Australian Government

Australian Centre for International Agricultural Research

Final report

project

Enhancing private sector-led development of the Canarium industry in PNG

project number	FST/2014/099
date published	21 June 2021
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approved by	Dr Nora Devoe
final report number	FR2021-022
ISBN	978-1-922635-18-1
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

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1 Acknowledgments

We would like to thank the NARI leadership team - Dr Sergie Bang, Dr Ramakrishna Akkinapally and Dr Birte Komolong for their commitment to the vision of a galip nut industry for PNG and support for the project.

A very special thanks to the NARI Kerevat team for their persistence, tireless work, dedication and commitment to seeing the growth of a galip industry in PNG. They have at times been required to put in extraordinary efforts to sustain smallholders expectations as the industry develops.

We are very grateful to the people of East New Britain - smallholders, microenterprises, entrepreneurs and small business owners who were willing to share their knowledge and time with us and partner with us to build an industry. We would especially like to thank Dorothy Luana, Denis Hill, Douglas Tsang, James Bushell and ENBWYiACS.

We are grateful for the sharing, collaboration and support of the ACIAR Transformative Agriculture and Enterprise Development Program (TADEP) team especially the leadership of Peter Horne, Liz Brennan, Barbara Pamphilion, Phil Kean, David Guest and Phil Brown.

We would like to thank Mahesh Patel and Raj B Shahi for providing public advocacy and distribution space of Galip Nut Company. We would like to thank Bruno Carrocci, Steve Wilkins and Scott Tiplady for their assistance in branding, labelling and packaging.

A very special thank you to Dr John Moxon and Tio Nevenimo, for their vision and leadership for galip.

Lastly, we are deeply indebted to Tony Bartlett and Nora Devoe (Forestry program manager ACIAR) and other ACIAR research program managers for their help, guidance and governance throughout the project.

This project could not have proceeded without the financial support of DFAT/ ACIAR.

This report is dedicated to the memory of Carson Waaii, an integral part of the project team and someone who played a significant role in the development of the Canarium industry in Papua New Guinea.

2 Executive summary

Nuts have huge potential to improve the livelihoods of rural poor in developing countries and can help to eradicate poverty and hunger. Many indigenous nut species have great commercial potential, however only five species of nuts make up 90 % of world trade. Major constraints to commercialising indigenous nut trees are the need for available technology, private sector investment and developing markets.

This project aimed to enhance private sector investment for an indigenous nut species *Canarium indicum* (galip) in East New Britain, Papua New Guinea. We adopted a transdisciplinary research approach with scientists, social researchers, markets specialist, and nut industry experts to address the processing challenges, set up a demonstration factory and create new markets for *Canarium indicum* nuts. We trialled a range of interventions including market research, technical advice, capacity building, business mentoring and access to infrastructure for both private and public sector stakeholders.

This project created new markets for processed canarium (galip) nut products in East New Britain and New Ireland. A new industry has emerged as a result of this project, improving livelihoods for smallholder farmers, and creating new opportunities for entrepreneurs and SMEs in Papua New Guinea.

Key achievements

- A demonstration factory was established at NARI producing over 2.4 tonnes of processed products in the final year of operation. Technical research underpinning this included depulping, drying cracking roasting, nut quality, food safety, shelf life and nutritional analysis.
- A range of products were developed and markets tested in East New Britain and Port Moresby. The prices for final product ranged from 140 PGK/ kg-170 PGK/ kg. Products were formally launched in mid-2018. The sales trials delivered consumer sales for retailers exceeding PGK 450,000. The factory was unable to meet the demand from Port Moresby markets and products were frequently out of stock. Over the initial 6 months, production capacity and supply was unable to provide sufficient stock to maintain allocated shelf locations. Consumer demand was overwhelming resulting in many stockouts and empty shelves. It is quite likely that the factory could have achieved 1 million kina of revenue if supply had matched demand.
- A range of training interventions were delivered for smallholders, small-scale entrepreneurs and SMEs, with an emphasis on female smallholders and microenterprises. These included quality standards for supplying to the factory, factory awareness tours, small scale processing and value adding, food safety, and processing methods.
- Negligible volumes of processed canarium products were traded in 2014 prior to the start of the project, and there were few opportunities for smallholders to sell canarium to distant markets. The demonstration factory more than doubled production of processed nut products each year and over 1300 farmers and entrepreneurs were selling to the demonstration factory by the end of 2018. The farm gate value of sales of unprocessed Canarium products to the factory was over 400,000 kina during the life of the project.

Impacts

Private sector investors entered the industry in 2019 and at the end of the project there were 4 active processors. These were sourcing and producing their own value-added product separately to the NARI factory. The emerging industry has an estimated farm gate value of 300,000-400,000 kina per annum, in addition to the demonstration factory. It has also created employment for approximately 40 people.

There is evidence that the emerging industry has improved livelihoods for female smallholders. Many women are making small regular sales to the factory. The impact stories emerging from women include:

- A local widow with 7 children has been able to access additional income to support her family.
- A young mother of 3 sold 155 kg of nut-in-pulp and was able to support her children financially which was a relief during a difficult time.
- A teenage girl of 15 was selling galip during the school holidays and using the money to pay for her new school uniforms.
- A young mother of 3 is selling galip to buy basics for the family and buy medication for her sick child.

The emerging canarium industry is at a critical phase and needs to harness the momentum built by this research. Further research on buying models, increasing supply, gender dimensions, increasing efficiency and mitigating risks such as the galip weevil is needed to build confidence of the private sector to invest to grow the industry, utilise the nut resources coming on stream and improve access to distant markets.

3 Background

Nuts have huge potential to improve the livelihood of the rural poor in developing countries and meet the Millennium Development Goal to eradicate poverty and hunger. Nuts have excellent nutritional value and can be stored for long periods and therefore can improve food security. Packaged nuts can be sold for cash, processed and exported to distant markets, thus enhancing self-reliance, and reducing poverty. Globally, just five species, walnuts, hazelnuts, pistachios, almonds and cashews make up more than 90 % of the trade in tree nuts. Many other species of edible nuts have great potential to be commercialised.

Canarium indicum (galip) is an agroforestry tree in Eastern Indonesia and the Pacific that produces edible nuts and timber. The tree has been domesticated in traditional agricultural systems in Papua New Guinea (PNG) for over 6000 years. Currently *C. indicum* is grown mostly in smallholder blocks or harvested from the wild. Canarium nuts have been the focus of efforts by donor agencies to commercialise the industry in PNG and the Pacific. In PNG, approximately 250,000 elite trees have been produced with various donor funding and distributed to smallholders and cocoa plantations over the past four years. Most of these have been planted in East New Britain (ENB) with a small number going to West New Britain (WNB). Approximately 27,000 of these trees have been planted by East New Britain Development Corporation (ENBDC) and about 19,000 by Agmark. The remaining trees have gone to smallholder cocoa farmers and garden plots. At present there is no commercial market or processing factory for these nuts. Significant volumes are expected to be produced by these trees by 2016 with volumes steadily increasing in the next 10 years.

This project seeks to expand markets and processing of canarium nuts in ENB, by strengthening private sector capacity and engagement to achieve a medium scale industry utilising nuts from existing trees. Women conduct the majority of canarium nut growing and trading activities, including, nut cultivation, harvesting, processing and selling. However, women simply sell the raw nuts in village and roadside markets as there are no reliable commercial markets for value-added products. ACIAR's work has developed appropriate technologies for value adding and there is a pilot nut processing facility at NARI (established with EU funding) that is only utilised on an ad-hoc basis.

The canarium industry has great potential for expansion and a strong industry will improve livelihoods for rural smallholders in PNG. However, the canarium industry lacks private sector investment to grow the industry, utilise the nut resources coming on stream and improve access to distant markets.

4 Objectives

The aim of this project was to increase commercial processing and expand markets for canarium nuts in East New Britain (ENB), Papua New Guinea (PNG). This project trialled a range of interventions to reach this goal including market research, technical advice, capacity building, business mentoring and access to infrastructure for both private and public-sector stakeholders. The emphasis of this project was very much to develop the potential industry building on previous research investments by ACIAR and other donors.

The specific objectives and major activities of each of the four key objectives were:

Objective 1: *Assess the needs of the private sector to participate in the canarium industry.*

- Evaluate the existing scale of market participation by smallholders, SMEs and large-scale enterprises in canarium growing, collection and post-harvest handling, processing, marketing and consumption, at the start of the project for a baseline reference.
- Understand the nut flow: Number and age of trees planted, volumes available, and distance to factory and nearest buying point and identify options for collection and distribution of nuts to processors.
- Undertake household, community and enterprise surveys and market analysis to determine how best to match operational scale with product types, and market segments for the PNG domestic market and niche export markets.
- Identify barriers to scaling up sale and processing of nuts.
- Review edit and finalise the canarium industry roadmap.
- Identify the priority research training and extension needs of female smallholders, small-scale entrepreneurs, small to medium enterprises and large-scale processors and distributors such as ENBDC, Agmark and Paradise Foods to expand and grow the canarium industry in ways that benefit smallholders and women.

Objective 2: *Develop and undertake research-based interventions that address the needs of the private sector including smallholders, small scale entrepreneurs (especially women) SMEs, and large-scale processors.*

- Research and refine methods for small scale processing.
- Provide in-situ training and access to equipment for female entrepreneurs on small-scale processing e.g. solar drying models, food safety and packaging.
- Design collaborative training with related ACIAR projects for women smallholders in Bougainville.
- Provide in-situ training to female smallholders on quality postharvest handling to provide to SMEs.
- Provide training packages and access to equipment to SMEs for processing and marketing of canarium (including commercial drying, food safety, processing, and marketing).
- Provide business and organisational mentoring for small-scale entrepreneurs and SMEs including logistics, distribution and sales and marketing training.

Objective 3: *Develop an appropriate commercial model for a medium scale value adding factory for the canarium industry.*

- Conceptualise product-to-market options that could lead to sales at the local community level, the domestic market and niche export markets.
- Identify and prioritise products for commercial up-chain customers.
- Research and refine appropriate methods for medium and large-scale processing (including R&D on large scale storage, mechanical crackers, testa removal, mechanical pulp removal and drying).
- Create a working model of a canarium factory at NARI producing large volumes of high-quality products in sufficient quantities to test the market.
- Undertake a financial analysis of the different working commercial models for each of the different sized value chains prioritised and generic business model for use by a range of SMEs.

Objective 4: *Create a model for public-private partnerships in the canarium industry in PNG.*

- Explore the opportunities for public-private partnerships using the pilot NARI factory at Kerevat with groups such as Women in Agriculture, ENBDC and others.
- Train groups such as Women in Agriculture in processing and marketing of canarium in the NARI factory.
- Build capacity in NARI and relevant government departments in markets and agribusiness skills to support the growth of the private sector.
- Provide public relations material including promotional and other information packages, training and technical advice to provincial governments and private industry with an interest in commercial canarium processing ('scale-out' of public-private partnership).

5 Methodology

This project was mostly carried out the Gazelle Peninsula, in the East New Britain (ENB) province, Papua New Guinea (PNG) with some activities in New Ireland, Port Moresby, and the Autonomous Region of Bougainville. Activities centred around a demonstration factory for galip nut processing based at The National Agricultural Research Institute (NARI) Islands Regional Centre (LAES) Keravat, ENB.

This project involved a transdisciplinary team using a range of agribusiness research methods, scientific methods (for processing) and social science research (participatory action research) methods. Three complementary research approaches were combined in the project. The first, a value chain framework, examined, identified, and analysed constraints and opportunities for growing domestic and export canarium chains in ways that benefited smallholders and communities. The second approach used scientific methodology to solve technical issues and trial the commercial operation of the processing plant. The third, participatory action research (PAR), identified ways to improve the ability and confidence of the private sector to invest in the canarium industry.

The team implemented an action research methodology with 3 action research cycles. Each year research interventions were evaluated and future activities planned on the basis of successes and lessons learnt. The team was truly transdisciplinary in approach with ideas and information shared among team members, and a collaborative approach by team members to challenges as they arose. All members of the team participated in robust discussion and planning each year during the action research cycle.

The Australian project team and the project team from NARI worked closely with a range of stakeholders from the private sector in PNG. These included:

- individual smallholders and traders selling galip nuts
- microenterprises and small-scale entrepreneurs
- small and medium enterprises
- large locally owned firms and multinational corporations.

Specific methods used for each objective are detailed below.

Objective 1: Assess the needs of the private sector to participate in the canarium industry.

The social findings were generated from a range of methods implemented during research with different stakeholders from the canarium industry. Both participant and non-participant observations were made with farmers and workers at all stages of the growing, harvesting, and transporting of products to the pilot factory during field work. Data-gathering extended to the operations of the factory itself and the purchasing, processing and production of a line of commercially viable products, with 38 interviews from people working, or on the periphery, of the industry. Similarly, data was gathered from 210 farmers and female stallholders participating in both the formal and informal canarium markets, 42 women whom sell at roadside markets and stalls through to 8 SMEs sourcing product and processing their own commercial product.

Alongside this data-gathering there was 176 semi-structured interviews with 131 smallholders, 18 industry representatives, 16 contract and ancillary staff, and 11 other similar downstream processors. Data analysis informed the training and awareness activities that the project has delivered. Training needs analysis sessions involving 55 smallholder farmers were used to inform both training expos delivered around the region for 280 groups/ individuals and large-scale awareness and extension training catering to hundreds of participants at annual World Food Day celebrations (held at UNRE in 2016, 2017 and NARI Kerevat, 2018). These activities, drawing from established participatory and community

development principles, have targeted objectives of the project alongside identified needs of participants.

Objective 2: Develop and undertake research-based interventions that address the needs of the private sector including smallholders, small scale entrepreneurs (especially women) SMEs, and large-scale processors.

Initially the project team investigated the local community and surrounding galip producing areas, consulted a variety of groups/ co-operatives and held discussions with the range of SMEs and micro enterprises operating in ENB Province. This process included a Training Needs Analysis informed approach that identified the areas and opportunities that these groups required. Training packages were developed utilising a multidisciplinary team using agribusiness research methods, scientific methods (for processing) and social research (participatory action research) methods. Training packages incorporated methods/ technologies that have been developed and researched in the pilot factory around the processing, packaging and handling of galip nuts.

These training events, in a range of models, were held across ENB and into neighbouring provinces where galip is also common. Entrepreneurs were identified and worked with intensively. Access to the factory and training events was enabled for small businesses and the agricultural sector. Training materials were developed and distributed. The multidisciplinary project team contributed in their respective areas with scientific advice on every step of the process, from growing, harvesting, storing, processing, drying and storing of galip. The business development team provided expertise on market access and opportunity. These trainings were provided to a wide range of females including smallholder farmers, producers, collectors, market sellers, and small-scale entrepreneurs.

Objective 3: Develop a commercial medium scale value adding factory for canarium.

Objective 3.1 and 3.2: Development of commercial business scenarios and galip product range

The key steps in developing commercial business scenarios were as follows:

- The Galip Nut Company brand was established as a vehicle to demonstrate a practical approach to validate product to market realities.
- A range of potential product concepts were developed and tested using consumer insights gathered from research in organised wholesale and retail markets and other nuts marketed around the world.
- A series of processing steps from farm to table were developed and product concepts customised.
- Accurate costing models to ensure attractive prices of galip fruit offered to farmers to encourage participation as a cash crop were developed.
- Understanding costs from resulting yields after drying cracking and processing to achieve packaged safe and saleable nuts were established.

Market channels and potential distribution partners were identified and a successful market launch to consumers undertaken. Following the launch in ENB and Port Moresby, potential investors have a baseline of information that can commercially assist in new product design and market development planning.

Safe food handling and nut processing techniques that are economically viable have been developed to help new entrants understand how commercial opportunities in a new industry can be realised. New methods and processes for fruit purchasing, handling, de-pulping drying and cracking of fresh harvested galip fruit that can be dried and stored safely for

extended periods have already been introduced and adopted mainly by small-scale entrants in ENB.

Extended shelf life and the use of modern packaging has enabled galip to be sold in new ways maintaining supply throughout the year when fresh fruit is not in season. Galip nut configurations in peeled, roasted, flavoured or enrobed in savoury or sweet forms are now feasible options and can be pursued by innovative marketers to reach new markets.

The market pricing positions established via the launch of The Galip Nut Company provide a commercially attractive base for scaling up industry capacity enabling trading profits to be realised.

There are opportunities for farmers processors and other input providers to participate in a cash crop and several new operators in PNG and overseas are now indicating a willingness to participate in a new industry.

Objective 3.3 and 3.4: Research methods for medium to large scale processing and working commercial factory model

We conducted research on a range of technical issues related to large scale processing. Critical needs of the factory that were explored included:

- Large scale nut-in-shell (NIS) drying and storage systems at the NARI factory to enable year-round processing.
- Options for large-scale mechanical crackers and the efficiency of existing mechanical crackers in a commercial situation.
- Options for large-scale depulping.
- A range of trials on nut quality, shelf life and nutrient composition (below).

Understanding the canarium kernel quality and shelf life under different conditions

The canarium nuts are processed and/or stored using various methods in PNG both in the galip factory and local business. Therefore, we undertook series of experiments to examine the effects of various post-harvest handing commonly practiced in PNG on kernel quality or shelf life. All experiments were established in the galip factory to ensure the results were obtained base on local conditions. The samples were then transferred to Australia for further chemical analysis.

The summary of the trials included:

- Assessing the effects of roasting on kernel quality.
- Assessing the befits of kernel-in-testa (KIT) storage to preserve kernel quality.
- Measuring the effects of refrigeration on kernel shelf life.
- Exploring the effects of freezing on kernel shelf life.

Exploring the kernel nutrient concentrations

Nutrient concentrations of kernels are influenced by (a) maturity stage of collected fruit and (b) plantation designs. Therefore, series of trials were established at the NARI research station, Keravat, to further understand the effects of fruit maturity and plantation designs on kernel nutritional composition. Additionally, nutrient compositions of canarium kernels were assessed compared with peanuts and other popular tree nuts (i.e. almond). The samples were collected from the galip factory or various cocoa-canarium plantations in Keravat. All kernel samples were transferred to Australia for further chemical analysis.

The summary of the trials included:

- Comparing nutrient concentrations of canarium nuts with peanuts and other tree nuts (almond, cashew and pistachio).

- Exploring the effects of fruit maturity on kernel nutritional composition (green vs. purple fruits).
- Understanding the effects of plantation design (both shade tree spacing regimes and shade tree species) on kernel nutritional composition.
- Assessing the nutrient composition between canarium kernel and other nuts (i.e. peanuts).

Exploring soil nutrient concentrations in the cocoa-canarium and cocoa-gliricidia plantations

Shade tree spacing regimes and shade tree species can affect soil nutrient availability for the neighbouring cash crops. We selected three plantations where *Canarium indicum* or *Gliricidia sepium* used as shade trees for cocoa. The plantations were established eight years prior to our study. The shade-tree spacing regimes included either 8 m × 16 m or 8 m × 8 m in the cocoa + canarium plantations and 12 m × 12 m cocoa + gliricidia plantation. Soil samples were collected at the depth of 0-10 cm where cocoa was planted to cocoa or shade trees with five replicates. Three fully matured leaf samples were also collected from each individual tree where soil samples were collected. leaf samples collected at each tree were pooled to constitute one sample per tree. The soil and leaf samples were then used to measure their nutrient concentrations.

Objective 3.5: Financial analysis of the commercial model

Financial analysis has been undertaken at all stages of the project and has informed operational and strategic decisions. In the early stages of the project, the financial analysis concentrated on introducing logbooks to collect regular and detailed data on the production process. This was augmented by undertaking multiple timed trials of various processes such as cracking, removing testa, drying kernels etc. The data was then analysed to identify maximum, minimum, and average throughput times and volumes for different stages of production. The large sample size allowed for more accurate estimations of relative weight of the different components of the fruit: pulp, shell, testa, kernel and moisture. By tracking the time, labour, materials, energy and other variable costs for each stage and the associated volumes of throughput, a detailed breakdown of the average cost of the final product was produced that determined the relative cost contribution of each of the stages. This allowed the project team to focus on improving efficiencies in specific stages of the production that would most impact the total ex-factory cost of the product.

Objective 4 Create a model for public- private partnerships in the canarium industry in PNG

Objective 4.1 - 4.4: Development of public-private partnerships, training of women in processing and marketing Canarium, capacity building in NARI and development of information and training packages for public-private partnerships

The project team initially worked across the ENB Province and Port Moresby identifying existing businesses operating in the agricultural downstream processing industry, or those with active social responsibility plans that could include the galip industry. A review of the literature on public-private partnerships (PPP) in innovative agricultural products was conducted. The findings were used to inform the consultations with these groups about possible PPP and some were invited to initiate such an arrangement including the use of the Kerevat facility. Initially, despite some encouraging enthusiasm, no one was prepared to invest in an unproven industry. The project then successfully developed and marketed galip products into the domestic market. This gave private sector players confidence to invest, resulting in the development of an industry with several of those who previously were reluctant to risk entering the market.

The project team has aimed to ensure that during all in-country visits by experts whom were in PNG for project work that there was an opportunity for PNG national team members to learn about their area of expertise. This saw the running of several workshops and training events that provided knowledge and capacity in areas that would otherwise not have been available. Each of the project team areas of expertise were actively transferred through to PNG national staff whom were closely associated with these areas. The business development area worked with Carson Waii. The social team worked with Simaima Kapi-Ling. Tio Nevenimo and Dalsie & Godfrey Hannett worked closely with the entire team.

The team has provided tours and demonstrations of the factory over the course of the project to all whom have shown interest including the current PNG Prime Minister and politicians, previous Australian and New Zealand ambassadors, European Union representatives, international funding bodies, farmer groups and collectives and co-operatives. These have included feasibility studies, fact finding missions, general interest, financial investment seekers and business studies. The project team has promoted the industry and always shared the technological understandings developed through the pilot factory. Often this consists of days of demonstrations and hands on opportunities for businesses and groups to come and see the inner workings of the pilot factory's operations.

The team has also produced an information manual for processors interested in investing in the industry and a standard operating procedure manual for the pilot factory. These information products detail current knowledge on equipment needed, costs, suppliers, methodologies and best practice for canarium nut processing.

