussion was the need to train farmers in processing methods to ensure quality standards. Reflecting on the training farmers received for the coffee and sandalwood industry, many people stated that the canarium industry could also be successful with proper training about harvesting and postharvest handling.

Figure 27. Participants in the first regional canarium workshop, Vanuatu.

- October 2013, Solomon Islands – A regional canarium workshop was held in Honiara (Fig. 28a). The information sharing workshop was attended by about 25 participants from government, industry and Canarium stakeholders from both Solomon Islands and Vanuatu, and researchers from Australia (see appendix 11.24 for the workshop minutes). A field day was also held in the Western Province. Votausi McKenzie and Elektra Grant visited a village on Rendova Island that had been visited by researchers in 2011 (Fig. 28b). Joseph Tungon (Vanuatu DoF), met with Philip Zekele (SI DoF) on Kolumbangara Island and viewed the canarium selection trial there along with Helen Wallace, Bruce Randall and Kim Jones (Aust partners) (Fig. 29).

Figure 28. a) The opening of the Workshop by the Minister of Agriculture and Livestock and b) Votausi, Lapita Café at a meeting in a village on Rendova Island as part of a field visit to exchange information

Figure 29. Stakeholders at the regional canarium workshop in Solomon Islands, examine a canarium selection trial.

PNG:

- September 2014 PNG – A canarium fair and a workshop were hosted by NARI in East New Britain (Fig. 30). The fair was titled 'Growing the Local Economy – The Role of Canarium Commercialisation in Papua New Guinea.' The canarium fair was opened by The Deputy Prime Minister, and in attendance were The Minister for Trade, Commerce and Industry, The Minister for Agriculture and Livestock, The Minister of Higher Education, Research, Science and Technology, representatives of provincial governments (Madang, Morobe, and East Sepik), NARI, representatives from SMEs and NGOs (e.g. Women in Agriculture).

Figure 30. A traditional welcome for the ministerial delegation, attendees developing the canarium industry roadmap

The conference featured presentations on market access, value adding, industry partnerships, research and development, standards and commercialisation. Project personnel attending the conference and workshop were Helen Wallace, Kim Jones, Craig Johns, Bruce Randall and Colin Bunt. Project team members presented papers at the conference and Kim Jones facilitated the Workshop. Ms. Votausi McKenzie from Lapita Café in Vanuatu also shared her experiences in the PARDI project and in processing and marketing of Canarium.

A large group of stakeholders from the Government, Private Sector, community groups and supporting agencies also attended. The workshop considered key industry development issues in terms of priorities and actions needed and developed a draft industry roadmap. Topics discussed included grower training needs, SME development, establishing a model Canarium harvesting and processing system, research and development priorities and the benefits of a Canarium Industry Association in PNG.

- November 2014 PNG – Melanesian Spearhead Group Investment Roadshow and Trade Fair in Port Moresby marked an early milestone in terms of market development and building industry confidence. Canarium produced at the NARI pilot factory was promoted and sold at the trade fair.
  NARI Director General Dr Sergie Bang asked that Colin Bunt assist NARI staff wherever possible in preparation for and participation in the trade fair. Bruce Randall also assisted NARI at the pilot factory in preparing retail standard packaged product for sale. Dr Bang noted that the main objective of NARI's participation was the promotion and sale of canarium products from the NARI factory and generating broader interest and exposure for canarium among the buying public and the media. This was the first time that product from the NARI pilot factory was to be presented for sale and therefore the demand for the product was uncertain. To the satisfaction of all involved the NARI stock sold out and trade fair attendees from throughout the Pacific, Australia, New Zealand, the EU and South East Asia were unanimously positive as to the look and taste of the product. There was no price resistance to the premiums set from either Papua New Guineans or visitors to PNG.
  The trade fair also presented an excellent networking opportunity. The trade fair attracted exhibitors from throughout Melanesia and the Pacific. These included a large number of food and beverage companies producing a broad spectrum of conventional and indigenous products. Contact was made with representatives from Pacific trade and promotion agencies and leading Melanesian food producers and marketers. There was also significant media interest and coverage of the NARI booth and the emerging canarium industry.