6 Achievements against activities and outputs/milestones

Objective 1: To assess the needs of the private sector to participate in the Canarium industry.

no.	activity	outputs/ milestones	Completion date	Comments
1.1	Evaluate the existing scale of market participation by smallholders, SMEs and large-scale enterprises in canarium growing, collection and post-harvest handling, processing, marketing and consumption, at the start of the project.	Baseline data on the industry and participation of smallholders, SMEs and large-scale processors in the canarium industry	Yr1 m6	There were no SMEs and large-scale processors at the start of the project. Surveys and interviews of women selling canarium at the market were conducted (objective 1.4 below).
1.2	Understand the nut flow and identify options for collection and distribution of nuts to processors.: (survey number and age of surviving trees planted, volumes available, distance to factory and nearest buying point)	Data on size of production and options for nut collection and pre-processing. Data will be compared with ACIAR impact assessment series 73	Yr1 m6	Interviews with smallholders suggested that many had not planted trees distributed in ENB by other donor projects (Appendix 11.1). Data recorded by from sellers to the factory in the 2017 and 2018 seasons has shown that 85% of nuts were coming from wild trees (section 8.2 below).
1.3	Undertake household, community and enterprise surveys and market analysis to determine how best to match operational scale with product types, and market segments for the PNG domestic market and niche export markets	Review of existing market information and further market analysis where required Household, and enterprise study outlining opportunities for PNG domestic market and niche export markets	Yr1 m6 Yr1 m8	Informal interviews with smallholders and young people (26), market stall holders (6), industry representatives (9) and government staff (6) were conducted, as reported in Appendix 11.2.
1.4	Identify barriers to scaling up sale and processing of nuts (including a financial analysis and policy)	Report on options for collection and distribution of nuts to processing plants	Yr1 m8 Yr2 m8	The report on scaling up the sale and processing of canarium nuts identified the key barriers (Appendix 11.1)
1.5	Review, edit and finalise the Canarium industry roadmap	Finalised plan for development of canarium industry in PNG	Yr1 m6	The roadmap was completed and revised at the end of the project (Appendix 11.3). As the industry evolves, this will be revised and assist in the strategic plan for the subsequent project.

1.6	Identify the priority research training and extension needs of female smallholders, small scale entrepreneurs, small- to- medium enterprises and large-scale processors and distributors such as Agmark, ENBDC Paradise Foods to expand and grow the canarium industry in ways that benefit smallholders and women	Report detailing the needs of female smallholders, small scale entrepreneurs Small- to- Medium enterprises and large-scale processors and distributors such as Agmark, ENBDC Paradise Foods to participate in the canarium industry.	Yr1 m8	The priority research training and extension report (Appendix 11.1) identified the following needs: – Small-scale entrepreneurs need to improve processing, packaging and labelling. – Small-scale entrepreneurs need training to build economically viable cracker built locally (potential for a local business in manufacturing crackers) and training in this specific cracker (potential for smallholder processors) – Smal- scale entrepreneurs need training to build economically viable solar drier built locally (potential for a local manufacturer of solar drier business) and training in this specific solar drier (potential for smallholder processors) – Female smallholders continue to emphasise training for younger generations and request marketing options for produce from their gardens. These needs have been met through the training workshops that have been undertaken.

PC = partner country, A = Australia

Objective 2: To develop and undertake research-based interventions that address the needs of the private sector at all scales.

no.	**activity**	**outputs/ milestones**	**Completion date**	**Comments**
2.1	Research and refine methods for small scale processing	New methods for small scale processing using locally available materials	Yr1 m6 Yr2 m6 Yr3 m6	Research included cracking technology, pulping, and processing methods, solar drying and value adding.
2.2	Provide in-situ training and access to equipment for female entrepreneurs on small scale processing e.g. solar drying models, food safety and packaging	Provision of a range of small-scale infrastructure for female smallholders, small scale entrepreneurs to enable canarium business development	Yr1 m8 Yr2 m8	Training delivered in 4 training events. 95 females attended and 38 males, 35 not recorded (section 7.2 below). Training packages had 3 aspects: galip growing and processing, value adding and business mentoring (Appendix 12.3).

2.3	Evaluate the success of the first, second and third processing season interventions including commercial factory research and public private partnerships and plan for the next season. This will include a formal monitoring and evaluation process.	Report detailing the effect of research-based interventions on participation and decision framework for next year's interventions	Yr1 m9 Yr2 m9 Yr3 m9	The annual review was conducted with Tony Bartlett and held in June 2017 with the project team in Port Moresby and again in May 2018 in Kerevat. The end of project review was conducted with Nora Devoe and 2 external reviewers in May 2019. Each review was used to inform the following year's project activities.
2.4	Design collaborative training with related ACIAR projects for women smallholders in Bougainville	Collaborative training on solar drying delivered to women in Bougainville	Yr2 m2	Training was delivered with Family Farms Teams to 20 male, 33 female participants in Bougainville. An additional training in collaboration with Family Farm Teams was delivered in Djoul Island, New Ireland (70 participants, 35 male and female) Training has focused on hygiene, value adding of baking products, food preservation of jams and pickles, making cordials and food dehydration using solar driers. (Appendices 12.3).
2.5	Provide in-situ training to female smallholders on quality postharvest handling to provide to SMEs	Training programs on nut post-harvest management (100 women trained in quality post-harvest handling to provide to SMEs)	Yr2 m6 Yr3 m6	Smallholders were continually trained on the quality standards required by the factory at the point of purchase. This was initially in the village but later at the factory gate when the buying model changed to factory purchase. Over 1000 smallholders sold products to the pilot factory in 2018. Large scale events in the region were utilised to train smallholders on postharvest techniques required to sell to the factory: ENB Fire Dance Festival, Kokopo Agricultural Show, World Environment Day (2016, 2017, 2018, 2019). Each of these events had several hundred participants.
2.6	Provide training packages to SMEs for processing and marketing of Canarium (including commercial drying, food safety, processing, and marketing)	Training and information packages provided to SMEs	Yr2 m6 Yr3 m6	Training provided to small-scale entrepreneurs and microenterprises early in the project due to lack of SMEs participating in the industry. Training packages targeted to microenterprises are given in appendix 12.3. Training provided to SMEs later in the project (year 3-4). Factory standard operating procedures and minimum standards are given in appendix 12.4 and 13.6.
2.7	Provide business and organisational mentoring for small-scale entrepreneurs and SMEs including logistics, distribution and sales & marketing training	Business and organisational mentoring provided to 5 small scale entrepreneurs, and SMEs	Yr2 m10	Mentoring was provided to both microenterprises in year 1 and 2 and to SMEs in year 3 and 4 as they entered the industry.

PC = partner country, A = Australia

Objective 3: Develop a commercial medium scale value adding factory for the canarium.

no.	activity	outputs/ milestones	Completion date	Comments
3.1	Conceptualise a number of product-to- market options and commercial business scenarios (small to large scale) that could lead to sales at the local community level, the domestic market and niche export markets.	Commercial business scenarios developed for different scales A range of product-to-market options developed	Yr1 m6 Yr2 m3	Commercial business scenarios have been developed and tested in the ENB and Port Moresby market. Product specifications and food safety have been developed and shelf life experiments have been conducted. Nutritional information, packaging, labelling and website were designed and developed. The official launch of the Galip Nut Co product range in ENB was on the 4th May 2018 and Port Moresby on the 17th July 2018.
3.2	Identify and prioritise products for different scale commercial up chain customers	Products created to meet the needs of up chain customers	Yr2 m6	A range of galip nut products have been developed and trialled including roasted, salted, testa on and testa off products. The pilot factory has been selling galip nuts commercially since 2015. Repeat demand for the products is very strong and production is not meeting demand. New packaging was developed and rolled out for the official product launches.
3.3	Research and refine appropriate methods for medium and large-scale processing (including R&D on large scale storage, mechanical crackers, test removal, mechanical pulp removal and drying)	Report detailing processing methods and equipment for medium- large scale processing	Yr1 m8 Yr2 m8 Yr3 m8	**Research outputs -** Effects of post-harvest handling on canarium nut quality: – Mild roasting does not affect kernel quality (Bai et al. 2017; Appendix 13.1.1a & b) – Store canarium kernels as kernels-in-testa (Appendix 13.1.2) – Storage temperature effect on shelf life of kernel (Appendix 13.1.3) – Canarium kernels have high mineral concentrations (Bai et al. 2019a, b; Appendix 13.1.4a & b) – Soil nutrient concentrations were not affected by canarium with the spacing of 8 m × 16 m planted next to cocoa (Bai et al. 2017; Appendix 13.1.5) – A non-destructive determination of peroxide values, total nitrogen and mineral nutrients in an edible tree nut using hyperspectral imaging (Bai et al. 2018; Appendix 13.1.6) Product specifications have been developed and refined with new equipment purchased including: – Testing the mechanical cracker, Appendix 13.2). – Mechanical pulp remover (Preliminary results, Appendix 13.4) – Solar assisted dryer (Construction and operation of an energy efficient, solar assisted, drying system for canarium nuts, Appendix 13.5)

3.4	Create a working model of a canarium factory at NARI producing large volumes of high quality products in sufficient quantities to test the market	Working commercial model of a factory produced including factory design, costs, equipment, products, and markets potential and financial analysis	Yr3 m8	The demonstration factory increased production from several hundred kg for research purposes in 2014 to 207 tonnes of raw material in 2018. Critical infrastructure for large scale processing of canarium was developed and included mechanical crackers and solar assisted dryers. Total revenue from the sale of all products including kernel, cake, oil, and shells was PGK in 2018/2019 was 246,222 Kina.
3.5	Undertake a financial analysis of the working commercial model and each of the different scale value chains prioritised	Financial analysis working commercial model and Financial analysis models for each value chain prioritised	Yr3 m8	Financial analysis has been undertaken at all stages of the project and has informed operational and strategic decisions Key findings are that fruit purchase price remains the largest contributor to the final ex-factory cost of kernel. 95 % of raw material purchased from the farmer is wasted, highlighting the need for NIS buying systems rather than nut in pulp buying systems (Appendix 13.3).

Objective 4: Create a model for public-private partnerships in the canarium industry in PNG.

no.	**activity**	**outputs/ milestones**	**Completion date**	**Comments**
4.1	Review the literature and explore the opportunities for public- private partnerships using the pilot NARI factory at Kerevat with groups such as women in agriculture and others	Public- private partnerships created using the pilot NARI factory at Kerevat including training for NARI staff	Yr1 m8 Yr2 m8	A review of the literature was conducted in 2016 (Appendix 14.1). The project has **created 2 public private partnerships** in its final year. The project team and NARI worked closely with Equanut, NZ based investor, co-funded by MFAT, NZ in 2018/2019 on a factory sharing arrangement. After the departure of this company due to Covid-19, another processor has since expressed an interest in sharing the factory on a similar arrangement. CPL, a PNG based company has partnered with the project team to act as a distributor for the product for the market testing phase in Port Moresby.
4.2	Train groups such as Women in Agriculture in processing and marketing of canarium in the NARI factory	Training provided for private sector stakeholders and women's groups (30 women) in processing and marketing of canarium in the NARI factory	Yr2 m8 Yr3 m8	Training provided to Women and Youth in Agriculture Co-Operative Society (WYiACS) targeting lack of opportunity for youth (section 7.4 below).

4.3	Build capacity in NARI and relevant government departments in markets and agribusiness skills to support the growth of the private sector.	Government officers trained in markets and agribusiness skills to support the growth of the private sector	Yr2 m8 Yr3 m8	Staff at NARI have been trained in using the equipment, plant hygiene and plant maintenance required to run the factory producing a high-quality export ready product in a commercial manner. Project staff have worked with NARI staff on a one-to-one basis to build their skills with use of technology, food technology, health and hygiene, experimental design, plant and soil experiments and marketing. Some examples: – Videography and short movie composition (delivered by Sam Hagen) – Commcare Programming Amber Gregory (CommCare) Jack Hetherington (ACIAR) – Commcare Training (3 day workshop) 12th- 15th September 2017.
4.4	Provide public relations material including promotional and other information packages, to provincial governments and private industry with an interest in commercial canarium processing ("scale-out" of public-private partnership)	Information and training packages produced for "scale-out" of public-private partnership	Yr3 m8	A processor information package that details equipment needs, and cost structures is (Appendix 14.2). The information is designed processors wishing to enter the industry. A website has been developed to market and promote the new product range; www.galipnutco.net

7 Key results and discussion

Overview

We adopted a transdisciplinary research approach with scientists, social researchers, economists, market specialists, and nut industry experts to address the processing challenges and create new markets and products for *Canarium indicum* nuts. Our approach was truly transdisciplinary in the sense that the project team regularly interacted, planned and discussed challenges as they arose.

The project team adopted an adaptive action research methodology. Initially this was planned on a yearly cycle, but adaptive planning was needed much more frequently as the challenges rapidly changed and the project evolved. The key challenges in the first year (2016) of the project was lack of engagement by both smallholders and investors, technical challenges and lack of supply. Financial analysis in the second year of the project recommended a buying price of 1.5 kina at the factory gate. This encouraged smallholders to sell to the factory, and some technical challenges were then resolved, resulting in increased supply of raw material in 2017. Once processing challenges were resolved the products were sold in local retail outlets supply could not keep up with demand in local markets. By 2018, smallholders had more confidence and knowledge and there was very strong supply to the factory, with over 200 tonnes of raw material purchased. There was also very strong demand from markets in Port Moresby after the product launch in July 2018, with product often out of stock in the few retail markets where it was sold. However, the factory did not have the processing capacity to process enough product to match either the supply or demand. In 2019 there was little supply as other processors had entered the market coupled with a smaller production season. This illustrates how frequent recalibration and reassessment of the research directions were needed, generally involving integrated knowledge and teamwork from several disciplines.

Over 2000 smallholders are now participating in the emerging canarium industry in PNG and there are currently 3 active processors in 2020. This new industry has already improved livelihoods of smallholder farmers in both Vanuatu and PNG.

7.1 Objective 1: To assess the needs of the private sector to participate in the Canarium industry

What are the needs of the private sector to participate in the canarium industry?

Overview

The needs of the private sector were assessed in the first year of the project and the learnings from the first year's research are detailed in appendix 11.1. The needs of the private sector changed as the project evolved and some of the learnings from the later years of the project are discussed below.

1.1 Evaluate existing scale of market participation in the canarium industry

There were no SMEs and large-scale processors at the start of the project, and the only market participation was through women selling galip nuts wrapped in banana leaves in the informal markets. Over 1000 smallholders, along with entrepreneurs and on-sellers were selling to the factory in 2018. At the end of the project in 2019 there were 4 SMEs participating in canarium processing and marketing.

The project can also infer to some extent the level of market participation at different stages of the project. On the supply side, inference can be drawn from changes in the volume of fruit purchased over time, the number of farmers participating in sales, the primary locations of farmer supply, changes in the quality of fruit offered for sale, and the emergence of

arbitrage actors purchasing at the farm level and transporting and reselling at the factory gate. On the demand side, inference can be drawn from the initial availability and quality of different products at the retail level and the size and frequency of repeat purchases of finished product from the project for retail resale. These are detailed under Objective 3 below.

1.2 Understand the nut flow and identify options for collection and distribution to processors

Interviews with smallholders suggested that many had not planted the elite trees distributed in ENB by other donor projects and in the first year of the project, attempts to trace trees that had been distributed were not successful. Some of the planted trees in particular locations had suffered from borer damage. Data recorded in 2017-2018 season has shown that 85 % of nuts were coming from wild trees.

1.3 Undertake household, community and enterprise surveys and market analysis to determine how best to match operational scale with product types, and market segments for the PNG domestic market and niche export markets

Stakeholder interviews were a critical first step in constructing the value chain. At the start of the project, team members interviewed key target groups to explore knowledge about the existing status of canarium as a traditional crop and to test the economic and technical potential of commercialising the nut in formal market channels in PNG. The 3 target groups were:

1. ENB Industry Reference Group, consisting of key people involved in agribusiness in Kokopo, ENB. This group was updated on research progress, tested products and commercial aspects and provided insights as to the potential of a new industry throughout the project.
2. Market Channels (Retail - Food Service - Industrial) Target Groups to understand the demands and limitations of organised retailers and 5-star hotels in Port Moresby. Maintaining this group was critical in forming the galip product strategy that led to market, econometric and consumer testing and the creation of The Galip Nut Company. Some have since agreed to become purchasers and traders of galip and have helped the project to access shoppers for market testing. Many are waiting for increased supply of galip and eager to commence distribution in the next phase of the project.
3. Industry supporters/ Investors Group consisting of representatives of key institutions and investors in PNG. All listed in this group have contributed their time and expertise, institutional access and in many cases in-kind funding in the potential of galip as a new industry in PNG.

Market research undertaken in year 1 (2015) of the project was directed at developing an understanding of consumer markets for local and imported nuts in PNG. Effort was directed at mapping what potential organized market channels were available for potential distribution of galip nut in the main metropolitan cities of Port Moresby and Lae. The key findings were:

- Local nuts grown in PNG such as peanuts have not become commercially sustainable and do not feature in organised retail or food service channels and galip nut has historically not been commercially available to consumers. In fact, most packaged peanuts packed in consumer packaging or integrated in local food production in PNG are imported from China.
- In regional areas where galip trees are highly prevalent the nut forms part of the traditional subsistence diet and small quantities of cracked nuts are sold at local

markets and tourists by women vendors. Availability is limited only during the harvest season. This form of product wrapped in banana leaf (Karamup) was deemed highly perishable with associated food safety and quality control risks and was considered as not acceptable for distribution in modern organised markets.

- Any new consumer product that could be configured for development for new markets needed to satisfy modern food safety standards, product (organoleptic) efficacy and a storage shelf life exceeding 12 months at room temperature. This product would need to be appropriately packaged at the source of provenance, ENB, and be specified to meet modern transportation, handling and distribution systems Accordingly it would need to be positioned and priced to compete with an established range of imported nuts and snacks.
- The target market was defined to approximate 20,000 potential consumers mainly PNG`s high socio-economic segment including tourists and expatriates. Key market position attributes were defined in on package and point of sale communication.
- Industry consultation during year 1 related little confidence in the development of a locally sourced product, without clear market pull and sustainable profit returns. Further concerns around consistency of supply, large gaps in technical knowledge and processing, galip inherit low yield recovery, high fruit sourcing costs requiring significant capital and market development investment barriers were a consistent theme.

These insights informed the research team as to the forms of nut and packaging that could be developed in the pilot plant and airfreighted to target markets.

1.4 Identify barriers to scaling up sale and processing of nuts

Key barriers identified at the start of the project were (Appendix 11.2):

Smallholders

- The range of challenges that agricultural pursuits present are exacerbated in an innovation setting that can see smallholders unsure of investing their time and space on new cropping options.
- The history of agricultural innovation throughout the area has delivered a wide range of agricultural options to smallholders, with mixed results, that see them unsure of how to proceed.
- The insufficient knowledge of supply chains amongst smallholders and the factories potential to process are currently impeding the project from scaling up processing of the nut.

Structural

- Neoliberalisation of public institutions has stretched their capacity to deliver to the expectations of the project and private sector demands.
- Women were unsure of how to sell to the NARI factory as there were inconsistent buying practices.
- The capacity of the pilot factory was limiting wider community information program due to the need to avoid community members being let down.
- Women had variations in the amount of time they could devote to the local market, wholesale products and tourist products, especially when transport is limited and they have other livelihood commitments.

- Tourists were being advised not to purchase fresh nut-in-testa (NIT) that are wrapped in a banana leaf and smallholders required packaging/ processing standards to meet this market.

1.5 Review, edit and finalise the Canarium industry roadmap

The canarium industry roadmap was created at the start of the project and revised and updated at the end of the project (Appendix 11.3). Key findings are:

The industry is showing encouraging signs of growth and interest from commercial enterprises. At least 4 companies are now selling packaged product in local supermarkets and through the duty-free shops at Jackson International airport. The interest and involvement from private companies is an important step in establishing a viable industry, however there are still many gaps in knowledge, equipment and capabilities. The various sectors of the developing canarium industry require information and assistance that is specific to their individual circumstances:

- Small-scale farmers and collectors require information and training on product specification and quality control. They also require local buying points as transport is difficult and expensive.
- Farmers and collectors have recently begun value adding at the village level by cracking the nuts and selling KIT to processing companies. This supply chain has many risks in food safety and product quality. Research in quality control and training needs to be completed for this sector.
- Large-scale farmers need financial data, access to elite planting material and markets for large volumes of NIS.
- Micro-enterprises need information and training in food safety, value adding (roasting, salting etc.), packaging and marketing at the local level.
- SMEs require information on the current resource base and predicted production, mechanical processing, market potential and financial analysis.
- There is a lack of knowledge around pest threats (weevil) and control measures.

Interest has been shown from two large-scale enterprises who will need assistance in the initial stages for handling, processing, quality management and product development. Much of the action plan is aimed at developing the knowledge and financial data that this sector requires. The economic data, trial products and market intelligence developed from operating the NARI factory should be used as a vehicle to engage these larger enterprises.

The micro-enterprises, mainly women who sell in the local markets, need further support to develop their businesses. Support includes one-on-one mentoring to provide advice on developing products, packaging, food safety, shelf life.

Small-scale farmers and collectors have been supplying the factory at NARI and their knowledge of quality specifications has been improving. As the industry develops the quality standards will need to be refined to pay for kernel recovery. A bonus scheme needs to be developed to appropriately reward farmers supplying high kernel recovery (elite) varieties. Some entrepreneurs have entered the industry as regional buyers. This sector needs further development and training in quality control.

The large-scale farmers and plantation sector require access to elite planting material, financial information, information on tree management including pest and disease control, and cost/ benefits from inter-planting with cocoa, reliable information on market potential.

1.6 Identify the priority research training and extension needs of female smallholders, small-scale entrepreneurs, small- to- medium enterprises and large-scale processors and distributors to expand and grow the canarium industry in ways that benefit smallholders and women

The priority research training and extension report (Appendix 11.1) identified the following needs:

- Small-scale entrepreneurs need to improve processing, packaging and labelling.
- Small-scale entrepreneurs need training to build economically viable cracker built locally (potential for a local business in manufacturing crackers) and training in this specific cracker (potential for smallholder processors).
- Small-scale entrepreneurs need training to build economically viable solar drier built locally (potential for a local manufacturer of solar drier business) and training in this specific solar drier (potential for smallholder processors).
- Female smallholders continue to emphasise training for younger generations and request marketing options for produce from their gardens.

These needs have been met through the training workshops that have been undertaken.