Meetings and Field trips

- August 2012, Vanuatu – Department of Forests visited farmers on Malekula in the Malampa province to discuss forestry, cocoa growing and promote planting of canarium trees.
- October 2012, Solomon Islands – Bruce Randall and Elektra Grant met with Phillip Zekele (Department of Forests) to discuss results from the assessment in 2011 and discuss plans for the current year's research. Bruce Randall and Elektra Grant also met with Richard Pauku (Maraghoto Holdings) to discuss results from previous project and to commence planning to meet milestones for current project.
- November 2012 Solomon Islands – Helen Wallace met with Richard and Doris Pakau (Maraghoto Holdings) to exchange information on activities on canarium in Vanuatu and PNG and commence experimental sampling of canarium products for shelf life, nutritional and microbial analysis. Helen also met with Andrew Sale (PHAMA) to discuss market access and potential of canarium as an export crop; Mr Hans Henceyvaekesa, (Ministry of Commerce, Industry, Labour and Immigration), Mr Gordon Kainaramo, and Mr Richard Ramoflia, (Ministry of Forests) to exchange information on current ministry priorities and forestry activities (teak and canarium),

the vegetable project in Solomon Islands and the value chain analysis approach, and current priorities and challenges for each ministry.

- November 2012, Vanuatu – Bruce Randall met with Joseph Tungon and Michael (Department of Forestry) to discuss experiments to be undertaken. Following conducting the experiments, Bruce met with Department of Forestry staff to explain the results from the various experiments and answer their questions. Bruce also met with Votausi Mackenzie-Reur (Lapita Café) to discuss and explained the results from the initial data from moisture loss and shelf life experiments.
- August 2013 Vanuatu – Craig Johns and Camilo Esparza met with project partners to start plans for consumer research. Craig and Camilo communicated consumer research results collected from tourists and Australian nut processors to Votausi at Lapita Café. They also spoke with Sandrine Wallis from ACTIV about the possibility of producing canarium oil.
- September 2013 Vanuatu – Bruce Randall travelled to Port Vila where he met with processor/industry champion (Votausi MacKenzie-Reur) to explain and discuss results from a storage of canarium kernel experiment. Bruce also monitored Lapita Café's drying process and collected nut samples to bring to Australia for establish a storage experiment and monitor ongoing nut quality.
- October 2013 Solomon Islands – Kim Jones and Elektra Grant collected data for objective three of the canarium project and disseminated up to date information about the project. They met with the Ministry of Commerce, Industry, Labour and Immigration; the Ministry of Agriculture and Livestock; Alfred Ramo, the General Manager of the Commodity Export Marketing Authority (CEMA); Clement, Project Director of Kastom Gardens Association (KGA); Don Keli, owner of Jedom Organic Food Ltd; Des Davenport, production manager of Delight biscuits; and Richard Pauku.
- Bruce Randall met with Moses Pelomo's (a cocoa processor) and provided him with TinyTag data loggers that were placed into his solar driers to record temperature and humidity changes during drying.
- November 2013 Vanuatu – Elektra Grant travelled with Julie Lloyd to meet with farmers and other project stakeholders to interview and film for a PARDI project publicity video for YouTube.
- February 2014 Solomon Islands – Craig Johns trained enumerators and finalised the implementation of the canarium consumer survey with local households and tourists. The trip also provided an opportunity to meet up with our other important PARDI project partners, including PHAMA representatives.
- February 2014 Vanuatu – Kim Jones and Elektra Grant travelled to Port Vila and Santo to collect data for the stakeholder analysis objective of the project. They held two meetings with farmers that supply to Lapita Café. They also held meetings with Ben Brookman from the Summit, Charles Long Wah from South Pacific Nuts and Votausi MacKenzie-Reur and Geordie MacKenzie from Lapita Café.
- April 2014 Australia – Owners of Lapita Café, Votausi MacKenzie-Reur and Geordie MacKenzie, visited nut processing factories on the Sunshine Coast, and met with marketing experts.
- May 2014 Vanuatu – Helen Wallace travelled to Port Vila to meet with the Department of Forests, Lapita Café and Activ to discuss project progress and future plans.

- July 2014 Vanuatu – Helen Wallace and Maria Raciti, marketing expert, travelled to Port Vila and examined current marketing and branding activities aimed at the tourist market and provided advice on marketing and branding to Lapita café. Helen also met with the Department of Forests and Department of Industry to discuss current and new projects.
- September 2014 Solomon Islands – Bruce Randall travelled to meet with industry partners and interested individuals to discuss current project and assess interest for any future project. Bruce met with Met with Richard Paku, Don and Jenny Kelly and Moses Peloma.
- October 2014 Vanuatu – Bruce Randall travelled to meet with industry partners to discuss the current project and assess interest for any future project. Bruce also worked with Lapita Café to continue to develop protocols for developing a range of value added Canarium products.