7.2 Objective 2: To develop and undertake research-based interventions that address the needs of the private sector at all scales

What is the effect of research-based interventions on participation in the canarium industry for smallholders and small-scale entrepreneurs, especially females, as well as for SMEs and larger scale processors?

Overview

A range of training interventions were delivered for smallholders, small-scale entrepreneurs and SMEs, informed by the research training and extension report.

2.1 Research and refine methods for small-scale processing

Research for refinement of methods for small-scale processing included cracking technology, pulping, and processing methods. There were 3 main areas that were readily transferable:

Solar drier

The project team built a small scale solar drier suitable for drying galip and other fruit and nut products. This was constructed in 3 different provinces of PNG utilising the resources available locally to the area. Different models have been transported across ENB, New Ireland, and Autonomous Region of Bougainville tied to the back of utes, in boats and on top of trucks. It has demonstrated the versatility and effectiveness of this simple design and how it can be easily modified to suit a situation.

Drying

The team has developed a range of drying options that can be utilised dependent on access to electricity or gas. Simple procedures and tests have been developed to ensure that galip nuts are sufficiently dry for them to be stored, using electric dehydrators, a range of ovens and open fires and pans.

Value adding

Throughout the project there have been many opportunities to trial galip based, value added products with ongoing work in the Galip Nut Company kitchen and with small scale entrepreneurs looking to develop new products. The team has worked through many recipes and formulas to provide stable recipes using local ingredients that produce a safe, healthy and desirable product.

2.2 *Provide in-situ training and access to equipment for female entrepreneurs on small-scale processing e.g. solar drying models, food safety and packaging*

A series of expos were designed and delivered to share project knowledge on drying, processing, packaging and shelf life trials (Table 1). After a needs analysis of two representative communities from both an isolated and integrated location, it was seen that the delivery and content would need to be modified for each community's needs. These expos have now been delivered across the ENB and New Ireland Provinces each tailored to the particular community. They have delivered training and exposure to equipment for over 130 female entrepreneurs over the project (Figure 1).

Food dehydration techniques including locally constructed solar driers were demonstrated with a functioning drier constructed for each delivery and actively displayed drying a range of produce (Appendix 12.2). Dependent on the location of the community being trained, and their access to electricity, dehydration techniques have varied from solar drying and solar assisted through to electric domestic dehydrating units. A range of locally grown fruits and vegetables have proven to be adaptable for successful dehydration and storage, including mango, banana, tomato and nuts.

Packaging demonstrations have included the use of second-hand jars from local products through to the use of electric vacuum sealers. Again, these workshops are tailored to the community's access to electricity and packaging supply. Products could be dried and stored even in remote communities, extending the availability of seasonal food crops. The storage of products in these scenarios also requires a solid understanding of health and hygiene to keep foods safe to eat.

A standard component across the training events highlighted the importance of health and hygiene and was delivered in local language and accompanied by an interactive presentation delivered in Tok Pisin. A tennis ball that had been rolled in glitter was handed between participants demonstrating the spread of contagions from hands through to food. Participants were astonished by the end of the day to see how far the glitter had travelled and how it appeared on nearly everyone's mouth, face, hands and clothes.

There has been a mixed response in the take-up of these technologies amongst these communities, often with some initial engagement with the ideas, although often communities found different ways to use the technologies and adapt them to their own purposes. This was particularly true in the remote communities, with one example of the solar drier being repurposed to dry down the sea cucumber that they harvest and sell. Their response was that the solar drier avoided the smoke taint that reduces the price of this rare commodity. Another community was actively utilising the wood fired oven to bake bread weekly and sell to passing boat traffic.

Table 1. Training programs for female entrepreneurs and small-scale processors

Location	Year	Training	Participants
NARI Kerevat, East New Britain	Aug 2017	Solar drier, mechanical cracker and market capacity	35 participants, galip farmers with PPAP project
Tianagalip	Oct 2016	Solar drier and mechanical cracker demonstrations, Capacity building around Galip industry, food safety and hygiene	14 participants 13 female, 1 male
Vunamarita	Nov 2016	Solar drier and mechanical cracker demonstrations, Capacity building around Galip industry, food safety and hygiene	41 participants 15 female, 26 male
Kavieng, New Ireland	Nov 2018	Lead farmers with FFT ACIAR project Food preservation, hygiene and composting, baking, value adding with galip and general nutrition, galip factory and solar drying.	78 participants 67 female, 11 male

Figure 1. Godfrey Hannett training female smallholders on cracking technology.

2.3 *Evaluate the success of the first, second and third processing season interventions including commercial factory research and public-private partnerships and plan for the next season. This will include a formal monitoring and evaluation process.*

The annual review was conducted each year and used to inform the following year's activities. This process was critical as the project evolved and problems were solved a different set of challenges emerged. Early in the project key challenges were the lack of raw material available, lack of knowledge of how to sell by smallholders and lack of interest in industry by SMEs. As the project evolved and the factory began buying nut-in-pulp (NIP), key challenges were increasing processing efficiency and getting products to market. By the third year of the project, market demand very strong, and many farmers were keen to sell their products to the factory, but the factory did not have enough processing capacity to cope with either demand or supply. SMEs entered the industry in the fourth year and supply of raw material became very limited. These challenges required the project team to constantly change and adapt research to solve the problems. The annual review with all of team meeting was critical to planning and strategising for these challenges.

2.4 *Design collaborative training with related ACIAR projects for women smallholders in Bougainville*

Collaboration with the TADEP partner project 'Improving Opportunities for Economic Development for Women Smallholders in Rural PNG' identified opportunities to again share much of the knowledge that had been learnt on the galip project with the groups that had been engaged in the Family Farm Teams training delivered by the other project. These lead farmers and enthusiastic groups were hungry for all opportunity and new income generating ideas that could be utilised to further support their communities and family groups.

Training was delivered to approximately 53 participants (Table 2). Active demonstrations and hands on activities included health and hygiene, baking breads and cakes, food dehydration and packaging, the development of the galip industry and better utilisation of the crops that are prevalent in the community. Both ACIAR projects benefited from the opportunity to deliver the training with the FFT group happy to receive further training in economic opportunities and the galip project able to better spread the knowledge of the growing galip industry and motivate farmers to become involved, whether it be through sales of raw product to the factory or beginning some downstream processing themselves.

A further TADEP collaborative small grant was utilised to again roll out a similar training style event in New Island on the remote Djoul Island. This required a 2 hour dinghy ride to access the community were the project team again delivered active demonstrations and hands on opportunity for participants from the community to better utilise the produce they have around them and how to preserve them for later use. The galip industry was discussed and plans made for this galip rich island to begin to ship their product back to Kavieng to be purchased by one of the processors there.

Table 2. Collaborative training programs for women stallholders

Location	Year	Training	Participants
Bougainville Training	Nov, 2017	Hygiene, value adding of baking products, food preservation of jams and pickles, making cordials and food dehydration using solar driers.	53 participants 20 male, 33 female
Djoul Island, New Ireland	Jan 2019	Capacity building, food safety, food processing, value adding, nutrition and soil health (composting)	70 participants even distribution of male and female

2.5 *Provide in-situ training to female smallholders on quality postharvest handling to provide to SMEs*

Smallholders were continually trained on the quality standards required by the factory at the point of purchase. This was initially in the village but later at the factory gate when the buying model changed to factory purchase. This was reinforced with posters, announcements on the radio, NARI booklets and product samples used to demonstrate standards required for the factory to purchase. This was predominately around the colour/ maturity of the product and about harvesting and storage methods to preserve the quality of the galip before processing.

Large-scale events in the region were attended and utilised to train smallholders on postharvest techniques required to sell to the factory (Table 3). This included demonstrations and hands on opportunities to use the mechanical cracker developed in the pilot factory, presentations on the industry and opportunities for farmers to engage in further training and sales to the factory. Mechanical crackers were setup to crack the smaller nuts that comprised the rejects from the factory and were made available at these large gatherings. Smallholders were encouraged to come and try a mechanical cracker for the first time. Posters and other promotional material were on display with staff fielding questions from hundreds of participants that attended each day. Many were interested in how they could sell to the factory and how they could access genetic material to plant on their garden blocks.

Table 3. Training events for female smallholders

Location	Year	Training	Participants
University of Natural Resources and Environment, Vudal	Oct 2016 Oct 2017 Oct 2019	World Environment Day (2 day event) Training farmers on nut post-harvest management and quality requirements to sell to NARI	Several hundred
NARI, Kerevat	Oct 2018	World Environment Day & LAES 90th Anniversary Celebration. Training farmers on nut post-harvest management and quality requirements to sell to NARI	Several hundred
Gaulim	Oct 2019	East New Britain Fire Dance Festival (2 day event) Training farmers on nut post-harvest management and quality requirements to sell to NARI	Several hundred
Kokopo	Sept 2019	Coca Cola Kokopo Agricultural Show (3 day event) Training farmers on nut post-harvest management and quality requirements to sell to NARI	Several hundred

2.6 Provide training packages to SMEs for processing and marketing of canarium (including commercial drying, food safety, processing, and marketing

Early in the project there were no SMEs interested in marketing canarium, so the focus of activities was on microenterprises and small-scale entrepreneurs. In August 2017, 25 small-scale entrepreneurs already selling galip nut at local markets between Kokopo, Rabaul and Kerevat were trained in improving market access and capacity in the canarium industry. They were taken on a tour of the facilities and then participated in a value adding workshop in the processing facility. This demonstrated how these women could incorporate the techniques utilised in the factory in their own small enterprises. This included simple moisture tests that they could carry out to ensure extended shelf life, packaging options and the benefits these provide and some marketing ideas around labelling and brand identification. Some training packages for microenterprises include:

1. A food safety booklet was produced for female entrepreneurs in the market (Appendix 12.3).
2. A health and hygiene leaflet in Tok Pisin (Appendix 12.3).
3. Food drying techniques, snap test (Appendix 12.3)
4. Preparing recipes in Tok Pisin (Appendix 12.3)

Later in the project SMEs and larger scale processors became interested in processing galip. The following training and information packages were prepared for SMEs:

1. Factory standard operating procedures manual, to train staff in procedures for high quality canarium products (Appendix 13.6)
2. Minimum standards for raw blanched and roasted galip nut (Appendix 12.4).

The project has been actively working with all the emergent processors across ENB and New Ireland. These include:

Dennis and Debra Hill from Niugini Organics, an established coconut downstream processor and exporter. Identified early in the project when exploring options for private sector partners this group initially suggested that power costs would be prohibitive with the model we were running and that they were busy with their existing business. The project has a solid working relationship with the group often collaborating on challenges in downstream processing and factory efficiencies. Trials were run using galip shells in the boilers at their factory. They have visited the factory and utilised testing equipment from the project. After initial trials in 2018 the group began processing galip for both domestic and international markets in the 2019 season. This group looks to continue to be a strong player in the galip industry, investing in further downstream processing models including building a dedicated galip milk factory in Australia.

Dorothy and Rodney Luana from Devine Management Services, an advocate and supplier of PNG products into the capital Port Moresby. The project has worked extensively with this group around packaging, marketing, processing methods and product development. Dorothy and Rodney have visited Australia and taken tours of nut processing and downstream value adding facilities with the project. They have also represented the project and ACIAR at the Montpellier World Agroforestry Congress. They continue to be great ambassadors for the industry and demonstrate the projects collaboration towards a sustainable future.

Douglas Tsang from the BISI trading group, a large wholesaling and retail group operating out of Kavieng, New Ireland. This group service the Northern section of New Ireland and many surrounding islands such as New Hannover with regular trucks and delivery services. Alongside trying to revive the copra industry in the Province they have also begun purchasing galip nuts, which they are processing themselves and retailing through their own outlets. The team has visited the group several times over the project and have worked with them around the technologies and findings that have been made in the factory. They have

visited the factory with representatives spending several days on site working at the factory to gain insights around our operations and project outcomes. This group has a strong commitment to see the social and economic improvement of the local populations of New Ireland and are investing in new industries. They see galip as a big part of this and are continuing to purchase, process and work on improving the awareness of the industry in their region.

All these groups, along with Equanut, GNC and NARI representatives, were hosted by the project at the inaugural Canarium Buyers Reference Group Meeting held in Kokopo in April 2019. This meeting allowed all of those purchasing and processing galip to discuss concerns and challenges they had faced. It was an open discussion that raised multiple points around pricing and purchasing models.

The Galip Club. This is a group of farmers and persons interested in participating in the development of a galip industry. The group works across the Gazelle Peninsula in ENB and have a strong focus on local sustainability and ensuring all members can benefit from the industry. This can be from farmers whom are looking to sell their nuts, those interested in propagation and groups looking to value add to their products. The club organises regular training opportunities and allows communities to decide what is best for them.

The project has supported the Galip Club with a range of training including factory tours, farm visits, agricultural methodologies, biochar production and composting workshops, baking for profit workshops (Table 4). This training has been with representatives from each of the four wards that the club covers, and they have since taken the training back to their communities and shared these skills and knowledge. The galip research team provided training for the Galip Club in January 2018, both in Port Moresby and ENB. The training included food hygiene, food safety and value adding options (Appendix 12.3). A factory tour for Galip Club members was also held (Appendix 12.3) alongside a farm training day was held to discuss farm management for galip, fruit ripening and fruit collection (Appendix 12.3).

Table 4. Training packages to SMEs for processing and marketing of Canarium

Location	Year	Training	Participants
NARI, Kerevat	August 2017	Women Market Sellers from ENB Market Authority Markets Capacity building of galip products, food safety and hygiene, sales & marketing training	25 women entrepreneurs
Port Moresby	Jan/Feb 2019	Uniting Church Women's Federation Capacity building of galip products, food safety and hygiene, sales & marketing training	22 participants 18 female, 4 male
NARI, Kerevat	Jan/Feb 2019	Galip Club – factory tour and lesson learnt from industry	15 participants
Rum Jungle Plantation, Warangoi	Jan/Feb 2019	Galip Club – spacing, sustainable farm management, pruning, health and hygiene	10 Farmers

2.7 Provide business and organisational mentoring for small-scale entrepreneurs and SMEs including logistics, distribution and sales & marketing training

Microenterprises

A mentoring program was offered to 7 women whom regularly sell galip in the Rabaul markets attended a training event at the Rabaul Urban LLG offices in March 2017 (Table 5). The event covered financial literacy and value adding opportunities. The Bank of South Pacific (BSP) delivered their business savings and development training working with these women market sellers to develop business plans and savings goals tailored to their situations. This included budgeting and projections of not only their spending but activities to optimise their incomes.

The 2 small-scale entrepreneurs, Doreen Frank and Anna Kopang who were identified in the original Kokopo Market seller training, received further mentoring and assistance with packaging and labelling to develop their products. This resulted in the sales of packaged product with longer shelf life through the local markets. One of these ladies reported in 2018 she trialled roasting left over nuts and sold out 10 packets of roasted nuts during the Easter period and all sold out at 3 kina per 70 gram packets with her labels on. She has now realised the importance of preserving her leftover galip nuts and adding value to her product. They have tried to encourage younger members of their family to participate, though, face a range of obstacles in further participation. Both mentees have not changed their traditional market activities for a range of reasons, including access to facilities, ovens etc., although more so the local community response to new ideas and those that step outside of traditional activities attracting attention and social stigmatisation.

SMEs

Devine Management Systems (DMS) is a local SME working in bringing sustainable PNG products to market in Port Moresby retailers and through their own shopfront stalls. As galip farmers they are proud to sell their own product as well as purchasing from across the region. The project team has been working with this organisation closely with weekly contact support and mentoring around packaging, distribution, safe handling and marketing. Dorothy Luana the proprietor of DMS has since become a great ambassador for the industry and role model for women to engage in the next step to becoming a small enterprise. She has participated in many of the training sessions we have run and has openly shared her wisdom and enthusiasm for the opportunities that exist in primary production in PNG. Her business is a great motivator for others. On a recent work trip to Australia the project was able to facilitate the tour of several operating macadamia nut and other value adding businesses operating in the Sunshine Coast region of Queensland, Australia.

Table 5. Training packages to SMEs for processing and marketing of canarium

Location	Year	Training	Participants
Rabaul LLG Offices	Mar 2017	BSP Financial Literacy Training with Women Selling Galip from Rabaul Markets	7 women market sellers
Sunshine Coast, Australia	Dec 2018	Australian visit of factories Rodney and Dorothy on Sunshine Coast	DMS business proprietors
DMS Kitchen Takubar, ENB, PNG	Jan/Feb 2019	Baking Days at Takubar DMS- develop a commercially viable galip products to add to the already successful galip cake business	5 women from the DMS group
NARI factory, Kerevat, PNG	Dec/Jan 2018	Product development, label design and marketing	7 women identified from Kokopo markets

Feedback on training

Participants of all workshops and expos were hungry for knowledge and new ideas to try not only for their own households and family members but also to give them options for saleable products at the local market (Figure 2 and 3). One male participant summed this up, “We are so happy to get new ideas to try. We don’t have the access to these ideas in our homes. It is good to have fresh things to try.” Another male participant said, “I want to make these things for my children. I want to help their health.” Two younger female participants commented, “These products are much better for our children because we can control what goes into them.” Another female participant commented, “I have never read the ingredients on the back of the cordial I buy from the supermarket. I don’t like that these artificial ingredients are a part of my family’s diet at the moment.”

Reusing and recycling generated much interest in participants. The cycle of using excess fruits and vegetables in preserves for consumption later and then the utilisation of waste from this process to make further food products (cordials/ ice blocks) and finally the addition of wastes back into the soil via compost to make ‘strong soil’ for ‘strong plants’ and then ‘strong people’ resonated with participants. One middle aged female participant commented, “I did not know that I could add things like paper and cardboard into compost. I didn’t realise that these could be good for my soil.”

Positive feedback from the Galip Expo held at the end of 2018 in New Ireland included reports that there had been an uptake of the technologies around food preservation and making cordials and jams.

All the feedback that was received by the trainers was positive, though some participants suggested that they would have preferred 2 or 3 days of training so they could take their time rather than feeling rushed through the workshops. The following comments were recorded on the day and are initial indications of some of the outcomes achieved. During the next year it will be stories from participants around the uptake of these technologies that constitutes success of the training.

“Has learnt a lot of very life skills training on making our own products and consuming and importantly making money from the resources we have already. The galip nut also being

overlooked by locals but now we have come to know how important it is in health wise and also to earn money. And the drying processes, especially the solar dryer is one that will be easier for storing dried food/ meat for longer time. Food preservation is a big area we lack." (*male participant*)

"She has taken up a lot of trainings but has not utilise them, she believes it's the peoples ways of thinking especially their mindset has to change to adapt for the better. She has been doing Hygiene of Households for the last 5 years and together with our galip nut trainings she believes their people will now realise and gradually do gradual changes in their lives and households." (*female participant*)

"As a man, now he has come to realise the use of all our natural fruits and nuts to earn good money. He comments also if we could have 2-3 days training. Very knowledgeable, picked up a lot of good things for sustaining lives at the farmer or grassroots level." (*male participant*)

Figure 2. A group of participants preparing pineapples for a pineapple and ginger jam, the skins from the pineapple being used in the cordial

Unexpected outcomes from some of the training workshops

Within this style of event there are often positive unexpected outcomes that were not planned as outcomes. Some of the comments received on the day that are unexpected results include:

Some gender equality role reversal scenarios with several men explaining that they had never had to prepare vegetables before, and many complaining of the heat when cooking over an open fire.

"I have to apologise to my wife, cooking is really hard work". (*male participant)*

Figure 3. (left) Chutney making using chokos from the local markets, this was the first time this male participant had prepared this vegetable before. (right) Male participants stirring jams and cordials over open fires realising the difficulties that women face daily

7.3 Objective 3: Develop a commercial medium scale value adding factory for the canarium

What is an appropriate commercial model for a medium scale value adding factory the canarium industry?

Overview

This project took an innovative approach to enhancing private sector investment in canarium industry by setting up a demonstration processing factory, producing commercial canarium nut products, undertaking a financial analysis of the business model and testing the market for processed canarium products.

Key learnings:

- The demonstration factory increased production from several hundred kg for research purposes in 2014 to 207 tonnes of raw material in 2018.
- Critical infrastructure for large scale processing of canarium was developed and included mechanical crackers and solar assisted dryers.
- Commercial canarium products were launched into formal markets in 2018 and demand was very strong. The factory was unable to meet demand for the products.
- In 2019 four SMEs began processing and marketing canarium nut products. These SMEs are using a modified small-scale processing model, where kernel is hand cracked in the village and dried and packaged by the processor.

3.1 Conceptualise a number of product- to- market options and commercial business scenarios (small to large scale) that could lead to sales at the local community level, the domestic market and niche export markets.

Commercial business scenarios have been developed and tested in the ENB and Port Moresby market. The principle approach used was to develop an attractively designed product range, targeting consumers shopping in premium supermarkets and duty-free buyers/ tourists/ expatriates keen to buy something unique from PNG. Premium pricing with limited distribution would be led by the development of purpose designed consumer brand and a targeted promotional campaign directed at point of purchase. Educating consumers and raising awareness about the features and benefits of a new food product and where to taste and buy galip for the first time in PNG were key objectives.

The outcome was the development of the Galip Nut Company brand as a practical vehicle to demonstrate consumer acceptance. This required the development of a range of great tasting varieties, tightly managed product specifications for food safety, extended (12 month use by shelf life) using premium oxygen barrier packaging, nutritional information, smart labelling using QR codes to direct users to additional product information via a website.

3.2 Identify and prioritise products for different scale commercial up chain customers

A range of canarium nut products have been developed and trialled including roasted, salted, testa-on and testa-off products. These were sold into retail outlets in ENB only up until 2018. **A range of products with new packaging were developed specifically for formal markets in Port Moresby in 2018** (Figure 4). Three main products were launched in the Port Moresby market in July 2018 (and ENB in May 2018) including natural, roasted and peeled products. These were distributed in 3 CPL supermarkets and Prouds Duty Free at Jackson Airport.

Figure 4. Galip Nut Co. product range

Figure 5. Professor Helen Wallace, Simiama Ling-Kapi and Tio Nevenimo launching the product range in a CPL supermarket.

The official launch of the Galip Nut Co product range in ENB was on the 4th May 2018 and Port Moresby on the 17th July 2018 (Figure 5).

3.3 Research and refine appropriate methods for medium- and large-scale processing (including R&D on large-scale storage, mechanical crackers, testa removal, mechanical pulp removal and drying)

This activity was a major component of the project. We examined a range of methods, technologies and systems for medium- and large-scale processing. This also included research on the quality, microbial load and shelf life of canarium products produced in factories, the impact of different processing models on quality, and research on growing systems and nutrient content of nuts.

The mains findings included:

Mild roasting does not affect kernel quality

This study aimed to assess the effects of roasting on kernel chemical quality *Canarium indicum*. The kernels were subject to various roasting temperature 110°C, 120°C and 150°C at 5, 10, 20 minutes. Both increased roasting time and roasting temperature decreased peroxide value (Figure 6). Decreased peroxide value could be related to degradation of

peroxides to secondary compounds while roasting. Roasting did not alter fatty acid compositions of kernels at 110°C, 120°C. Thus, mild roasting at 120°C can be used to enhance health benefits of kernels.

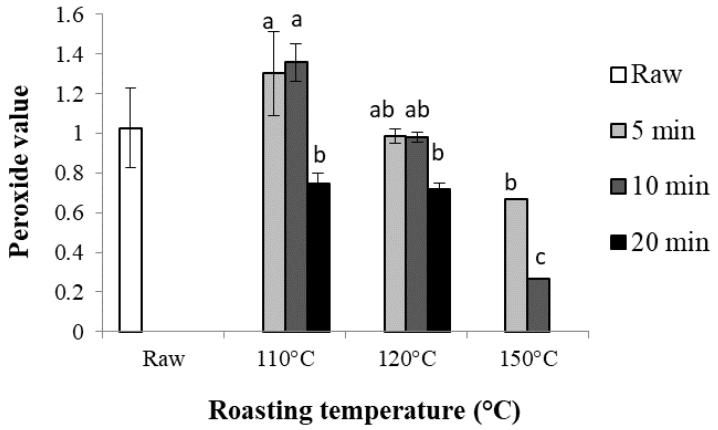

Figure 6. Peroxide values of the roasted *Canarium indicum* kernels at 110°C, 120°C and 150°C temperatures for 5 min, 10 min and 20 min compared with the raw kernels. Different lower case letters indicate significant differences at P<0.05.

Publications related to roasting include:

1- Bai, S.H., Darby, I., Nevenimo, T., Hannett, G., Hannett, D., Poienou, M., Grant, E., Brooks, P., Walton, D., Randall, B. and Wallace, H.M., 2017. Effects of roasting on kernel peroxide value, free fatty acid, fatty acid composition and crude protein content. *PloS One*, *12*(9). Please see appendix 13.1.1a.
2- Hosseini Bai, S., Nevenimo, T., Hannett, G., Hannett, D., Jones, K., Trueman, S.J., Grant, E.L., Walton, D., Randall, B. and Wallace, H.M., 2019. Freezing, roasting and salt dipping impacts on peroxide value, free fatty acid and fatty acid concentrations of nut kernels. *Acta Horticulturae*, 1256, pp.71-75. Please see appendix 13.1.1b.

Benefits of storing canarium kernels as kernel-in-testa

This study investigated how the presence of testa affects oxidative stability of canarium. We measured hexanal production as an indicator of oil oxidation. The absence of testa in canarium kernels (blanched kernels) led to greater hexanal concentrations than kernel-in-testa (unblanched) at day 24 following of the incubation (Figure 7). The presence of testa, which acts as a natural coating, slowed oxidation in canarium. Slow oil oxidation may have implications on the shelf life of canarium kernels over time. Storing kernels as kernel-in-testa (KIT) would help to prolong shelf life of canarium. Therefore, we recommend that canarium is stored as KIT.

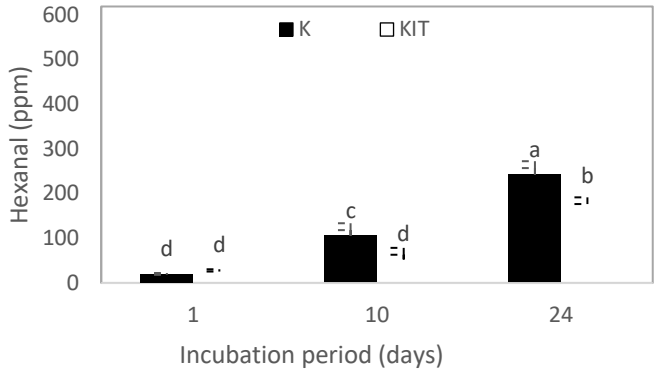

Figure 7. Hexanal concentrations of canarium for blanched kernels (K; black columns) and kernel-in-testa (KIT; white columns) at days 1, 10 and 24 following incubation. Lower-case letters indicate significant differences among treatments over the period of study at each nut species (one-way ANOVA; $p<0.05$).

For full text please see Appendix 13.1.2.

Refrigeration prolongs shelf life of canarium kernels although kernels could be stored for 12 months at 25°C

This study was undertaken to determine the effects of storage temperature on shelf life of canarium kernels kept in-shell for 3 or 12 weeks before storage. Canarium nuts were kept in shell for 1 week or 12 weeks before processing (referred to as fresh and aged canarium, respectively). The kernels were then stored at 4°C or 25°C for 12 or 15 months. Free fatty acid levels of fresh and aged canarium kernels stored at 25°C were significantly higher compared with kernels stored at 4°C from 9 months of storage onwards (Figure 8). Our study indicated that refrigerating canarium kernels extends their shelf life. However, free fatty acid levels of kernels stored at 25°C were still under acceptable limits after 12 or 15 months of storage (Figure 8). In the absence of refrigerator, the kernels can be safely stored at 25°C up to 12 months.

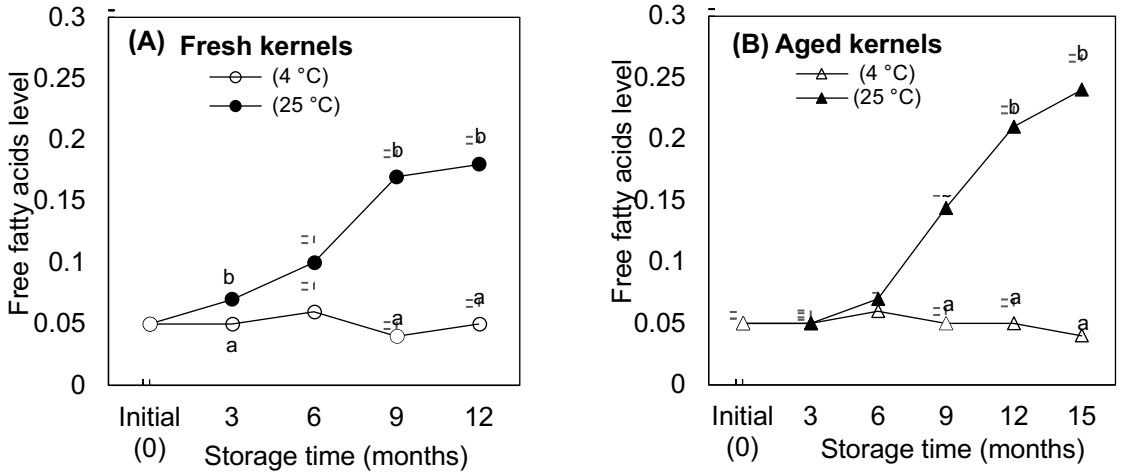

Figure 8. Levels of free fatty acids (% oleic acid) of canarium kernels during storage at different temperatures (A - fresh canarium kernels, B - aged canarium kernels). Means followed by different letters at the same storage month are significantly different at $p<0.05$.

For full text of this experiment please see Appendix 13.1.3.

Freezing of kernels needs to be avoided

The study evaluated the effects of freezing (-20°C) before storage on shelf life of canarium during a 9 month storage period at 25°C. Freezing increased peroxide values of canarium kernels at 3 months of storage (Figure 9). Peroxide values are an important quality measure during the storage of nuts as they indicate the initiation of lipid oxidation. The peroxide values of frozen kernels were over 3 (meq O_2/kg oil) at month 3 of storage. Therefore, the kernels were considered rancid by month 3 of storage because the acceptable threshold of peroxide values for canarium is 3 (meq O_2/kg oil). Therefore, freezing of canarium is not recommended as it accelerates lipid oxidation of canarium kernels.

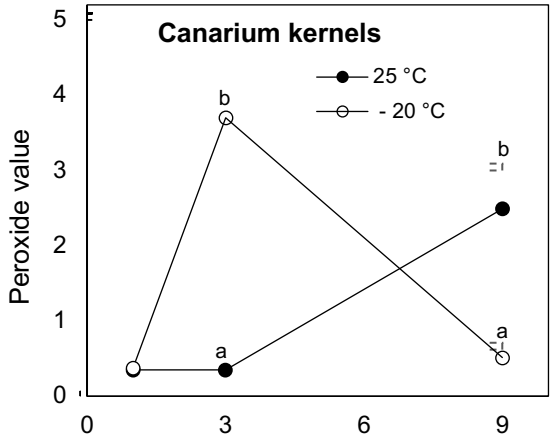

Figure 9. Peroxide values (meq O_2/kg oil) of canarium kernels frozen at -20 °C before start of this experiment compared with those kept at room temperature (25 °C)

For full text of this experiment please see Appendix 13.1.3.

Canarium kernels have high mineral concentrations

This study aimed to assess the nutrient composition of canarium compared with popular nuts including almond, cashew, pistachio and peanut. Our study indicated that 50 grams of almond provided over 50 % of the recommended daily intake for manganese. Pistachio was richer in potassium compared with other nuts and canarium was richer in boron, iron and zinc than other nut species. Canarium could provide approximately 50 % of the recommended daily intake for iron in males and 25 % of the recommended daily intake for iron in females (Figure 10A). Canarium kernels were rich in iron, phosphorus and zinc when compared with peanut, almond, cashew and pistachio (Figure 10 and 11). Mature canarium kernels were richer in boron, iron and zinc but contained less potassium than immature canarium (Table 6). Our study suggested that (a) canarium can provide a wide range of mineral nutrients when consumed and (b) mature canarium might be more nutritious than immature canarium when consumed. However, it should be noted that the bioavailability of nutrients after consumption is required further examination.

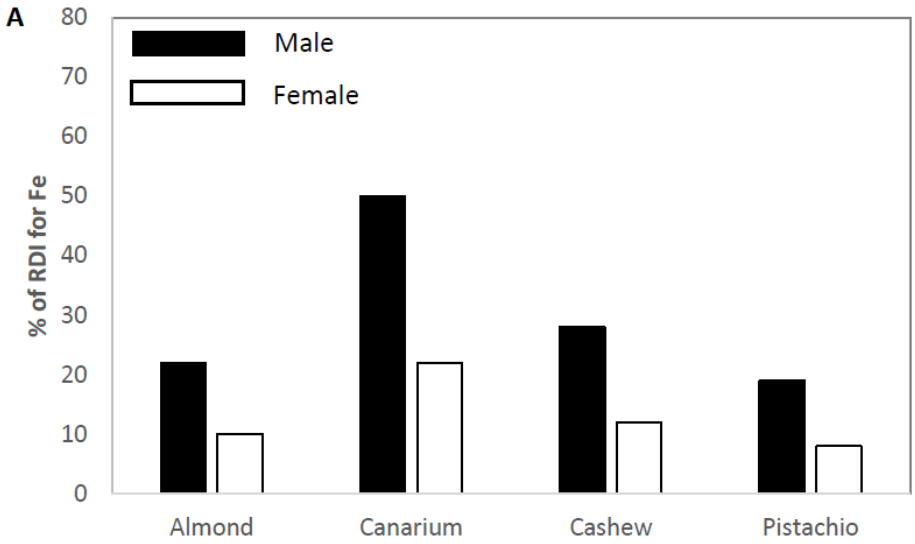

Figure 10. Recommended daily intake (RDI) of (A) iron for male (black columns) and female (white columns) in almond, canarium, cashew and pistachio

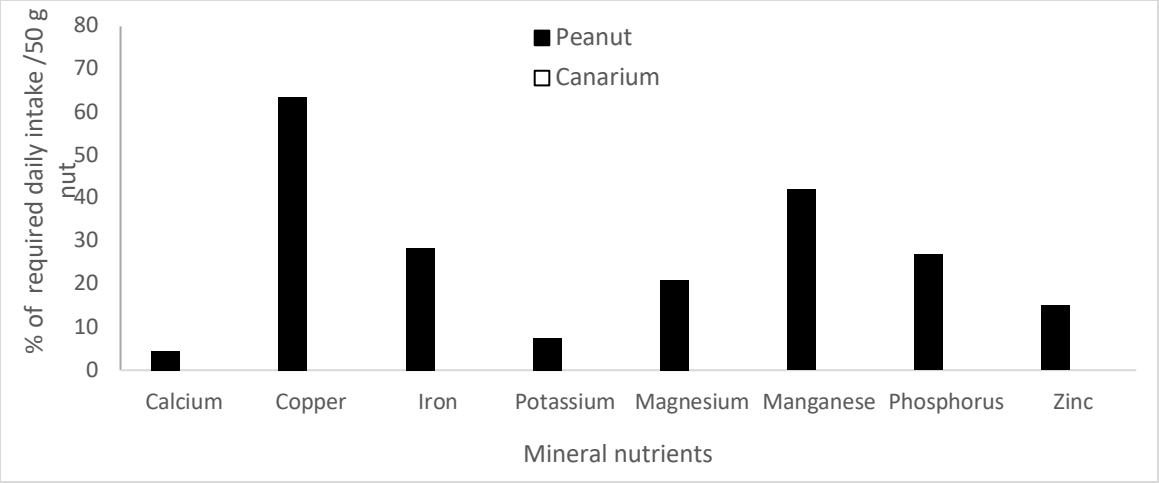

Figure 11. Percentage of required daily intake for minerals in human diet when a handful (50 g) of canarium or peanut is consumed.

Table 6. Nutrient concentrations of the kernels from green (immature) and purple (mature) nuts. Different lower-case letters at each row indicate significant differences at P<0.05.

	Green nut (immature)	Purple nut (mature)
Crude protein (%)	13.8(0.2) a	14.1(0.3) a
Calcium (mg/kg)	536(69) b	851(92) a
Copper (mg/kg)	11.2(0.6) a	9.46(0.5) a
Iron (mg/kg)	57.5(5)b	81.0(5) a
Potassium (%)	0.61(0.03) a	0.36(0.02) b
Sodium (mg/kg)	24.7(7) a	8.87(2) b
Zinc (mg/kg)	37.5(3.3) b	50.3(2.7) a

Publications related to nutrient compositions of canarium kernels under various conditions can be found in the following publications:

1- Bai, S.H., Brooks, P., Gama, R., Nevenimo, T., Hannett, G., Hannett, D., Randall, B., Walton, D., Grant, E. and Wallace, H.M., 2019. Nutritional quality of almond, canarium, cashew and pistachio and their oil photooxidative stability. *Journal of Food Science and Technology*, *56*(2), pp.792-798. (Appendix 13.1.4a)

2- Hosseini-Bai, S., Trueman, S.J., Nevenimo, T., Hannett, G., Randall, B. and Wallace, H.M., 2019. The effects of tree spacing regime and tree species composition on mineral nutrient composition of cocoa beans and canarium nuts in 8-year-old cocoa plantations. *Environmental Science and Pollution Research*, *26*(21), pp.22021-22029. (Appendix 13.1.4b)

Soil nutrient concentrations were not affected by canarium with the spacing of 8 m × 16 m planted next to cocoa

This study investigated the effects of shade tree species and spacing regimes on soil and plant nutrient concentrations of three cocoa plantations at 8 years after plantation establishment in PNG. The cocoa trees were planted with either *Canarium indicum* or *Gliricidia sepium*. The shade-tree spacing regimes included either 8 m × 16 m or 8 m × 8 m in the cocoa + canarium plantations and 12 m × 12 m cocoa + gliricidia plantation. Soil total carbon (TC) and total nitrogen (TN) were significantly higher in the cocoa + gliricidia plantation and the cocoa + canarium plantation (8 m × 16 m) than in the cocoa + canarium plantation (8 m × 8 m). The foliar TN values did not indicate N-limitation for cocoa trees in any plantation because all concentrations were above 0.09 %. The cocoa + gliricidia plantation had higher soil available phosphorus (P) than the two cocoa + canarium plantations. Higher P in the cocoa + gliricidia plantation could be associated with frequent pruning and the N_2 fixation ability of the *G. sepium* trees. However, all 3 plantations were P-limited indicating a need to apply P-enrich fertilisers to sustain cocoa production. Our study indicated that non-legume timber trees can be used as overstorey shade trees for cocoa but the spacing regimes need to be optimised to prevent nutrient limitation for cocoa trees.

Please see the following publication related to this experiment in Appendix 13.1.5:

1- Bai, S.H., Trueman, S.J., Nevenimo, T., Hannett, G., Bapiwai, P., Poienou, M. and Wallace, H.M., 2017. Effects of shade-tree species and spacing on soil and leaf nutrient concentrations in cocoa plantations at 8 years after establishment. *Agriculture, Ecosystems & Environment*, *246*, pp.134-143.

3.4 Create a working model of a canarium factory at NARI producing large volumes of high quality products in sufficient quantities to test the market

The project team has created a working model of the factory, including large-scale processing methods and equipment, producing large volumes of galip products and testing markets with product sales. The factory also implemented and tested the research on processing, marketing and sales strategies described in 3.1-3.3 above and developed factory standard operating procedures (Appendix 13.6).

Processing methods

Some critical interventions were:

Depulping: NARI Kerevat tested various methods for removing the pulp including cement mixer with some stones and metal, tyre depulpers and other machinery. The best solution was a modified fruit juicing machine. The machine can depulp 2-3 tonnes of nut-in-pulp (NIP) per hour with at least 3 people. Previously it would take a full day to do this amount of NIP with 5-8 people. The modified machine has cut the labour and resource put into depulping by over 50 % (Appendix 13.4).

Drying: A large scale nut-in-shell (NIS) dryer was designed that is solar assisted to improve energy efficiency (Appendix 13.5). The dryer was constructed using a decommissioned refrigerated container and local materials (Figure 12). The dryer uses a small 2 kW heating element and passive solar heat to successfully dry about 4 tonne of nuts per week.

Figure 12. a) Nut-in-shell dryer constructed from a decommissioned refrigerated container and local materials, pictured Kim Jones, b) internal setup of the large-scale dryer.

Cracking: a mechanical cracker and processing line was commissioned to increase the capacity of the cracking. A modified mechanical cracker from the macadamia industry was installed, tested and adjusted (Figure 13). A series of trials were undertaken to examine the efficiency of the cracker and adjust the cracker for different size of galip nuts. The cracker and processing plant have increased the processing capacity from 250 kg per day to about 1 tonne per day. We can expect about 50 % whole kernel and the rest a mixture of large and small chips. The large chips would be suitable for snack packs and the small chips for industrial uses or oil (Appendix 13.2). However, there is still significant development needed to engineer the cracker for large scale processing, in particular a system of grading nuts is needed to make the cracker efficient.

Figure 13. a) Mechanical cracker and b) processing line commissioned to increase cracking capacity.

Factory production and market testing

The pilot factory has produced a range of products, including raw and roasted kernel and oil, sold into formal markets in ENB and Port Moresby. There is strong repeat demand. The team identified that market testing has proven sales demand exceeding supply. Products are often

out of stock and the NARI factory has been unable to supply the markets in Port Moresby (Appendix 13.7).

Total revenue from the sale of all products including kernel, cake, oil, and shells in 2018/ 2019 was 246,222 kina (Table 7). Eighty percent of the revenue came principally from 10 orders distributed through CPL Stop n Shop and Prouds outlets Port Moresby. 90 % of those orders came from NIP purchased prior to October 2018 and 10% from the 2019 season when raw material was in short supply. It is quite likely that should supply had met with original sales estimates the factory could have achieved 1 million revenue PGK target customers had anticipated late in 2018.

Table 7. Summary of sales and revenue from pilot factory

Summary	Volume Tonnes	Value PGK	Value AUD 0.42	
ENB Sales	0.20184	17,140	7,198.80	
CPL POM Sales	2.001	202,033.20	84,853.94	PGK 84.92/kilogram
Cash Sales ENB	0.19766	21,016.55	8,826.95	PGK 101.01/kilogram
Total Nut Sales PNG	**2.4005**	**240,190**	**100,879.69**	PGK106.78/kilogram
				56.294 tonnes NIP
Oil ENB	0.0453	5,541.50	2,327.43	PGK 122.32/Litre
Cake/ charcoal/ shells ENB		490	205.80	
Total Other Sales		**6,031.50**	**2,533.23**	
GROSS PROFIT CENTRE SALES		**PGK 246,222**	**$103,413.03**	

Factory production was greatly upscaled from less than 1 tonne of raw material (NIP) at the start of the project in 2014 to 207 tonnes of NIP purchased in 2018 as a result of these interventions. The factory provided direct income for over 1300 smallholder farmers in 2018. Furthermore, the factory created opportunities for entrepreneurs to enter the supply chain, as agents collecting galip from farmers and hiring trucks to transport galip to the factory (Table 8). In 2019, raw material was in short supply due to the entry of commercial galip processors and a poor nut producing season.

Table 8. Impact of the pilot factory throughout the project

Year	Nut in pulp purchased (1-1.5 kina per kg)	No of farmers selling	Farm gate value
2014	Small volumes (<1000 kg) for research trials	N/A	N/A
2015	11 tonnes	243 smallholder farmers	10,669 kina
2016	25 tonnes	647 smallholder farmers	26,349 kina
2017	65 tonnes	659 farmers recorded (many others not captured in data app) 544 selling at factory gate,115 on farms	65,000 kina at farm gate
2018	207 tonnes	1349 purchases recorded (many others not captured in data app) 44 purchases at farm gate, 1305 at factory door Women selling direct, entrepreneurs collecting from farmers and selling to factory	310, 500 kina at farm gate
2019	4 active commercial processors, Limited supply to NARI factory. Estimated purchase equivalent to 300-400 tonnes	Active processors purchasing from ENB, New Ireland	NARI factory: Commercial processors: Estimated factory gate value 300,000-400,000 kina assuming 20 kina kg for cracked kernel

3.5 Undertake a financial analysis of the working commercial model and each of the different scale value chains prioritised

Financial analysis has been undertaken at all stages of the project and has informed operational and strategic decisions. An early observation was that the purchase of the fruit contributed 49 % of the total cost of the final product in 2017, due to the costs of sending the project team to the villages to purchase at 1kina/ kg. A cost benefit analysis determined that it would be more cost effective to offer a higher purchase price (1.5 kina per kg) at the factory gate. This led to the dual pricing strategy which largely replaced farm gate purchasing with factory gate purchasing and reduced the ex-factory product cost of dried testa off kernel by 31 % per kg.