PNG:

- September 2012 – Helen Wallace and Bruce Randall met with Tio Nevenimo, Godfrey Hannet, James Laraki and Ofara Petilani (NARI, PNG) to contact with NARI partners, exchange information on activities on canarium in Vanuatu, Solomon Islands and PNG and commence planning for the project on canarium product development and marketing in PNG. They also met with Emily Flowers and Rebecca Bogosia to exchange information on canarium activities in PNG, Vanuatu and Solomon Islands and activities with the NARI team in PNG.
- March 2013 – Helen Wallace met with Tio Nevenimo, Godfrey Hannet, Belinda Yawanies, Dulci Hannet, Ofara Petilani (NARI) to discuss plans for canarium processing research, product development and marketing in PNG and monitor progress with the canarium project. Helen also met with John Moxon (Productive Partnerships in Agriculture Project) to discuss issues with the canarium industry: Semi Vuia (East New Britain Development Corporation) to discuss planting large-scale canarium planting and Dr David Thiele, Dr Darren Bito, Dr Khin Maung Kyi and other senior staff of the Pacific Adventist University to discuss product market research, climate change, biodiversity, ecology and production-focused research.
- March 2013 – Kim Jones and Colin Bunt held meetings with Tio Nevenimo, Godfrey Hannet, Belinda Yawanies, (NARI); John Moxon {project manager, Productive Partnership in Agriculture Project (PPAP)}; Graham McNally(Agricultural Production Manager, Agmark), Gerald Castronuew (cocoa trader), and Semi Vuia {team leader- projects, East New Britain Development Corporation Ltd (ENBDC)}.
- May 2013 – Bruce Randall visited NARI to discuss experimental protocols, data analysis and equipment needs. Bruce coordinated the nutcracker modifications for the processing factory at NARI.
- May/ June 2013 – Helen Wallace and Elektra Grant visited the research station at NARI to oversee progress on canarium activities at NARI, especially the experimental work. Helen met with The Open Bay timber company at NARI who had come to NARI to seek information on canarium. Elektra was introduced to the research team and stayed on to assist with processing experiments. This included assisting with running experiments on drying kernel using the cocoa dryer; assisting with experimental design of drying trials; meeting with smallholders to conduct interviews; and training NARI staff on assessing timber volume.

- September 2013 – Bruce Randall worked with NARI to assist with experimental design, data entry and analysis of results from scientific experiments. He also assisted with establishing the canarium pilot processing plant.
- September 2013 – Helen Wallace and Colin Bunt travelled to Lae to exchange information with partners in NARI on the value chain approach and the canarium project. Helen discussed the current canarium project with members of NARI, including the Raghunath Ghodake, the Director General, and gave a presentation on the PARDI project and the agribusiness value chain approach with the examples of Canarium. Helen and Colin also met with food processors and the food service sector to assess interest in Canarium. Activities included a phone meeting with David Ferrier, Technical Applications Manager Operations of Nestle Pacific, Theresa Tariga, Production manager of Paradise Foods and with David Peate, creator of Queen Emma chocolate. Helen and Colin also visited Lae International to meet with hotel managers and discuss the potential of canarium as an indigenous meal ingredient.
- November 2013 – NARI held an opening of their pilot canarium factory in Kokopo. Helen Wallace attended to oversee progress on canarium activities at NARI. David Peate, the managing director of Paradise Foods also attended the factory opening and provided canarium nut biscuits he had made from 15 kg of sample provided by Tio Nevenimo and the team (Fig 31). He met with Dulcie Hannett and discussed the value added product. Nick Austin, Emily Flowers and Helen Wallace met with David Peate the next day to discuss how best to facilitate the food industry development in PNG.

Figure 31. Galip nut cookie artwork for packaging by Paradise Foods

- July 2014 – A delegation from Vanuatu travelled to East New Britain to examine canarium and cocoa production and processing. They examined the Canarium nut factory and examined processing methods and quality of the nut products being produced (Fig 32). The NARI team explained the depulping, drying, cracking, testa removal and kernel drying methods and demonstrated cracking the canarium with the Chinese crackers.