While the initial intention of the financial modelling was to develop micro- and macro-level financial models, undertake advanced DuPont Analysis etc., it became apparent that financial information that only related to the factory could not be extracted from whole of project costs at sufficient detail to produce accurate figures. Further, the project as a whole

did not function like a traditional commercial operation with loans, shareholders, dividends, equity, assets, depreciation schedules etc. As a result, the financial analysis focused greater attention on producing a detailed and accurate gross-margin analysis concentrating on variable costs associated with the production process for various product lines which could be triangulated with the time and throughput figures collected in the logbooks. Gross margin indicates how much profit a company makes after paying the cost of the goods sold. It is a measure of the efficiency of a company using its raw materials and labour during the production process, which made it a more appropriate approach for first phase of the project.

The following is a summary of the main findings for 2018, the year in which the project launched its main product line and engaged in substantial sales to retailers.

In 2018 the ex-factory average variable cost of producing 1 kg of packaged natural or roasted kernel (testa on dry - 2% MC) was 55.63 kina and the peeled kernel (testa off dry - 2% MC) was 74.02 kina. The analysis allowed the total cost to be decomposed into the contribution of the different stages. For example, for the peeled product, 29.37 kina related to the purchase of the fruit, 8.05 kina to depulping, 9.56 kina to cracking, 5.20 kina to testa removal, 7.41 kina to drying/ sorting/ packing, 1.92 kina to electricity, 0.18 kina to diesel, and 12.34 kina to overhead.

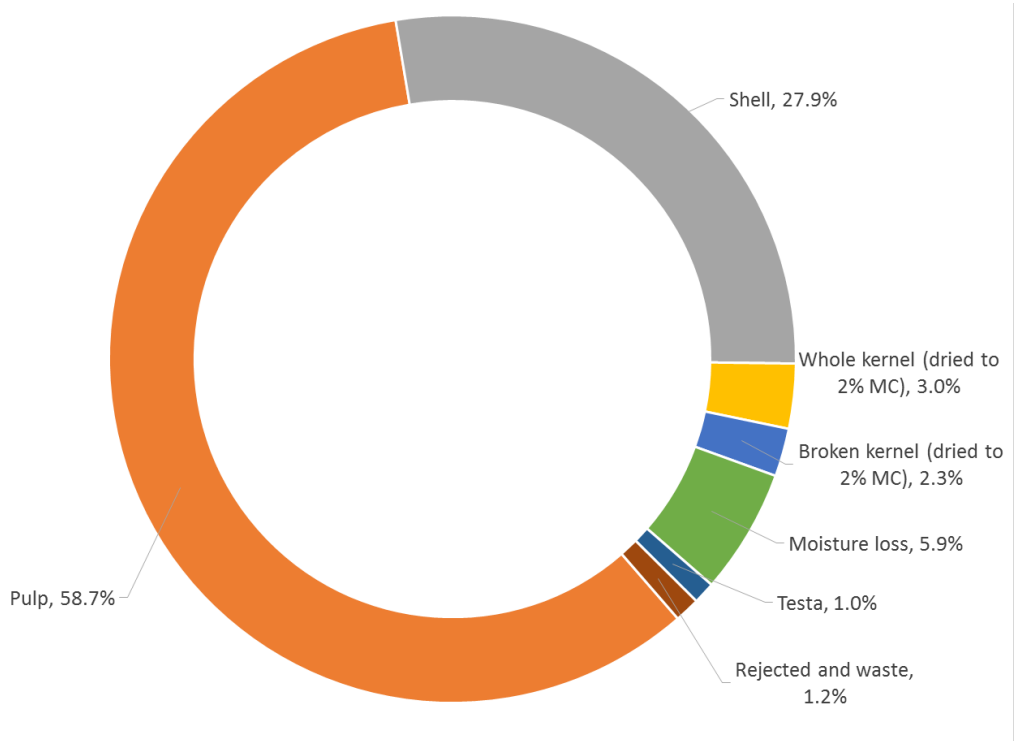

Figure 14. Ratio of product components from fruit to dried kernel

Between January and December 2018, 248 unique sales were made totalling 1241 kg. This included of 371 kg of peeled, 408 kg of roasted, and 461 kg of natural product. A further 90 unique sales were made of oil, cake, and shells. Among the nut sales, the vast majority (84 %) was to CPL in Port Moresby with the remainder to a combination of private and retail purchasers in Kokopo, Keravat, Lae, and Rabaul. The sum of revenue was 125,328 kina, sum of ex-factory costs was 75,835 kina, and sum of profit was 49,492 kina. This equates to a gross profit margin of 39.5 %.

To summarise, the findings of the financial and market analysis are positive. On the supply side, farmers are motivated to collect and sell at the prices offered for fruit. On the demand

side, the project is getting repeat orders at premium prices with reasonable gross profit margins. Looking forward, there is considerable scope to reduce costs as our production process matures and becomes more efficient and we develop new product lines that take advantage of the lower average costs of the mechanised production process and expand domestic and international sales.

Analysis of costs from 2018 indicate that a factory gate fruit purchase price of 1.5 kina per kg is equivalent to purchasing NIS (10 % moisture content) for 4.23 kina per kg. This suggests the upper boundary of a NIS purchase price under a decentralised model where NARI purchased nut in shell instead of fruit. Ex-factory costs of the final product could be considerably reduced if NARI was able to purchase high quality NIS from at a price of 2 to 3 kina per kg. However, an accurate and efficient method of assessing NIS quality at the point of purchase would be required.

7.4 Objective 4: Create a model for public-private partnerships in the canarium industry in PNG

What are the most effective strategies for public-private partnerships in the canarium industry in PNG?

The project team trailed a range of strategies to create and enhance public-private partnerships and build capacity in PNG. Some partnerships emerged as a result of project activities (e.g. partnerships with Equanut and CPL) and were critical to achieving the project outcomes. The partnership with CPL is still in existence, the partnership arrangement with Equanut has now concluded but is being used as a model for other private sector investors who wish to partner with NARI. A range of training and capacity building activities will have lasting impact for the participants, e.g. some graduates of the youth program have gained employment, and NARI staff have developed new skills that will help them to support the emerging industry.

4.1 Review the literature and explore the opportunities for public-private partnerships using the pilot NARI factory at Kerevat with groups such as women in agriculture and others

Investigating the literature and opportunities around the potential for public-private partnerships (PPP) in the emerging canarium industry in ENB provides a range of examples and challenges. There is a lack of academic literature around the establishment of PPP relationships in innovative agricultural products and downstream processing. There is an example of an emergent industry similar to canarium, a nut harvested for oil found in Africa, where a PPP has been established around this new product. This industry, whilst still emerging, has faced several challenges around supply concerns and income expectations. The literature identified further challenges around the establishment of these style relationships, raising the issues of different expectations from the public and private sector, and the need for clear contractual arrangements and suggested the use of intermediaries. Exploring the potential private partner opportunities in ENB provided a range of feedback and whilst overall was enthusiastic there were too many challenges identified, primarily that most businesses and groups were too preoccupied with their core businesses. Other issues raised included the prohibitive cost of electricity in the drying process. Of the businesses identified there was one that operated as an extension of the provincial government and as such already had access to networks of growers. It is was found that these style partners would be a viable option moving forward because of these existing networks.

Two private sector players have partnered with the project team.

The 2 private sector partners during the life of the project included:

Equanut: This company partnered with the project team in 2018-2019 to process canarium in ENB. MFAT assisted Equanut to set up operations for canarium nuts, oils and meals as organic products that can substitute for almond. The cracking component of the pilot galip nut factory was leased to Equanut for the 2019 season. Equanut withdrew at the start of 2020 during the Covid-19 crisis. Another company has expressed interest in partnering under a similar arrangement.

CPL Group: This has been the key distribution partner working closely with the project team facilitating the distribution of (natural, peeled, and roasted) packaged galip nut product for the market testing trials in Port Moresby. CPL Group is a publicly listed company with supermarket and hardware outlets and PNGs largest pharmacy chain City Pharmacy. Founder and Chairman Mr Mahesh Patel AO offered the distribution power of the company to assist the development of galip. This included free space in selected Stop n Shop supermarkets and the Prouds duty free outlet at Jackson`s international airport and favourable trading and payment terms for the Galip Nut Company. The company's contribution via their community and social responsibility Foundation has been critical to progress to date.

Other Donors are interested in investing in galip processing to seed public private partnerships. IFAD (International Fund for Agricultural Development) new project on 'Markets for Village Farmers' project includes a sub-component aiming at stimulating commercial galip nut processing.

4.2 Train groups such as Women in Agriculture in processing and marketing of canarium in the NARI factory

Working with the Women and Youth in Agriculture Co-Operative Society (WYiACS) the project heard that these members were most concerned for their children and the lack of opportunities they had. The project then designed a 2-week work experience program at the pilot factory (Table 9; Appendix 14.1). WYIACS were responsible for providing the project with the 12 participants, whom were representative of the many co-operatives in the group situated around the factory.

This program provided opportunity for young people to experience the workplace and the processes behind downstream processing and marketing of galip nuts (Figure 15 and 16). Working across all the different aspects of the processing facility gave the participants an insight to how these could be replicated in different environments. Many visiting Australian scientists and experts of their field were able to present to the group about their careers and study options. From the original group of 12, 2 participants have found employment in the galip industry, 1 with a permanent position at NARI. Several others are currently pursuing further studies in agricultural science and related fields.

Table 9. Training opportunity with Women and Youth in Agriculture Co-Operative Society (WYiACS)

Location	Year	Training	Participants
NARI, Kerevat	2016	Operation of canarium processing facility, factory tour, presentations from entomologists, economists, marketing experts and social, livestock and agricultural scientists	Youth Galip Training Program

Feedback from the Young People Galip Training and Work experience program in 2016:

“This is the first time I experienced such training because I come from a remote area and is not accessible to development” (Youth Participant).

“It broadened my mind to think of something to do that will benefit me into the future” (Youth Participant).

“I have never experienced such agricultural trainings before and the process gone through under the galip project and was a great bonus to me and my family (Youth Participant).

“Didn’t like cracking and touching the insects especially those weevils! Made me decide to stick to livestock” (Youth Participant).

“They are the next generation but are lost with nothing to do. I’m worried for them. So thank you for giving them an opportunity” (Parent of Participant).

“It strategically pulled key people and institutions to give hope to our young people. Exposing the young people through this work/ training program is unique and never been done before” (Canarium Project Staff).

‘It is about broadening young people’s exposure to a lot of different options that may inspire just one of them to pursue a career in the field” (Canarium Project Staff).

Figure 15. a) Participants working in the canarium processing plant sorting nuts into grades. b) Participants working with resident entomologist Fidelis identifying life cycle stages of insects that can attack agricultural crops including canarium

Figure 16. Participant explaining the processes of the canarium processing facility at NARI to group visiting from the Western Highlands region.

4.3 Build capacity in NARI and relevant government departments in markets and agribusiness skills to support the growth of the private sector

Staff at NARI have been trained in using equipment, plant hygiene and plant maintenance required to run the factory and now have the skills to produce a high-quality, export ready product in a commercial manner. NARI now has the equipment and ability to purchase, process and market galip nuts in a domestic market on a commercial scale.

Project staff have worked with NARI staff on a one-to-one basis to build their skills with use of technology, food technology, health and hygiene, experimental design, plant and soil experiments and marketing. An example of these skills and their subsequent use include:

- *Dalsie Hannett:* Delivered shelf life experiments at NARI, prepared and analysed samples for quality (e.g. peroxide value, free fatty acid, and microbial load), provided testing services to other export processors. Training in product processes, design, filling, packaging and labelling. Storage and stock management for finished goods for sale and sourcing packaging and related consumables from Australian and PNG suppliers.

Figure 17. Dalsie Hannett with the Galip Nut Co. product range that she is responsible for.

- *Godfrey Hannett:* Commcare design and programming of several surveys, performed litter decomposition experiment, random sample collection, soil and leaf sample processing.
- *Simaima Ling-Kapi:* Delivered food safety and hygiene workshops for locals, preparing leaflets for farmers. Working with several other ACIAR projects delivering skills learnt through her time with the project.
- *Carson Waai:* Worked with Theo Simos to build skill on commercial distribution and marketing and product to market skills. Maintained and serviced a domestic market supply of commercial quantities of galip nuts. Development of new customer account

management system to liaise with buyers, process and receive orders and revenue collection.

All NARI Staff at the Kerevat IRC attended the following training sessions facilitated by the project:

- *Taking photographs for reporting* (delivered by Connor Ashleigh)
- *Take better pictures using mobile devices* (delivered by Connor Ashleigh)
- *Videography and short movie composition* (delivered by Sam Hagen)
- *Commcare Programming* Amber Gregory (CommCare) Jack Hetherington (ACIAR)

Commcare Training (3 day workshop) 12th – 15th September 2017

As a part of the Commcare SRA the galip project was invited to attend a training package designed to assist projects in designing and implementing commcare surveys. Rather than hold the training in Australia and try to develop surveys to be implemented in the field in PNG, the galip project held the training at the Kerevat station with the staff whom are going to implement the surveys.

Originally this was meant to be for 6 key staff so that they could develop and test surveys for the galip project. We had 18 participants from across the organisation including Ofara RDC, Matthew (Propagation), Fidelis (Entomology), Ku (Livestock). It was the addition of these participants that saw real capacity building opportunities for the organisation. These numbers reduced for the subsequent days, but both Ku and Fidelis developed surveys for their own work from the training.

There is sense of ownership of the program and their skills since having the opportunity to participate in the training. This ownership has potentially provided further stimulus for the PNG team to ensure that the surveys are implemented. Training the end users has hopefully reduced the need for further on the ground training and modifications.

4.4 Provide public relations material including promotional and other information packages, to provincial governments and private industry with an interest in commercial canarium processing ('scale-out' of public- private partnership)

An information package for future processors has been created to provide information on methods of processing, equipment, risks and costs and suppliers (Appendix 14.2)

Other technical information packages have been created and made available to private investors with an interest in processing (Appendix 13.6 and Appendix 12.4)

A website to promote the galip product range has been developed: www.galipnutco.net

A range of promotional events have taken place (See section 8.4 below) the most significant of these was the product launch in ENB and Port Moresby (see section 8.4 below). These received significant media coverage and were attended by the Australian High Commissioner, the NARI Council Chairman, Minister of Police and member for Gazelle, Minister for Agriculture and Livestock and the Governor of ENB.

8 Impacts

Overview

The key impacts of the project are:

- Smallholders, via access to new markets for their canarium products. Over 1000 smallholders were selling to the factory in 2018.
- Microenterprises/ entrepreneurs are also collecting nuts from farmers and selling to the factory. Other entrepreneurs are value adding and selling products such as cakes, bread and biscuits (https://aciar.gov.au/node/13321).

SMEs have commenced processing, resulting in an emerging galip nut industry with wide ranging economic and social benefits (see below).

8.1 Scientific impacts – now and in 5 years

This project has built scientific capacity within NARI by undertaking research in partnership with NARI researchers on galip nut processing. Project partners have developed new skills in scientific equipment and data analysis and are co-authors on all publications.

The project team has also undertaken research on the galip production system to strengthen the capacity of project partners in scientific studies on canarium-cocoa and canarium-coffee cropping systems including nutrient competition of cacao and coffee trees with canarium (Appendix 13.1.5).

This project pioneered the use of hyperspectral imaging to detect nut quality, resulting in a collaborative publication (Appendix 13.1.6). Project teams outside of the project have started using hyperspectral imaging to examine the potential of this technology to predict nut quality and assess the nutrient concentrations in soil and leaf samples.

8.2 Capacity impacts – now and in 5 years

Change in knowledge and skills of individuals

The major achievements in building capacity in knowledge and skills of individuals include:

- Building capacity of smallholders to sell their product to the pilot NARI factory. Over 1000 smallholders and small-scale entrepreneurs were trained at the factory gate in quality standards.
- Building capacity of microenterprises to process and value add to their galip products. This was delivered through a series of workshops on food safety, financial literacy, crackers, solar drier construction, business opportunities and value-adding with community members, and market skills training. These workshops were delivered to approximately 300 participants in ENB, New Ireland and Autonomous Region of Bougainville (Figure 18 and 19).


Figure 18. Tio Nevenimo (NARI) delivers solar drier training in ARoB. Dorothy Luana of the East New Britain Galip Club participating in a baking demonstration held in Takubar developing and sharing recipes for commercial sales.

- NARI staff have developed agribusiness skills, public-private partnerships, processing techniques and value-added training workshops. In particular, NARI staff such as Tio Nevenimo, and Dalsie Hannett have developed extensive knowledge of buying, processing and marketing galip nuts. NARI staff will be able to use these skills to support the growth of the emerging canarium industry.

Figure 19. Dalsie Hannett and Simaima Ling-Kapi (NARI staff) demonstrated making galip cookies to participants

The project team undertook wide series of experiments to understand shelf life, post-harvest handing and nutritional values of canarium. These have had major impacts on the capacity of the emerging industry to process canarium nuts. The major changes observed as a result of research include:

- *Prolonging the shelf life of the nuts*: The nuts were usually sold and consumed freshly which had as shelf life of up to 72 h prior to this project. the project undertook the experiments to find the best ways to dry or roast the nuts to prolong the shelf life of the nuts. The nuts now can have the shelf life of up to 12 months under ambient conditions at 24°C when they have been processed and packed properly. The properly drying or roasting of nuts are now practiced in the private sectors including DMS and BISI.
- *Revealed the proper storage conditions:* Traditionally, nuts are stored in freezers and project showed that the freezer storage needs to be avoided because it led to decreased nut shelf life.

- *Consumed as snack*: The nuts are traditionally consumed raw or incorporated as an ingredient in cooking. We developed value added products (e.g. Kalami) which now has been used as snack. As a result of this consumer behaviour, the private sectors now have also developed their own value added galip nuts which did not exist prior to this project.

SMEs have built their capacity to process and market canarium nut products through interaction with the project team, demonstration days, factory tours and information packages. This has resulted in a growing canarium nut industry.

Change in equipment, buildings and infrastructure

This project has built a working model of a factory able to produce canarium products in sufficient quantities to test the market. Critical equipment for this was a hot water based depulping system, a solar assisted dryer capable of drying 4 tonnes of NIS each week, a mechanical cracker and production line. This pilot factory has attracted private investment with one nut processor undertaking a lease arrangement in 2018/2019 (Equanut) and another expressing interest in leasing the pilot factory in 2020.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Factory capacity

The factory has more than doubled production each year, since commencement in 2015 and established a supply chain into formal markets in Port Moresby and ENB. Equipment and methods for commercial production have been developed and refined by the project team. Major improvements include a 4 tonne drier, mechanical crackers, ovens and cool storage containers. As a result of our research on upscaling factory equipment, processing procedures and skill levels, production has rapidly increased from less than 1 tonne NIP when the project commenced in June 2015 to 207 tonnes NIP during the latest harvesting season (Table 10). **This has generated income of 310,500 kina to local farmers in the period May - December 2018.** Farmers were selling product directly to the factory and entrepreneurs were collecting NIP from farmers and selling to the factory (Figure 20).

Figure 20. a) daily offloading of NIP with sellers lined up at the factory and b) NIS stockpile waiting to be processed.

Table 10. Impact of factory on farmers in East New Britain during the project.

Year	Nut in pulp purchased (1-1.5 kina per kg)	No of farmers selling	Farm gate value
2014	Small volumes (<1000 kg) for research trials	N/A	N/A
2015	11 tonnes	243 smallholder farmers	10,669 kina
2016	25 tonnes	647 smallholder farmers	26,349 kina
2017	65 tonnes	Women selling direct, entrepreneurs collecting from farmers and selling to factory	65,000 kina at farm gate
2018	207 tonnes	Women selling direct, entrepreneurs collecting from farmers and selling to factory	310, 500 kina at factory gate

In 2019 there were **4 active processors with an estimated farm gate value of 300,000-400,000 kina.** One processor was operating from the factory in a public-private arrangement with NARI (Equanut) the other 3 were operating in addition to the factory.

Economic impact for female smallholders

Many women are making small regular sales to the factory (Figure 21). The impact stories that have emerged from women included:

- A widow with 7 children having additional income to support her family.
- A young mother of 3 sold about 155 kg NIP and was able to support her children financially which was a relief during a difficult time.
- A teenage girl of 15 was selling galip during the school holidays and using the money to pay for her new school uniforms.
- A young mother of 3 was selling galip to buy basics for the family and buy medication for her sick child.

Figure 21. Mother and child delivering galip nuts to the factory

Data was collected on a sample of galip suppliers in 2017 and again in 2018 to understand the demographic and geographic supply of the galip using the CommCare app.

The main findings were:

- The purchase at the factory gate was 79.2 % of the total purchase in 2017 and increased to 96.7 % in 2018 (Table 11).
- Over 85 % of galip was sourced from wild trees in 2018 (Table 11).
- Most of the nuts originated from Gazelle district in both 2017 and 2018 (Figure 22).
- The majority of galip suppliers were male (Table 12, Figure 23).
- The average income per sale was between 60-90 kina (Figure 24).
- 78 % (2018) and 45 % (2017) of the suppliers had between 3 and 7 children in their family (Figure 25).

The data gathered at the point of sale for smallholder farmers suggested that more women were selling to the factory when the purchases were made at the farm gate rather than when the purchase were made at the factory door. This could indicate that women are facing more difficulties in transporting their product to the factory and/or that men are taking control of the galip monies now that it is moving beyond the informal economy. Whilst there is still some conjecture around the gendered division of labour in PNG, rural smallholder families (Mikhailovich et al. 2016), there is an understanding that it is traditionally men whom work on the commodity crops like cocoa and copra, whilst women are predominantly involved in the informal markets such as kumul and betel nut (Cahn & Liu 2008, Sharp et al. 2015). Before the development of the galip industry and large scale purchasing by multiple downstream processors, the industry was the domain of women and children who were responsible for the collection, cracking and trading of the nuts. This raises further research opportunities around women's involvement in the industry as it further develops and a challenge to industry to create best practice purchasing systems that can most benefit the work of women and children rather than commoditise, and remove, what is an important part of their informal economy.