Figure 32. The delegation of cocoa producers and processors tours the canarium pilot factory and sample products

- May 2015 – Helen Wallace met with NARI Director General Dr Sergie Bang, Dr Sim Sar and Dr Nora Omot to plan and discuss future opportunities with Canarium. An upscaling of the industry is planned under a new ACIAR project.

9 Conclusions and recommendations

9.1 Conclusions

This project has addressed some of the key processing challenges and explored new processing systems such as kernel drying and solar drying. Kernel drying in particular is a very energy efficient method of processing. Shelf life tests have found that the dried kernel can be stored for 3-9 months, although initial moisture content of the kernel is critical for effective storage. Microbial testing found that fresh nuts were higher in all forms of microbial contamination levels. Processed nuts contained significantly lower standard plate count and *E.coli* contamination compared to fresh nuts.

This project has resulted in substantial growth of the canarium nut industry in Vanuatu. Capacity to supply value added product to the domestic market has increased as a result of the increase in the number of processors. The industry has grown from one processor at the start of the project to five processors and value adders and increased sales of value added product in Vanuatu's domestic and tourist markets.

In Solomon Islands, localised domestic demand and a high price in the market has made it difficult for processors to access raw materials. There is further potential for expansion in tourists and export markets for a range of products. Tourists were most interested in raw, roasted/salted and chocolate coated products and were willing to pay between 500-1000 Vatu (AUD$5-10) for a packet of snack nuts.

Much of the human capability to understand, use and apply value-adding resources and techniques in Canarium nut processing exists, particularly in PNG. Capacity development could include greater awareness to bring more actors into the supply chain, and potentially the design and development of a collection system in Vanuatu and the Solomon Islands to scale out the industry. More knowledge dissemination could occur through regional Canarium supply networks around the costs and benefits of supplying Canarium nut versus other commodities. Large gains in production and processing efficiency can be made by tree selection. The best trees in this study had kernels that weighed twice as much as the worst trees. If growers had access to the best trees this could result in up to double their returns for effort for activities such as harvesting and cracking. A clonal propagation and is required to capture the best germplasm and along with a seedling distribution program to realise these gains to the industry.

More than two thirds of Australian nut enterprises believed canarium nuts have commercial appeal in the Australian market. Best value adding products was thought to be roasted and salted kernels. Other export market opportunities have been identified, with nut samples provided to chocolate companies and cosmetic manufacturers.

9.2 Recommendations

Objective 1

- Australian tourists represent the priority market for canarium nut products.
- The Vanuatu marketing strategy should be framed with three principles to appeal to this target market. Namely, a) a focus on using the nut in products familiar to the tourists; b) products that can be eaten in Vanuatu and as gifts, preferably premium, to be taken back to their home country; and c) creating an overarching brand, with tiered sub-brands for longevity.
- Branding should focus upon three major selling points – 'nutritious', 'fresh' and 'delicious'. A female-oriented brand personality that highlights a sense of exoticness based on the country-of-origin is also suggested.
- Export market opportunities exist in Australia for Australia nut enterprises and cosmetics but volume and consistency of supply need to be addressed before this can be realized
- A range of food and non-food products form the recommended product hierarchy addresses short-term and long-term growth options. Roasted and salted canarium nuts are to be the immediate focus.
- There are excellent opportunites and evidence of market demand in PNG but commercial processing is needed to test and develop the markets. In the long term there are opportunites for export to China, Japan and Australia for both food and cosmetic products.

Objective 2

- There are large gains to be made from selecting the best trees for nut production. A tree selection and clonal propagation program is needed to improve the efficiency of the emerging industry in the medium term (5-10years).
- Modifed crackers can produce excellent results with around 80% of whole kernels. A commercial pilot factory in PNG has demonstrated that high quality products can be produced with appropriate equipment.
- Kernel drying is an efficient way of processing and temperatures of 50-60°C will reduce kernel moisture content to below 10% without loss of quality. However kernel moisture of around 3% was associated with a shorter shelf life and further studies are needed to determine the best kernel drying regime and final kernel moisture content for long term commercial storage.
- The best product was produced by roasting at 150°C for 10 minutes for nuts dipped in brine solution and roasting at 150°C for 30 minutes for sugar coated nuts.
- Fresh and solar dried nuts were higher in all forms of microbial contamination levels. Training on quality standards and food handling at every stage of post-harvest processing is required.
- Solar drying of kernel in the village is an efficient processing method and can open up local markets to village scale entrepreneurs. However food safety needs to be addressed, and training is needed.

Objective 3

- Conduct research on cost-effectiveness of supplying Canarium nut to various markets, including PNG factory, and against potentially competing commodities.
- Design and develop collector systems to expand purchasing in Solomon Islands and Vanuatu.
- Raise awareness of Canarium nut potential amongst potential purchases.

10 References

10.1 References cited in report

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Vanuatu National Statistics Office 2014, *International Arrival Statistics Dec 2013 Highlights*, Government of Vanuatu. Accessed 14 January 2015, http://www.vnso.gov.vu/index.php/economic-statistics/tourism-news

10.2 List of publications produced by project

2014 Pro-social local food consumption motivations and behaviour: An exploratory study of tourists departing Vanuatu, Bi-Annual International Social Marketing Conference, Monash University, Melbourne,6-7 July.

The following journal articles were presented at the 29th International Horticulture Congress 2014 in Brisbane during August 2014 and have been accepted for publication:

Wallace H, Randall B, Grant E, Jones K, Walton D, Poienou M, Nevenimo T, Moxon J, Pauku R. Processing Methods for Canarium Nuts in the Pacific. Acta Hort (Appendix 11.7)

Walton DA, Randall B, Wallace HM, Poienou M, Moxon J. 2015 Maturity Indices of *Canarium indicum* (Burseraceae) Nuts. Acta Hort.

Randall B, Walton D, Grant E, Zekele P, Gua B, Pauku R Wallace H. Selection of the tropical nut *Canarium indicum* for early fruiting, nut-in-shell size and kernel size. Acta Hort.

Walton D, Randall B, Poienou M, Moxon J, Wallace H. A roasting study for the tropical nut *Canarium indicum* (Burseraceae). Acta Hort.

Other publications in preparation:

- Three year study on early fruiting and nut size (Appendix 11.19).

10.2.1 Project Reports

Johns, C., Wallace, H., canarium Value Chain Review (available at: http://www.spc.int/lrd/pardi-publications/pacific-agribusiness-research-for-development-initiative-pardi?start=5

Johns, C., Fargher, S., Esparza, C., (2013) Australian Nut Processor Research Insights, canarium nut enterprise survey.

Johns, C., Fargher, S., Esparza, C., (2013) Vanuatu canarium Tourist Research Insights

Johns, C. Bateman, L. (2014) Solomon Islands canarium Consumer Research Insights

Raciti, M. (2015) Draft Canarium nut marketing strategy, Vanuatu.

Raciti, M. and Bunt, C. (2015) Developing markets and products for the PNG canarium nut industry.

11 Appendixes

Appendix 11.1 UoA PARDI Objective 1 Summary Report

Appendix 11.2 Case study 1: Macadamia

Appendix 11.3 Case study 2: Nutmeg

Appendix 11.4 Canarium nut marketing strategy: Vanuatu

Appendix 11.5 Developing markets and products for the canarium nut industry: PNG

Appendix 11.6 Commercial roasting of *Canarium indicum*

Appendix 11.7 Processing methods for canarium nuts in the Pacific

Appendix 11.8 New processing methods for canarium: Drying fresh canarium nuts

Appendix 11.9 Methods for processing by-product broken pieces (oil, nut-meal for biscuts)

Appendix 11.10 Information provided to processors about shelf-life experiments

Appendix 11.11 Trainer training presentation: Introducing the canarium package

Appendix 11.12 Trainer training presentation: Post harvest physiology

Appendix 11.13 Farmer training presentation: Good practices

Appendix 11.14 Trainer training presentation: The risk of aflatoxin in canarium nuts

Appendix 11.15 Results from risk of contamination and microbial testing of the supply chain

Appendix 11.16 Best practices for canarium: Harvest and post-harvest care

Appendix 11.17 Industry quality standards and product specifications

Appendix 11.18 Selection of the best trees for early yield and nut characters

Appendix 11.19 Three year study on early fruiting and nut characteristics of the Tropical nut, *Canarium indicum*

Appendix 11.20 Tourism research insights: Vanuatu

Appendix 11.21 Tourism research insights: Solomon Islands

Appendix 11.22 Australian nut processor research insights

Appendix 11.23 Information brochure for communities in the Western Province, SI

Appendix 11.24 Canarium industry development workshop