Table 11. Statistics of the purchase data in both 2018 and 2017

	2017	2018
First sellers (number)	163	422
Repeat sellers (number)	400	926
Total number of sales	563	1348
Total purchased galip (kg)	34, 256	76, 786
Purchase location		
Factory gate (%)	79.2	96.7
On-site (%)	20.8	3.3
Type of tree		
Elite (%)	30.7	13.5
Wild (%)	69.3	86.5

Table 12. First suppliers gender ratio in 2018 and 2017, the gender of repeat sellers was not recorded

Female (%)	30.7	24.4
Male (%)	69.3	75.6

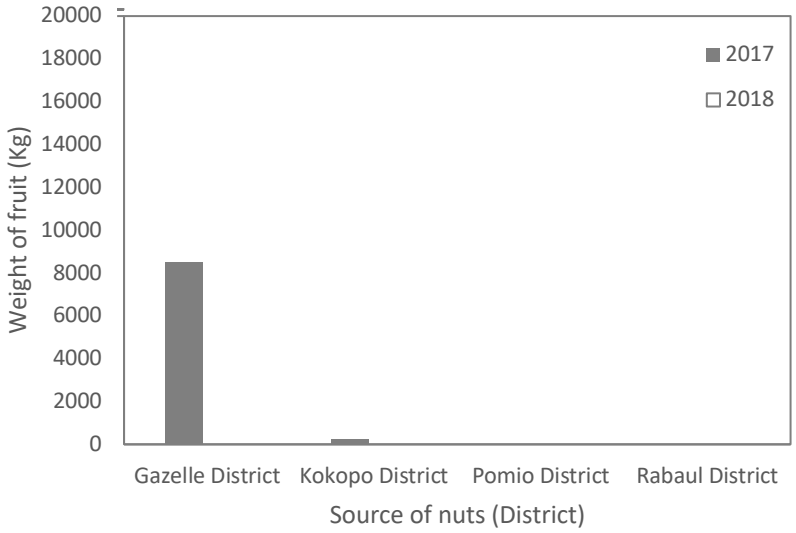

Figure 22. Total galip nut in pulp sales sourced by first suppliers from various districts in 2017 and 2018

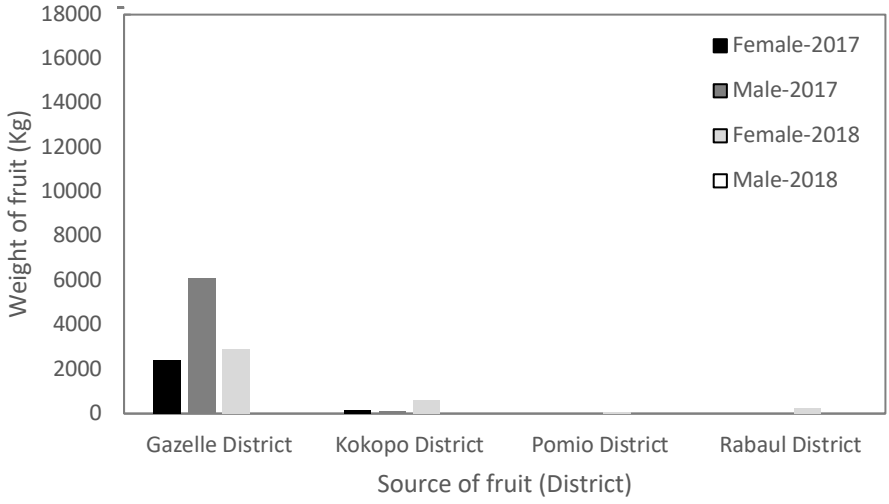

Figure 23. Galip fruit weight (kg) sold by first suppliers to factory based on gender at each district

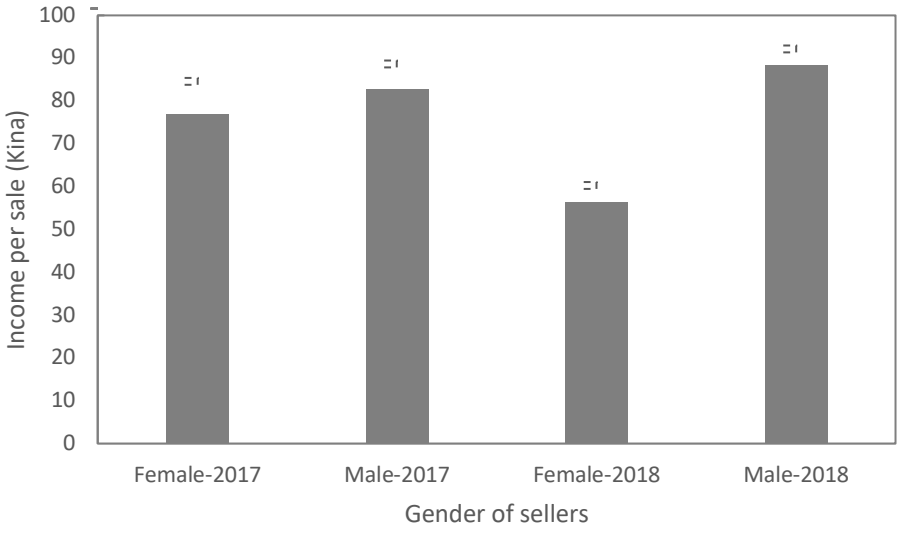

Figure 24. The Average income per sale (calculated based on 1.50 kina/Kg)

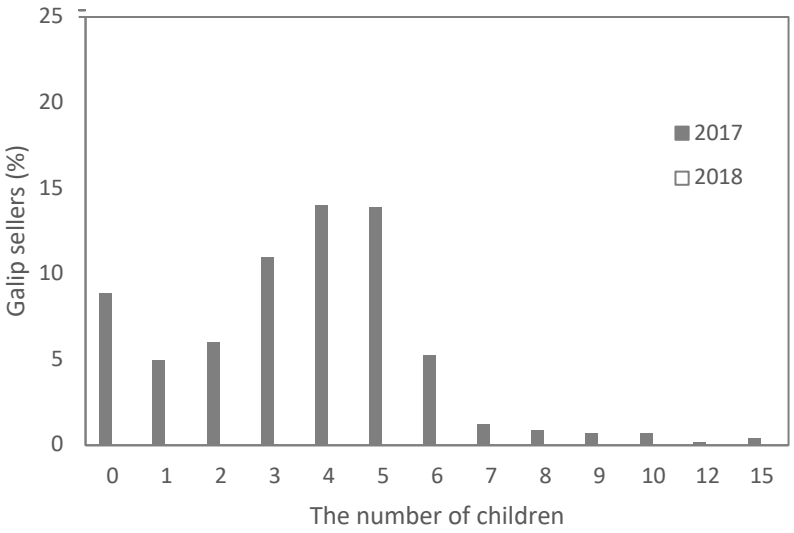

Figure 25. Household size for suppliers of Galip in 2017 and 2018

The emerging private sector canarium industry in PNG

Four private sector processors have started operating in PNG, along with the ACIAR and NARI pilot factory. These processors are sourcing their own nuts and establishing their own markets (Figure 26). All these operators have been in contact with the project team and have received technical support and advice from the project. The processors are:

- Divine Management Services (Dorothy Luana) is processing in ENB and has several outlets through Port Moresby, they have a strong network of farmers engaged in capacity building opportunities including nurseries and value adding training (the Galip Club).
- BISI Trading is a large wholesale/retail business operating out of Kavieng in New Ireland and has included canarium on their list of agricultural pursuits,

purchasing and processing themselves to be marketed in their retail outlets initially.

- Niugini Organics is a successful virgin coconut oil producer and exporter has also begun processing canarium with their signature glass jars.
- Equanut is a new PNG company focused on an export market. This company leased the pilot factory on a share arrangement during 2019.

Figure 26. Galip nut products produced by DMS, Nuigini Organics and BISI Trading for sale in retail outlets.

8.3.2 Economic impact in 5 years

Currently the emerging canarium nut industry is a cottage industry servicing domestic market demand. Sales of nut products have been strong, with supply unable to meet demand, product out of stock for long periods and consistent repeat demand. There is unmet capacity in the domestic market for nut products, along with other product such as canarium oils, gluten free flour, chocolate spreads. In the long term we anticipate this sector will grow, along with export opportunities in nuts as a snack food and value-added products such as nut milks. Several processors have already been experimenting with this market.

Other donors e.g. IFAD have investing in growing the canarium industry with funding expected to support the growing private sector. We anticipate a strong domestic industry in 5 years and an emerging export market. We have overseen more than doubling production during the life of this project. Assuming a conservative production increased from approx. 10 tonnes to 50 tonnes of kernel in 5 years farmers will receive an additional 750,000- 1 million kina per year, with overall value of 5 million kina per year in processed kernel value (Table 13). It is not possible to estimate the additional value of broken nut products and oil as these

have not yet been developed.

Table 13. Short –medium term galip nut processing projections

Year of operation	2020 NARI factory Buying nut-in-pulp at 1.5 kina kg)	2020 Other processors (buying kernel at 15-20 kina/kg)	2026 Commercial processors
Volume of kernel produced (nut in pulp)	2.5 tonnes (50 tonnes NIP)	10 tonnes (200 tonnes NIP)	50 tonnes (1000 tonnes NIP)
Farm gate value	75,000 kina	150,000 - 200,000 kina	750,000 - 1,000,000 kina
Processed kernel value (assuming 100 kina kg wholesale)	240,000 kina	1,000,000 kina	5,000,000 kina

8.3.3 Social impacts

Impacts of increased income

The new canarium industry has given over 1000 smallholders access to distant markets for their existing canarium nut resources. This has given them new sources of income. The majority of evidence collected suggests that the development of the galip industry is providing positive social impacts for smallholders in the ENB province with new income and opportunity. There are reports of family gathering activities, where what was traditionally women's work is now being undertaken by the whole family. Collecting nuts from under trees has allowed smallholders, without the available labour to process copra or maintain cocoa, to produce an income from their land. This has been evidenced with widows and grandmothers catching the bus to the factory with bags that they have collected with younger children. Farmers will often suggest that the monies that they are receiving will be spent on customary obligations that occur towards the end of the year and has meant that they can purchase goods that they would have been unable to obtain. Others suggest that they will save the money for the upcoming school and university tuition fees. It is through this input of funding that would not otherwise be available that social impact is evident – through the ability to participate further in the activities that require funding and alleviating the stresses associated with lack of money.

This same input of cash into the economy has also been seen to have some less desirable impacts socially. There have been some reports from communities that have said that the easy nature of the money has also translated as easy spending; rather than seeing this money as an input to the farmers' livelihood it is instead being easily spent on alcohol under 'the easy come, easy go mentality'. This has been addressed within communities and with the training that has been delivered by the Galip Club and through interactions at the NARI pilot factory. Another interesting social aspect of the money being earnt in communities has been the involvement of the church, who often require tithes to be paid to the church when money is earnt. Rather than split the cash they have earnt; farmers will often provide the local church with a percentage of their crop. This has seen several local ministers becoming the largest sellers to the pilot factory. There are some other examples of large sellers to the factory who have begun their own microenterprises, purchasing from many farmers at a lower price and then transporting to the NARI pilot factory for a better price. These

entrepreneurs have already displayed interest in further processing and will be among the first to trial a nut in shell model when it is ready. It is anticipated that, although these are economic impacts that accrue to individuals, there will be opportunity for others to be involved and continue to provide social impacts of fulfilling customary obligations, sending children to school and university, alleviating stress due to lack of cash and participation in other social activities.

As a traditional boundary crop that has been used for many generations as a form of property fencing, it has become evident that there are some issues of neighbours claiming the bounty of the crop and have sold this to the factory. With the new awareness of the industry in the area there could well be more issues arising around this which is another area for future research.

Increased employment opportunities for working age men, women and youth

The pilot factory has employed many local people in roles such as purchasing, cracking and processing. Three young women from the area (Figure 27), one of whom is a graduate of the 2016 Youth Work Experience Program, were recently employed in 2019. Helen Ronnie worked with the project as a participant and displayed a real ability to assist in the factory. She has since made several applications seeking employment and was successful in gaining a position assisting Dalsie Hannett with data entry and the processing of galip nut (Figure 28). Helen is a young single mother with 2 children who grew up in the area and is passionate about working for the project who now has a permanent position along with housing at NARI Kerevat.

The NARI pilot canarium factory a staff of around 10 people whom are actively engaged with factory operations. The Equanut venture has a staff of 12, including a dedicated extension officer. The DMS group has several assistants whom live on their galip block, they employ casual staff to meet demands during the purchasing season. This often varies around 6 staff mainly working in the processing and storage areas. They also have enlisted a field extension officer whom facilitated the groups purchasing days. The Niugini Organics group has been able to utilise many of their existing staff, otherwise dedicated to downstream processing of coconut products, to handle the processing of the galip nuts. They have a dedicated team of three working on drying and packaging during the season and also have diversified the role of their existing extension officer whim now works with both coconuts and galip. Similarly, the Bisi group has been able to utilise existing staff from their bakery and retail operations to assist with the processing of the nuts. They have suggested that during the busy periods that they have been using up to 5 staff to deal with the labour-intensive process of removing testa and adding flavours and packaging. Conservative estimates in this early period in the industry's development could suggest that there are 40 new positions available in ENB and New Ireland that previously did not exist before the project began.

Figure 27. Employment of 3 young women at the factory

Figure 28. Helen Ronnie a graduate of the NARI Kerevat youth work experience program, is now working fulltime with the factory and has proven to be a valuable member.

As the industry grows in the next 5 years there are likely to be increased employment opportunities within processing distribution and marketing.

8.3.4 Environmental impacts

We anticipate that the increased market opportunities for galip and research on the galip cocoa cropping system for galip will stimulate more investment in planting galip, resulting in more carbon sequestered and greater resilience of the cocoa cropping systems.

A possible negative environmental impact of the project is waste from factory de-pulping as the current process requires large volumes of water and produces a slurry of fruit pulp. Future activities on this and related projects include looking at methods of on-farm de-pulping and composting of the fruit pulp to turn the waste into an opportunity, along with more efficient methods of large-scale de-pulping.

8.4 Communication and dissemination activities

Key communication activities that disseminated project results and are likely to achieve impacts are as follows:

Product launches in East New Britain and Port Moresby

The first product launch was successfully undertaken in May 4th, 2018 in ENB (Figure 29 – 31). The product launch was attended by 50 participants, including the Hon Governor Nakikus Konga and senior government Ministers and received excellent media coverage (See below). This was a significant and proud event for NARI and local community groups and residents. It signalled a major step in commencing the testing/commercialisation of the galip industry in PNG. The NARI team and all the other stakeholders and funders were suitably praised for their dedication to get us this far and the challenge was set to use this major accomplishment as a stepping stone for the next phase of research and development to come.

Figure 29. Galip products presented at the launch in East New Britain

Figure 30. Galip team in the launch at the galip experience station in Port Moresby

Over 80 guests attended the official product launch held at the Stanley Hotel in Port Moresby in July 2018. Professor Helen Wallace was the MC and launch began with the PNG National anthem and prayers, followed by short speeches from Mr. Bruce Davis (Australian High Commissioner), Professor Chalapan Kaluwin (NARI Council Chairman), the honourable Jelta Wong, Minister of Police and member for Gazelle, the honourable Benny Allan Minister for Agriculture and Livestock, Mr. Mahesh Patel (Managing Director CPL), and Tony Bartlett (ACIAR). The launch also included Tolai welcome dance and singing program, and galip experience stations where the attendees could experience galip hand cracking and taste the products. The attendees also enjoyed 11 different galip incorporated canapés in the launch.

Figure 31. Dorothy Luana from Galip Club had a chance to showcase her galip product at the launch.

New Ireland Workshop: A workshop on value adding was delivered on the 16th January 2019 in New Ireland by the project team including: Shahla Hosseini-Bai, Emma Kill, and Brett Hodges (University of the Sunshine Coast) and Lucy Siki Aiyia. Dr. Shahla Hosseini-Bai and Dr. Brett Hodges met with Douglas Tsang and Rob from Bisi Trading Ltd who are one of the emerging businesses involved in galip value adding and selling in formal markets.

World Agroforestry Conference May 2019: Dorothy Luana, Prof. Helen Wallace and Dr. Shahla Hosseini-Bai presented at the Montpellier World Agroforestry Congress on the 22nd May 2019 and at the ACIAR pre-conference meeting on the 19th May. Galip entrepreneur (DMS) and one of the galip projects private partners – Dorothy Luana, had her products displayed at an ACIAR demonstration stall at the conference to showcase galip project and Dorothy's product success. Helen was one of the keynote speakers and presented a talk titled 'Transdisciplinary approaches to commercialising indigenous agroforestry trees: Galip nuts (*Canarium indicum)* in the Pacific'. Shahla presented a conference paper titled 'Root studies in agroforestry systems – a case study of coffee and cocoa trees.

8.4.1 Website development

A website has been developed in Australia by University of Adelaide to market and promote the new range to consumers.

The site aims to inform consumers about galip's nutritional and community benefits of the project. Find link to the website here: https://www.galipnuts.net/

8.4.2 Media coverage

- **December 2017 -** http://www.emtv.com.pg/galip-nut-a-global-opportunity-for-papua-new-guinea-agriculture/
- **May 2018 – *Newly established galip nut company launch product*,** EMTV Online https://www.youtube.com/watch?v=SzaiKwNqjXE
- **May 2018 – *ACIAR,*** Congratulations to 'The Galip Nut Company' after launching their first #galip nut products through a project we funded with @dfat https://twitter.com/ACIARAustralia/status/992260640382201858
- **May 2018 – *Development of galip nut to commercial product hailed,*** article by Elizabeth Vuvu https://www.thenational.com.pg/development-galip-nut-commercial-product-hailed/
- **May 2018 - *First commercial galip nuts get on the shelves*,** article by Elizabeth Vuvu https://www.thenational.com.pg/first-commercial-galip-nuts-get-shelves/
- **July 27 2018 – *EMTV Online broadcast the official launch*** https://m.youtube.com/watch?feature=youtu.be&v=M11D3mDOvXw
- **July 30 2018 - *Allan backs potential of galip,*** article by Matthew Vari https://postcourier.com.pg/allan-backs-potential-galip/
- **July 31 2018 - *Galip nut to be exported*** https://postcourier.com.pg/galip-nut-exported/
- **August 7 2018 -** https://www.aciar.gov.au/publications-and-resources/news/PNGs-galip-nut-commercialised
- **August 13 2018 - *Partners in Research for Development Magazine Issue 2*,**
- https://reachout.aciar.gov.au/canarium-nuts-empower-women-farmers-to-build-commercial-businesses
- **January 28 2020 - *Galip company inundated with orders, says Simos,*** article by Matthew Vari *https://postcourier.com.pg/galip-company-inundated-with-orders-says-simos/*

8.4.3 Scientific research outputs

Conference presentations

1. October 2017 (Horticulture Conference, Spain): Two talks delivered by Kim Jones
    - Freezing, roasting and salt dipping impacts on peroxide value, free fatty acid and fatty acid composition of nut kernels.
    - Construction and operation of an energy efficient, solar assisted, drying system for canarium nuts.
2. April 2018 (International Agroforestry Conference, Nepal): Four talks delivered by Helen Wallace and Shahla Hosseini Bai
    - Creating new commercial nut industries from agroforestry trees to benefit smallholders
    - Market driven approaches to improve livelihoods with Agroforestry.
    - Root abundance using metabarcoding and nitrogen cycling in cacao and coffee plantations
    - Biochar and nutrient improvement
3. UNRE World Food Day: Brett Hodges delivered a seminar on the development of the Galip industry in Papua New Guinea at the PNG
4. May 2019: Prof Helen Wallace and Dr. Shahla Hosseini-Bai presented at the World Agroforestry conference, in Montpellier, France:
    - Transdisciplinary approaches to commercialising indigenous agroforestry trees: *Canarium indicum* in the Pacific – (Keynote address by Prof Wallace)
    - Root studies in agroforestry systems – a case study of coffee and cocoa trees as an oral presentation by Dr Hosseini-Bai.
    - Nutritional quality of canarium nuts and cocoa beans in an agroforestry system in Pacific as a poster by Dr Hosseini-Bai.

Publications

Published

1. Hosseini-Bai, S., Trueman, S.J., Nevenimo, T., Hannett, G., Randall, B. and Wallace, H.M., 2019. The effects of tree spacing regime and tree species composition on mineral nutrient composition of cocoa beans and canarium nuts in 8-year-old cocoa plantations. *Environmental Science and Pollution Research*, pp.1-9.
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Currently under review

1. Hosseini-Bai, S., Tahmasbian, I., Zhou, J., Nevenimo, T., Hannett, G., Poienou, M., Wallace, H.M., A non-destructive determination of nut quality using hyperspectral imaging. – Under review.
2. Hosseini Bai, S., Nevenimo, T., Hannett, G., Hannett, D., Jones, K., Trueman, S.J., Grant, E.L., Walton, D.A., Randall, B., Wallace, H.M., Freezing, roasting and salt dipping impacts on peroxide value, free fatty acid and fatty acid composition of nut kernels – Under review.
3. Jones, K., Nevenimo, T., Hodges, B., Hosseini Bai, S., Hannett, G., Hannett, D., Grant, E., Randall, B., Wallace, H.M., Construction and operation of an energy efficient, solar assisted, drying system for canarium nuts – Under review.

Drafted – with co-authors for their comments

1. Autoxidation of blanched and whole kernels in almond and canarium.
2. Effects of postharvest storage temperature, roasting, and roasted/salted on oxidation stability of canarium and macadamia.
3. A short study investigating storage stability and auto-oxidation of *Canarium indicum* kernels.
4. The effects of tree spacing regimes and tree species compositions on mineral nutrient composition of cocoa beans and canarium nuts in three eight-year-old cocoa plantations.
5. Root abundance using metabarcoding and nitrogen cycling in cacao and coffee plantations.

9 Conclusions and recommendations

9.1 Conclusions

This project has demonstrated the potential of an industry based on canarium nut processing to improve livelihoods of smallholders in ENB. There was strong consumer demand for processed canarium products in formal retail markets in ENB and Port Moresby. There was also a willingness to participate by smallholders, microenterprises, entrepreneurs and SMEs once they had confidence that there was strong market demand for canarium products. There is great potential for the emerging galip industry to scale out to other areas and to create a sustainable export industry for the whole of PNG and the Autonomous Region of Bougainville.

The transdisciplinary approach taken by the project team was a strength of the project and enabled the team to adapt to constantly changing environment and new challenges. In particular, the strong focus on markets and consumers with close engagement and collaboration with private sector stakeholders delivered demonstrable economic benefits to producers and smallholders. The scientific approach enabled many breakthroughs in processing methods and equipment and the social research produced strong outreach and impact by engaging and partnering with smallholders and SMEs.

9.2 Recommendations

The emerging canarium industry is at a critical phase and needs to harness the momentum built by the current and previous research. Further investment is needed to build confidence of the private sector to invest to grow the industry, utilise the nut resources coming on stream and improve access to distant markets.

Some critical emerging issues that require further research are:

1) *What are the most efficient and food safe buying models?* Private sector processors are currently buying canarium nuts cracked by smallholders in the village and post-processed in their factory. This is very efficient in terms of reducing transport costs, costs of processing and waste material. However, this creates a range of food safety risks and potential product quality issues. The NIP buying model used by the NARI demonstration factory produces very high quality, food-safe products, but results in high transport costs. The NIP buying model is also very inefficient as more than 95 % of what is purchased is waste product. Pulp is a waste product and adds substantially to the costs of the final product. A more efficient and food-safe system would be to buy NIS, and this allows both farmers and small-scale entrepreneurs to financially benefit from early stage processing. However, methods that maintain product quality when nuts are processed on-farm need to be developed. Food safety of the kernel buying model also needs to be improved with targeted training and research on how to minimise risks.

2) *What is the potential supply of supply canarium?* The pilot canarium factory has only purchased raw materials from a very small area close to the factory in ENB. Canarium is common in lowland areas throughout the region e.g., Bougainville, New Ireland, Sepik and Madang. Nut-in-shell production is estimated to reach 40,000 tonnes by 2021 and 60,000 tonnes by 2035 based on canarium plants distributed in ENB alone from donor projects. However, tree survival and nut production from these trees needs to be confirmed. Furthermore, there is little information on the size of the resource base in other areas of PNG.

3) *How best to increase the supply of nuts?* Getting supply of large volumes of nuts to the factory is difficult, due to decentralised production of small volumes by smallholders, lack of existing collection systems and inefficient harvest systems. On farm tree management, harvesting systems and collection systems need to be improved.

4) *What are the gender dimensions and implications for women of the emerging industry?* This project has had a strong emphasis on improving the livelihoods of female smallholders and entrepreneurs. However, there is evidence that men are increasingly participating in the industry as it becomes more financially rewarding to sell canarium products. Canarium nut processing was traditionally the domain of women and children who were responsible for the collection, cracking and trading of the nuts. This raises further research opportunities around women's involvement in the industry as it further develops, and a challenge to industry to create best practice purchasing systems that can most benefit the work of women and children rather than commoditise, and remove, what is an important part of their informal economy.

5) *How can processing be made more efficient and profitable?* Private sector players have started investing but they see the industry as still 'unproven'. They are keen to see nut supply issues resolved and more and larger-scale market testing and need better evidence that canarium can be processed cost-effectively on a larger scale. They need to understand revenue streams and profit potential and time for investment in processing to break even. Further research is needed to improve profitability and optimize the value chain covering topics such as handling, drying, cracking, sorting, flavouring, shelf life extension, packaging, quality testing, processing to oil, paste or other products. This needs to be conducted in collaboration with the industry e.g. via the newly formed industry reference group.

6) *How can the galip weevil be managed?* A new pest, the galip weevil, while indigenous to PNG has emerged as a serious pest of canarium and has caused substantial tree deaths in the Gazelle Peninsula, ENB. This seems to have been exacerbated by the 2015 drought, but it is unclear whether trees recovered and if the threat receded as the drought eased. Factors such as susceptibility of certain canarium genotypes and higher canarium density in the affected area are hypothesised as having a role in the weevil outbreak and continued presence.

Addressing these issues will support the emerging industry and produce substantial benefits to smallholders, SMEs and private sector investors in PNG.

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7. Hosseini-Bai, S., Tahmasbian, I., Zhou, J., Nevenimo, T., Hannett, G., Poienou, M., Wallace, H.M., A non-destructive determination of nut quality using hyperspectral imaging. – Under review.

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11 Objective 1 Appendices

11.1 Report on enhancing private sector-led development of the Canarium Industry in PNG

Contributed by Emma Kill, Brett Hodges and Dr. Jennifer Carter

Introduction

This report combines work from objectives within the social sciences component of the above project primarily around two of its objectives. Those objectives are

Objective 1.4: barriers to scaling up sale and processing of nuts, and

Objective 1.6: identify the priority research and extension needs of female smallholders, small-scale entrepreneurs, small-medium enterprises and large-scale processors.

Whilst the above objectives are the focus of this report, some of the activities overlap with other objectives in this project; and participants may also have been involved in documenting aspects of the research where other project team members were present.

Literature review

The canarium industry in the Pacific has seen ongoing investment in its development over decades, and there is growing focus on niche products (AusAid 2009). Limitations to economic upgrading in small island states are argued to be compounded by the lack of micro-enterprise clusters, joint action and regional arrangements to develop networks of supply chains during economic upgrading (Carter & Smith, 2016). In developing countries elsewhere, small-medium businesses have expanded their businesses, primarily due to state-sponsored extension and the provision of professional and support services at critical nodes in the supply chain (Gomes, 2006; Oddone & Padilla 2014); often supported at least in part by the public sector due to the expense of private services.

Social upgrading is highly recommended to accompany economic upgrading (Milberg & Winkler 2011); and one of the key strategies within social upgrading is that of gender equity, not just gender equality (Alvarez-Castillo & Feinholz 2006). A key step is the scale at which decision-making occurs in order to facilitate community development (Peskett et al., 2008).

The trend towards engagement in public private partnerships for the provision of developmental aid is clearly documented (Ion et al. 2014; Callan & Davies 2013; Rowe et al. 2013). OECD member's spending through public-private partnerships has dramatically increased in the last few years and spending '*has risen from US$234m in 2007 to US$903m in 2010*' (Thorpe & Maestre 2015, p.8). Hayward-Jones (2008) suggests this is particularly so within Pacific Island countries where previous public sector and governance guided development assistance has not met expectations and public-private alliances need to generate better outcomes.

It is difficult to identify a clear and consistent set of guidelines around their implementation, design and potential and there is lack of research particular to PPP's that work with an existing indigenous product developing post-harvest processing and domestic and export markets from within a Melanesian context. There are risks to engaging private sector investment in the agricultural sector, with Ion et al. (2014) suggesting this a perception of high risk in agriculture due to weather, market fluctuations, and complexity in supply chains compounded by the low financial literacy, land tenure and poor-postharvest linkages between fragmented farmers. They further suggest clarity is needed around whether these partnerships are better targeted towards groups who are 'almost market ready' rather than the 'poorest of the poor', which requires resources to support a select few rather than broad ranging, extensive capacity building and extension needs. Another potential concern is the hidden costs associated with the implementation of a PPP arrangement where the time and labour-intensive nature of sourcing a partner, managing the relationship, and the continual monitoring and maintenance of the partnership. Further, there is a repeated call for these actions to be handled through a broker

style arrangement where an intermediary can provide an understanding of the needs of each sector (Callan & Davies 2013). There is little literature about the roles that these independent facilitators would engage in, though the initial feasibility of partners, the introduction of partners, the maintenance of relationships, assisting partners in adapting to change, and aid in the delivery of capacity building amongst producers are likely to be critical (Thorpe & Maestre 2015).

This report investigates several objectives to determine barriers to small-medium enterprises developing their commercial activity of the niche galip nut. It specifically targets female smallholders and female entrepreneurs of small-medium scale business. Intended outcomes are options for women in collecting and distributing nuts to processing plants, and meeting other needs of female smallholders, small scale entrepreneurs and small- to-medium enterprises to participate in the canarium industry.

Research design

A participatory action research methodology guides the research design. In this methodology, initial objectives are set and are iteratively reflected on in a structured approach to refine further progress in the research.

Year 1

A needs assessment was undertaken to identify initial needs on which the first year of engagement activity could be undertaken. A range of activities were then planned during which interviews and observations could occur.

Forty-seven semi-structured interviews were then undertaken in year 1, combined with non-participant observation in the factory, training, community and markets. A series of seven focus sessions were also held with smallholders, small-scale entrepreneurs and the Women and Youth in Agriculture (WYIA) network around their vision, expectations and concerns. At the end of year 1, data were organised into initial themes.

A draft review of literature about private-public partnerships was prepared and fourteen unstructured interviews with industry and government staff conducted about public-private partnerships. Informal interviews were also undertaken with 8 representatives of SMEs, 3 food processors and 3 development companies.

Year 2

In year 2 ethnographic field work was undertaken between July-December 2016, where a range of local situations were canvassed including interactions with local people at markets, training days, events, and generally living in Kokopo. Further discussions on public-private partnerships and interventions were conducted with 42 people from a diverse range of backgrounds within the community, including business operators, agricultural processors, potential investors and government representatives. Field notes were documented and iterative critical reflection through several discussions between team members helped to develop key themes.

Year 3

Final thematic analysis has revealed preliminary findings that the galip industry is providing positive social impacts for smallholders in the East New Britain province with new income and opportunity. There are reports of family gathering activities, where what was traditionally women's work is now being undertaken by the whole family. Collecting nuts from under trees has allowed smallholders, without the available labour to process copra or maintain cocoa, to produce an income from their land. This has been evidenced with widows and grandmothers catching the bus to the factory with bags that they have collected with younger children. Farmers will often suggest that the monies that they are receiving will be spent on customary obligations that occur towards the end of the year and has meant that they can purchase goods that they would have been unable to obtain. Others suggest that they will save the money for the upcoming school and university tuition fees. It is through this input of funding that would not otherwise be available that social impact is evident – through the ability to participate further in the activities that require funding and alleviating the stresses associated with lack of money.

This same input of cash into the economy has also been seen to have some less desirable impacts socially. There have been some reports from communities that have said that the easy nature of the money has also translated as easy spending; rather than seeing this money as an input to the farmers' livelihood it is instead being easily spent on alcohol under 'the easy come, easy go mentality'. This has been addressed within communities and with the training that has been delivered by the Galip Club and through interactions at the NARI pilot factory. Another interesting social aspect of the money being earnt in communities has been the involvement of the church, who often require tithes to be paid to the church when money is earnt. Rather than split the cash they have earnt; farmers will often provide the local church with a percentage of their crop. This has seen several local ministers becoming the largest sellers to the pilot factory. There are some other examples of large sellers to the factory who have begun their own microenterprises, purchasing from many farmers at a lower price and then transporting to the NARI pilot factory for a better price. These entrepreneurs have already displayed interest in further processing and will be among the first to trial a nut in shell model when it is ready. It is anticipated that, although these are economic impacts that accrue to individuals, there will be opportunity for others to be involved and continue to provide social impacts of fulfilling customary obligations, sending children to school and university, alleviating stress due to lack of cash and participation in other social activities.

As a traditional boundary crop that has been used for many generations as a form of property fencing, it has become evident that there are some issues of neighbours claiming the bounty of the crop and have sold this to the factory. With the new awareness of the industry in the area there could well be more issues arising around this which is another area for future research.

Year 1 results

Needs assessment

The initial needs assessment in year 1 showed that WYIA desired co-operative capacity building and governance training, while smallholders and small-scale entrepreneurs required training around solar-driers including possible construction with alternative materials, and value-adding opportunities. Vocational and entrepreneurship skills for young people was seen as desirable as a pathway to post-education employment.

Barriers

Agricultural Production Challenges: Many local residents suggested they currently experience a limited availability of galip and that the changing fruiting season may have been due to drought and global warming. There were some reports of a native bug that had decimated some stands of Canarium trees, which local participants again attributed to the drought, suggesting the trees were more vulnerable (although the trees were starting to reshoot). The canarium industry needs to build market support in order for participants to believe it will survive its environmental challenges. Smallholders have strong memories of the decimation of the cocoa industry with the cocoa pod-borer and are anxious of the impact this type of challenge can present, which could see them chose to plant a more tested cropping option.

Different cropping options and information: A multitude of agricultural development projects and initiatives over decades in the region, looking to promote diversity in cash crops. Smallholders discussed their experiences with a few of these agricultural options which included coffee, tea, nutmeg, vanilla, cardamom, balsa, palm oil, canarium and teak, as well as cocoa (the mainstay crop for the smallholder despite large price fluctuations until the cocoa pod borer was introduced). Cocoa had traditionally required very little maintenance but now required considerable time in cleaning up leaf litter and spraying for the borer. Canarium is promoted as an intercropping species that complements cocoa production by providing a shade with little maintenance, but other agencies were promoting other intercropping options and there were reports that canarium was underperforming. This leads to some confusion for smallholders as they express that they are unsure of what direction to take with so many options and misconceptions that come with so many different players offering their initiatives. Some free Canarium trees had not been planted because smallholders were aware of other free trees and didn't know which species to plant. At the scale of the smallholder there is a need for extension

that details each agricultural option to each smallholder, its expected returns (with fluctuations and impacts explained), and technical advice around how best to implement these options so smallholders can make the best decision.

Knowledge amongst farmers of nut supply chains: The insufficient knowledge of supply chains amongst smallholders and the factory's potential to process are currently impeding upscaling. Several announcements were made in local markets and a word of mouth campaign spreading awareness that NARI was buying nuts. Currently the supply of nuts is co-ordinated by NARI staff utilising phones and radio to contact an area to spread the word that they will be buying nuts. This approach is important in the first instance until capacity to process is set in place.

The capacity of the public institution to meet project and market requirements: The remote location of the public institution means that supplied such as spare parts and equipment (e.g. ovens for the factory, packaging materials) may delay operations. Papua New Guinea is currently experiencing the downturn in commodities and energy markets, particularly given its reliance on these as revenue, which has impacted upon all public institutions. This constrained fiscal climate means that even the project places expectations on staff that stretch their capacity, for example, to monitor, evaluate and report efficiencies with the processing chain. The factory has made progress in developing local domestic markets and a demand for product has assisted in industry sales generated from within the public organisation and may be a response to the pressures they face in the economic rationalisation of the public sector.

Research, training and extension needs

There was a need for solar drying to continue across the region to differing groups and for this to expand to cover a range of identified agricultural and value adding opportunities for improvement. Normally the diversity and fragmented nature of the East New Britain smallholder and small-scale entrepreneur populations would be overcome through co-operative and farmer groups, though there are several challenges that limit the effectiveness of this approach. Rather than utilising these structures alone as a means to engage with the target populations their needs will be addressed at three levels – the East New Britain Women and Youth in Agriculture (WIYIA) Co-operative, several family groups within smallholder communities, and the women whom regularly sell canarium nuts in the markets around Kokopo, Rabaul and Kerevat. Each of these groups has different priority needs around their vision and expectations for their families and livelihoods; the challenges that they currently face and those they see as potentially challenging; and sustainable solutions from their perspective. Each requires tailored training opportunities in conjunction with some generic extension needs that present challenges across these groups.

Although there has been training in budgeting and money management delivered by banks in the area, this is often seen as a customer building exercise for these institutions. Despite the wealth of extension training opportunities from other development projects, women from the co-operative and smallholders, all identified areas that had not been addressed in their experiences, including drug/ alcohol awareness and domestic violence. The overwhelming need identified from both smallholders and WIYIA members was for opportunities for the younger generation. WIYIA require a range of training opportunities to further their capacity to engage in market activity. The co-operative is faced with economic viability and the leadership structure is in a transition period with a new president coming in the next few months as the sitting president finishes her maximum term. Training in organizational/working cooperatives, governance and general entrepreneurship/ business skills is required, and should be conducted with all members rather than creating imbalances within the existing structure. This type of training equally positions WIYIA for future opportunities outside of Canarium. Members also identified a need for the younger generation to have a future, specifically through a program of engagement with young people building their capacity to engage in opportunities and develop their own livelihoods with the resources available to them, and to enable the poorest of the poor groups to access employment or opportunity through, for example, English and numeracy training. Many of the young people from this group have limited schooling, due to limited income for school fees, and hence limited English, which is seen as a prerequisite for many paid positions in the region. The programming could incorporate an entrepreneurship skills development component that would provide participants with the knowledge of small business and achievable money-making

ventures where they could build a sustainable business from resources they have available to them. Further investigation is required to see how much of this training is already available in the area to ensure there is no duplication of services, feasibility of running such a program, the logistical considerations and the linkages that could be established within the private sector in the region.

Smallholders who attended the first solar drying workshop indicated that they would like further training in solar drier construction and operation. Feedback from participants identified that the cost outlay was prohibitive to most smallholders and co-operatives at 500 kina per drier, although there was a consensus about the potential that this could have in prolonging the shelf life of not only canarium. Some participants suggested they could source the material and work from a plan to build a cheaper version and suggested that any further training could be around construction but a range of other seasonal crops. There were some concerns raised around the travel required to access the drier in situ at Kerevat and their reluctance to leave food unattended during the drying process. It was also noted that the first workshop was focused on women and several men of their district expressed interest in attending future training. Some initial training with smallholders on hygiene and value-adding with baked goods (incorporating galip) was undertaken.

Public-private partnership

Preliminary findings in the public-private partnerships literature revealed the similarities of the allanblackia nut industry to the fledgling canarium industry. The allanblackia is a tree in Ghana, growing to 30m high, producing nuts that can be harvested for their oil. Similar to canarium, this species has not benefited from the mainstream domestication of its nutritional and economic attributes (Assah et al. 2011). Similar to the East New Britain region, the predominant cropping option is cocoa, with the crop bringing in 40% of Ghana's foreign exchange earnings and involving an estimated 800,000 farmer families (Essegbey et al. 2013). Since 2002 the World Conservation Union (IUCN), the Netherland Development Organization (SNV), the World Agroforestry Centre (ICRAF), a research institution (Forestry Research Institute of Ghana - FORIG), local/ national government institutions and a range of other NGOs worked with Unilever as a private partner. Unilever initiated a new private enterprise 'Novel Development Ghana' to purchase and process allanblackia seeds from small holders and process and deliver the resultant oil to Unilever for use in food production (Ofori et al. 2013). This initiative was to provide a ready market for farmers, smallholders and collectors to supply nuts. Farmers were to be the direct beneficiaries with this development of a marketable product that provided diversity in their cropping options. Unilever also benefitted from the ability to incorporate a sustainable vegetable oil into their products. The buying group operates across three countries Ghana, Nigeria and Tanzania purchasing the unprocessed nut, which in 2010 is still predominately sourced from existing 'wild stands' and smallholder plots, rather than plantation plantings. The Novel Development group actively disseminated information around the value of the allanblackia nut; how it can be collected; and where it can be sold through radio broadcasts, public lectures, posters and video presentations. Unilever estimates that there is a potential global market of over 100,000 tonnes annually, though is still challenged to purchase the 240 tonnes of oil they require as a minimum to sustain the industry (Ofori et al. 2013). This has seen a development of the project to see its focus move from the value chain provision to a domestication and distribution of genetically superior stocks for farmers and smallholders, to improve the availability and consistent supply of product for the industry. This project model demonstrates the ability for public private partnerships to address a non-existing value chain for an indigenous product in a developing country, though this involved a multinational partner whom could be seen as a driver from the earliest stages of the project's establishment. This potential partner has not yet been identified or presented to the canarium project, and hence will not benefit from the early stages of direction and understanding that a partner whom was involved from the start would have. Another potential challenge that this model presents is that Novel Development Ghana was initiated to be a for-profit organisation, though it is yet to make a profit with the awareness levels of the project still relatively low and production volumes below expectations (Essegby et al. 2013).

Whilst the factors raised from within this sector could suggest that these challenges would prevent a partnership in the industry, the businesses that continue to run in this environment have factored these in and have adapted to this environment. One business was utilising the coconut husk by-product to fire the boilers required for the operation in oil and soap production. There are other larger operations that, whilst based in Port Moresby, operate facilities and have a strong connection with the region. These sized operations having displayed interest in product trials and initial marketing and could potentially be partners in the development of the industry and provide the local connections that the literature suggests are important. The region has several large corporations involved in the export of cocoa, coffee and copra from the region. These stakeholders are larger economic development drivers and are engaged with multiple co-operatives across the region, with established supply chains operating from central points. Some of them represent multinational interests, though the East New Britain Development Corporation Limited (ENBDC) is a business extension of the provincial government. The ENBDC represents a business arm (private sector) of the Provincial Government (public sector) and demonstrates the ability for public services in the region to diversify interests and develop sustainable operations in the private sector. The factory is beginning to operate as a commercial enterprise, generating sales that are used to subsidise running costs. The nursery is producing cocoa stock for sale generating income whilst balancing costs for production. These activities suggest that the public institution is operating within the private sector with the associated pressures and demands. This would also suggest that the existing partnership with ACIAR and NARI could be evolving into a PPP style arrangement without NARI having formalised a business arm. This would raise multiple areas for attention around project expectations, though as a private sector partner an extension business of NARI would also satisfy many other concerns, most importantly their involvement since the infancy of the project and the inherent understanding of its evolution to date.

Key initial findings were that multi-national and offshore partners need to be careful to not exacerbate poverty for some poorer sections of the community. NARI have commenced their role in the partnership through developing processes and markets, but neoliberalism is constraining their reach.

Year 2 Results

Barriers:

Ethnographic field work showed a range of barriers remain in year 2 around incomplete information until the market is ready, economic pressures and hygiene/food safety standards.

Incomplete information until market is ready: Women remain unsure of how to sell to the NARI factory, as there is an inconsistent approach to buying. Awareness can be increased through a widespread community information program promoted on radio, through local government structures and existing commercial supply chains that trade in cacao and copra; however, this can only be implemented once there is capacity of the pilot factory to cope with the demands of a community expecting payment for the crop they have harvested. The current situation of buying in a measured and controlled way may not promote local community awareness of the potential cropping option of Canarium, but should be continued until the factory is ready – rather than build expectations of community members and then let them down which echoes past agricultural innovation projects within the region.

Economic pressures: Economic pressures are faced by the majority of participants, many of whom consider the 70 kina investment in a mechanical cracker as exorbitant. They also raised concerns about the cost of transport for attending training opportunities when transport costs and the time that taken from their livelihood commitments (they could spend over half of a day just waiting for transport on occasions).

Hygiene/food safety standards: Women also identified that it is difficult to capitalise on the growing tourist market in the region, particularly with the cruise ships that are now regularly visiting the area. Tourists from these boats are often ferried around the area and through the markets in great numbers but are advised not to eat the local food nor bring product on board that will not clear customs. Women traditionally sold fresh galip in testa wrapped in a banana

leaf, but this does not provide the packaging or processing that is required for tourists to have the confidence to purchase as this traditionally practice sees nuts deteriorate after 1-2 days.

Training needs

Small-scale entrepreneurs: In terms of training, 25 small-scale entrepreneurs attended a NARI galip factory awareness and technology training day (held on 22/9/16). Specific training topics requested by participants were:

Participants who registered interest	**Topic**	**Details**
7 Participants	Solar Drier	Participate in a two day construction and operation of the solar drier
12 Participants	Mechanical Cracker	Register an interest in purchasing the locally made Guria cracker
15 Participants	Market Capacity	Improving processing, packaging, and labelling to improve market opportunities

Small scale entrepreneurs working in the local markets still require a better understanding of the marketing processes and local resourcing to implement improved processing, packaging and labelling in their marketing. This will negate some of their concerns about wastage due to unsold product and provide a longer shelf life and thus continuity of stock for continuous sale. With this improved labelling and marketing, local small-scale entrepreneurs can also reassure the cruise ship and tourist market that their product is compliant with food sale standards.

Female smallholders: Female smallholders continue to emphasise a need for opportunities for the younger generations and wish to capitalise on cropping options for their garden blocks, and new market opportunities. There is an overriding concern of female smallholders for their children and grandchildren, with the changing dynamics of village and social structures due to land shortage and overpopulation, and a lack of opportunity for employment.

Training implementation

Solar Drier: The solar drier was demonstrated to 37 female smallholders and small-scale entrepreneurs across two training events held on 27/10/16, 2/11/16 – 3/11/16 with the Tinanagalip and Vunamarita communities. The solar drier was transported to a remote community (Vunamarita) without access to power and demonstrated to local people through dehydrating local pineapples and mangoes (see table 1, 3.)

Crackers: The prohibitive cost of TJ Crackers were modified and made more cost- and time-effective; but were still too costly for smallholders. Local manufacturer Rabweld, a subsidiary of Agmark was assisted to produce an effective and affordable cracker. Several prototypes were iteratively developed and now a ‘Guria’ cracker will be stocked through Didiman stores across the region.

Several hundred people were exposed to demonstration of mechanical crackers developed by manning a stall at the World Environment Day (14th October 2016) at the PNG University of Natural Resources and Environment, Vudal. Participants experienced how to crack galip nuts with both the TJ and the Guria cracker. Applied demonstrations were also held at the NARI, Tinanagalip and Vunamarita training days held on 22/9/16, 27/10/16, 2/11/16 – 3/11/16 (see tables 1, 2, 3.)

Table 1. Tinanagalip smallholder co-operative training

Josein Co-operative Women smallholders Galip technologies and self-identified training needs day at Tinanagalip Community (27/10/16) delivered to 13 females and 1 male. This group is an established co-operative member of the Women and Youth in Agriculture, consisting of women from agricultural backgrounds who are actively growing a range of garden products for sale in local markets and family consumption.			
Training Component	**Venue**	**Facilitator**	**Main training activities**
Health and Hygeine	Tinanagalip meeting room	Simaima Kapi *NARI*	Health and hygiene training developed with cultural considerations and delivered in local language and context. Modified training to align closer with the needs for hygiene when working with products for resale which this group identified as a need.
Market Capacity	Tinanagalip meeting room	Brett Hodges *USC*	a presentation around technologies derived from the galip projects research, including packaging, labelling and presentation of galip products and market access. This included discussions around ways that participants already access markets and new ideas that they may wish to try.
Food Dehydration/ Preservation	Tinanagalip meeting room	Emma Kill *USC*	Oven and Electric Food Dehydrator demonstration and discussion of solar drying technology. Sampling of local fruits and vegetables that had been dried and were suitable for resale.
Food Preservation (self-identified need)	Tinanagalip outdoor cooking shed	Gloria Tenga, Katherine Warren *PNG UNRE*	Hands on demonstration and training for participants to make jams and cordials from their own fruit harvest
Mechanical Crackers	Tinanagalip meeting room	Brett Hodges *USC*	Demonstration of the imported TJ cracker and the locally developed Guria cracker with a supply of nut in shell for practical application.
Coconut Oil production (self-identified need)	Tinanagalip outdoor cooking shed	Godfrey Hannett *NARI*	Hands on demonstration of virgin coconut oil production using the fermentation technique providing further opportunity for market participation.

Table 2. Vunamarita remote smallholder community training

Vunamarita Co-operative Women smallholders galip technologies and self-identified training needs day at Vunamarita Community (2/11/16-3/11/16) delivered to 15 females and 26 males. This group is a recent co-operative member of the Women and Youth in Agriculture, consisting of women from agricultural backgrounds living in a remote community setting with limited access to local markets and services.			
Training Component	**Venue**	**Facilitator**	**Main training activities**
Health and Hygeine	Vunamarita temporary training facility	Simaima Kapi *NARI*	Health and hygiene training developed with cultural considerations and delivered in local language and context. Modified training to align closer with the needs for hygiene when working with products for storage in a remote setting.
Crop Rotation (self-identified need)	Vunamarita temporary training facility	Godfrey Hannett *NARI*	Presentation on crop rotation principles and strategies to better utilise garden blocks in a mixed species cropping environment. Provided seed stock for legumes to fix nitrogen between crops and demonstration of propagation techniques providing samples of some different Yam varieties that had high yields and good drought tolerance
Baking (self-identified need)	Vunamarita temporary training facility	Carolyn Misiel *Josein Co-Operative*	Hands on baking demonstration utilising wood fired ovens, providing value adding and further market access opportunities. The galip bread recipe has since been included in the ACIAR cookbook.
Sewing (self-identified need)	Vunamarita temporary training facility	Maybel Mesulam *WiYA*	Hands on sewing demonstration with four hand operated machines making 'meri' blouses that can provide further market access opportunities.
Food Preservation (self-identified need)	Vunamarita temporary training facility	Gloria Tenga, Katherine Warren *PNG UNRE* Emma Kill *USC*	Hands on production demonstration of preserves and cordials from local fruit supplies and soaps from coconut oil, providing value adding and further market access opportunities.
Coconut Oil Extraction	Vunamarita temporary training facility	Godfrey Hannett *NARI*	Hands on demonstration of virgin coconut oil production using the fermentation technique providing a needed commodity and further opportunity for market participation.
Solar Drier and Storage	Vunamarita temporary training facility	Brett Hodges *USC*	Hands on demonstration of solar drier loading, unloading, cleaning and dried products. Access to several different storage options.
Galip Nut Crackers	Vunamarita temporary training facility	Emma Kill *USC*	Demonstration of the imported TJ cracker and the locally developed Guria cracker with a supply of nut in shell for practical application.

Table 3. Small scale entrepreneur training

Small scale Entrepreneurs Galip Factory and Technologies Training Day **(22/9/16) delivered to 22 females and 3 males. This group is comprised of local market stall holders who were identified selling galip in the previous two months from the surrounding region.**			
Training Component	**Venue**	**Facilitator**	**Main training activities**
Commercial Health and Hygiene	NARI Meeting Room	Dr Shahla Hosseini *USC*	Demonstration of handwashing and basic hygiene practices required for the safe handling and storage of galip nuts when drying and packaging for commercial sales
Aflotoxins and Bacteria	NARI Meeting Room	Kim Jones *Cropwatch*	Discussion of the nature of aflatoxins and other bacteria that can be detrimental to food and galip storage
Solar Drying and other preservation techniques	NARI Meeting Room and outside displays	Dr Shahla Hosseini, Kim Jones, Brett Hodges, Emma Kill	Demonstrations of a range of food dehydration techniques for longer shelf life and safe storage of galip products including solar dryer, electric dehydrators and ovens, and pan roasting over open fire.
Pulp removal and sun drying	NARI Pilot Galip Processing Factory	Godfrey Hannett *NARI*	Hands on demonstration of latest techniques developed to safely remove pulp and dry galip. Submerging galip in boiling water for pulp removal and using racks to sundry nut in shell for storage.
Mechanical cracking	NARI Pilot Galip Processing Factory	Godfrey Hannett *NARI*	Cracking nut in shell using Chinese pincer crackers, imported TJ cracker, and locally developed Guria Cracker.
Processing	NARI Pilot Galip Processing Factory	Dalsie Hannett *NARI*	Demonstration of NARI pilot factory techniques and methods to process galip including blanching, testa removal, drying, roasting, oil extration
Packaging	NARI Pilot Galip Processing Factory	Dalsie Hannett *NARI*	Demonstration of different packaging techniques and labels that have evolved over the life of the project.
Improving Market Capacity	NARI Meeting Room	Brett Hodges *USC*	Discussion based presentation on incorporating the technologies from the project into current market activities including, cracking, processing, value adding, packaging and labelling, marketing and accessing the growing tourist market.

Table 4. Young People Galip Training and Work Experience Program 2016

Young People Galip Training and Work Experience Program 2016 (7/11/16-17/11/16) delivered to 6 females and 4 males. The East New Britain Women and Youth in Agriculture Cooperative (ENBWYIA) assisted in identifying these participants ensuring they represented areas from across the Gazelle Peninsula.			
Training days	**Venue**	**Facilitator**	**Main training activities**
Commercial Health and Hygiene	NARI	Simaima Kapi *NARI*	Demonstration of handwashing and basic hygiene practices required for the safe handling and storage of galip nuts when drying and packaging in a commercial factory
Communication	NARI	Emma Kill Brett Hodges *USC* Simaima Kapi *NARI*	Strategies for overcoming common communication barriers as well as essential skills like active listening, effective use of voice and tone, and questioning skills.
Solar Drying and other preservation techniques	NARI and outside displays	Brett Hodges, Emma Kill *USC*	Demonstrations of a range of food dehydration techniques for longer shelf life and safe storage of galip products including solar dryer, electric dehydrators and ovens, and pan roasting over open fire.
Pulp removal and sun drying	NARI Pilot Galip Processing Factory	Brett Hodges *USC*	Working in the pulping section using the latest techniques developed to safely remove pulp and dry galip. Submerging galip in boiling water for pulp removal and using racks to sundry nut in shell for storage.
Mechanical cracking	NARI Pilot Galip Processing Factory	Godfrey Hannett *NARI*	Cracking nut in shell using Chinese pincer crackers under initial supervision of local cracking team.
Processing	NARI Pilot Galip Processing Factory	Dalsie Hannett *NARI*	Working in all aspects of the NARI pilot factory using latest techniques and methods to process galip including blanching, testa removal, drying, roasting, oil extraction
Packaging	NARI Pilot Galip Processing Factory	Dalsie Hannett *NARI*	Grading, weighing and packaging using techniques and labels that have evolved over the life of the project.
Improving Market Capacity	NARI	Brett Hodges Emma Kill *USC*	Discussion based presentation on incorporating the technologies from the project into current market activities including, cracking, processing, value adding, packaging and labelling, marketing and accessing the growing tourist market. Value adding particle skills such as baking galip biscuits
Resume Writing	NARI	Emma Kill Brett Hodges Simaima Kapi	Resume' construction including references, qualifications and identification portfolio.
Livestock	NARI	Ku Kabila *NARI*	Visit of livestock and feeding stations on NARI Kerevat station. Participants were provided an opportunity to take a clutch of ducklings to raise and try to sell.

Entomology	NARI	Fidelis Hela *NARI*	Hands on demonstration of some components of entomologist role. A presentation on the galip weevil and field visit to the galip plantation to learn how to identify the weevil in their own gardens.
Guest Speakers		Kym Jones *Cropwatch* Theo Simos *(UA)* Barbara Pamphilon *(ANU)* John Warren *(VC of PNG UNRE)* Kiteni Kurika *(NARI)* Ofara Petalini *(NARI)* Elizabeth Ling *(NARI)* Carson Waai *(NARI)* Diana O'Donnell *(AVI)*	Speakers brief was to provide a background of their roles, the work they engage in and their journey to get there, resulting in inspirational and informative sessions.
Book Keeping/Accounting	NARI	Carson Waai *(NARI)*	Real life work experience and mentoring

Supply chain: A galip factory tour and applied demonstration of cracking, drying, processing, packaging, labelling was held for 25 small-scale entrepreneurs (already engaged in the marketing and sale of galip). This helped small-scale entrepreneurs to witness technology that could readily be utilised in their present market activities (see table 3). There has been several other opportunities for women to tour the factory and learn of the processing and marketing of galip including the small scale entrepreneurs from local markets (see table 3.)

Women and Youth in Agriculture Co-Operative Society selected nine young people from agricultural backgrounds to attend two week's work experience on galip collecting, buying, pulping, cracking, drying, processing, packaging and labelling. The young people came from across the region who were neither working or studying (see table 4).

Improved locally available packaging of vacuum packaging units, plastic storage containers and the use of jars and other available resources to increase the shelf life of galip and other produce was demonstrated to over 50 female smallholder and small-scale entrepreneurs.

Three small-scale entrepreneurs were mentored to source raw materials locally and improve processing, packaging and labelling. A local supplier is now working to package, design and labels is now working with these women who hope to have labelled product for the 2017 season.

Health and safety: Translation by a local trainer of food safety, health and hygiene and delivery to 50 female smallholders and small-scale entrepreneurs at 22/9/16 ,27/10/16, 2/11/16 – 3/11/16 training days (table 1, 2, 3.)

Market capacity: As noted above, 15 participants requested support in building the market capacity. Three women (2 from the Kokopo market and one from the Rabaul market) were intensively mentored to introduce some technologies into their existing practice and to value add galip nut (drying, roasting, salting, flavouring), packaging in plastic packets, developing labels

and marketing innovations. A local NARI Keravat staff member is continuing to mentor these women, and it is anticipated the women will sell in Rabaul and Kokopo markets. One woman has labels designed and printed locally in readiness for the upcoming season. A visit to NARI is planned for these three women to gain greater in-depth information from a local NARI staff member about drying and value adding. The remaining participants will have mentoring assistance in future, and will have the benefit of some of the early barriers being adapted.

A galip biscuit recipe using nut chips has been demonstrated and shared with the WiYA co-operative society, providing a new business pathway for local small-scale entrepreneurs and use for a by-product of the processing.

Public-private partnerships

During year 2, two partnership opportunities arose proposing galip processing facilities in the region. The Wellington Chocolate Factory and NZ Ministry of Foreign Affairs and Trade are hoping to establish an ethical business model of purchasing and processing galip from smallholders for the export market. The South Sea Plantation Ltd group is looking to invest in monoculture plantations galip and build a processing factory, supplemented by supply from local smallholders. They are represented by a plantation company from New Ireland that already have a large single species plot of Galip from the 2009 'elite stock' distribution. It is expected that these proposals will come to fruition in the coming year and could present private investment from the commercial sector that is needed in the industry.

Discussion and conclusion

Targeting a select range of women (and youth), whilst not ignoring the demands of males interested in the canarium industry, has thus far helped to contribute to social upgrading. Alongside economic upgrading through Canarium processing and products, two small businesses that might be co-located with small-medium scale nut processing activity are those of the emerging cracker manufacturer and the local label designer and printer, and there is potential for members of the WiYA co-operative society to sell biscuits baked with nut chips. Clearly there is room for more enterprises associated with Canarium processing to generate more micro-cluster activity.

There is a generally positive outlook for the establishment of a canarium industry and an interest in the production of the factory and the packaged product displayed across most of those spoken to. Many discussed the importance of developing a local product that works well with other cropping options and provides further economic benefits to the region. Operators of small to medium size businesses within the region identify their own challenges in operating in East New Britain. These concerns include the costs and reliability of electricity and the procurement and retainment of suitable staff, both skilled and unskilled. In a production environment where cost outlays need to be kept to a minimum, the questionable reliability of electricity supply in the region and the costs of running generators are exorbitantly high, with fuel being shipped in, there were questions raised as to the viability of the factory relying on electricity to process.

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11.2 Barriers to increasing capacity

Through the research conducted over seven trips to the East New Britain (ENB) region and the canarium processing factory at NARI we have identified several areas that can be seen as barriers to the scaling up of the sale and processing of nuts.

Smallholders

- The range of challenges that agricultural pursuits present are exacerbated in an innovation setting that can see small holders unsure of investing their time and space on new cropping options.
- The history of agricultural innovation throughout the area has delivered a wide range of agricultural options to smallholders, with mixed results, that see them unsure of how to proceed.
- The insufficient knowledge of supply chains amongst smallholders and the factories potential to process are currently impeding the project from scaling up processing of the nut.

Structural

- Neoliberalisation of public institutions has stretched their capacity to deliver to the expectations of the project and private sector demands.

Whilst these identified barriers present challenges to the upscaling of the processing and sales of canarium nuts many of them are interdependent, so as they are addressed, they should alleviate barriers across other areas.

Agricultural Production Challenges

Climatic conditions and exposure to both introduced and indigenous pest species pose a potential problem to many agricultural enterprises. The cocoa pod borer that has halved the cocoa industry in ENB is an example of the impact that these problems can have. The ENB region experienced a drought in 2015 and this has impacted on the availability of nuts for purchase and processing. The season of nut production was shifted with sporadic fruiting and there was not a consistent flush of nuts. Many locals readily identified that this was a sign of climate change and that everything with normal weather patterns was askew. People were discussing that there was not much galip due to the drought and that the fruiting season had changed. '*They used to know exactly when the season started and finished but not anymore*' (market stallholder (interpreter), Nov 2015). This seasonal nature of the nut presents another potential barrier as an inconsistent supply of nuts for processing presents a significant bottleneck in upscaling of the project, though as storage capacity improves this will be less of an issue.

There have been reports of a borer that has decimated some stands of canarium trees throughout the region. One local landholder with approximately 30 trees suggests that he has lost over half because of the borer (smallholder, Feb 2016). There was a consensus amongst small holders that the insect, which is not an introduced species, was able to breed and consume in greater numbers because of the long dry spell and that the trees were susceptible from lack of water (smallholders, March 2016). There have been some positive signs from the same farmer recently that suggest the trees may have survived reporting that there are green shoots appearing.

These issues, whilst barriers to production, are also synonymous with all agricultural pursuits exposed to the vagaries of climatic changes and infestation and could be managed with improved cropping practices and genetically improved stock, similar to the cocoa crop management courses run through UNRE and the PPAP project. The significance of this barrier is in the innovative nature of the canarium industry. Whilst it is an indigenous species to the region and has benefited from some level of selection to improve production and resistance, the canarium industry does not have the significant market support that the cocoa industry has drawn from to survive its environmental challenges. Smallholders have strong memories of the decimation of the cocoa industry with the cocoa pod-borer and are anxious of the impact this

type of challenge can present, which could see them chose to plant a more tested cropping option.

Different cropping options and information

Local smallholders could discuss the history of their garden lots with a list of different ventures that they had embarked upon (small holders, Nov 2015, Feb 2016). The mainstay crop for the smallholder in the region has always been cocoa despite the large price fluctuations that they have endured, although this has been threatened since the cocoa pod borer was introduced to the region, which has seen a crop that traditionally required very little maintenance now requiring considerable time in the cleaning up of leaf litter and spraying for the borer. Fluctuations in the price of cocoa, and the borer, have seen a multitude of agricultural development projects and initiatives over decades in the region, looking to promote diversity in cash crops. Smallholders discussed their experiences with a few of these agricultural options which included coffee, tea, nutmeg, vanilla, cardamom, balsa, palm oil, canarium and teak. Each of these agricultural options had their own unique challenges and outcomes, whose legacy continues through to the smallholders understanding today.

The vanilla story was explained as a shortage of supply from Madagascar post cyclone that saw prices of the commodity soar along with the planting in East New Britain (small plantation owner, Feb 2016). As Madagascar re-established its market dominance the prices fell such that this agricultural option was no longer viable. There were also suggestions that quality control of product was less than desired by the market. The balsa wood market also experienced a slump in price and expectations of smallholders whom planted the trees. This timber develops a heart wood after 5-7 years of growing which significantly lessens the quality of the timber to the factory. Several smallholders suggested that there are still trees in the ground that are worthless and not worth chopping down (February 2016). One small holder was concerned about the stories that he had heard of oil palm and its impact on cropping options but also social values (smallholder, Nov 2015). He explained that he had heard of women selling themselves on the roadside in West New Britain because they had planted oil palm on their blocks which prevented them from diversity in small cropping options and the associated food security these small gardens bring, as well as the money that can be made from selling these to pay for school fees and other such costs (smallholder, Nov 2015). The potential of canarium as a cropping option is that it is promoted as an intercropping species that complements cocoa production by providing a shade source that requires little maintenance, although there were reports from other agencies, promoting other intercropping options that the cocoa growing under the Canarium was underperforming.

This leads to some confusion for smallholders as they express that they are unsure of what direction to take with so many options and misconceptions that come with so many different players offering their initiatives. "*how do we know what to plant…last month it was galip now teak. How do we know what is best for us*" (Cooperative Member, February 2016). One smallholder had fifteen canarium trees in planter bags in a corner of his house garden that looked as though they had been there a while. When asked about these nuts, he replied *I don't know if I should plant these just yet as there is talk about free teak trees coming* (smallholder, Nov 2015). These canarium trees were delivered to smallholders through the World Bank funded PPAP project working with cocoa co-operatives supplying cocoa seedling, crop maintenance training, and Canarium trees as intercropping shade options. It was explained that this project had recently been refunded to extend to 2019 ensuring a steady supply of canarium stock in the ground as demand increases, this requires smallholders to plant them immediately rather than holding out for the next big agricultural opportunity. As an identified barrier this presents significant potential to derail the industry, if smallholders decide not to plant canarium because of distrust of the industry. The potential of the market requires trees in the ground that will supply the expected demands of an establishing market. If there is misinformation around price expectations and ability to supply, then this project risks being perceived by smallholders as yet another opportunity that has not met their expectations. It is the potential of this problem, of promoting an industry from the outset, that impedes on many other solutions and as such there needs to be a careful progressive rollout of information and promotion of supply chains to avoid price fluctuations and to sustainably meet sellers and buyers' expectations.

At the scale of the smallholder there is a need for a compilation of information covering the different agricultural options available, empowering them with the all of the knowledge required to make an informed decision on the direction of their livelihoods. This extension should provide the applicability of each agricultural option to each smallholder, its expected returns (with fluctuations and impacts explained), and technical advice around how best to implement these options. This process would alleviate some of the confusion and misconceptions that have arisen amongst smallholders regarding the best direction for their block. It would also see farmers able to rationalise decisions with access to all of the information on all of the options.

Knowledge amongst farmers of nut supply chains

Whilst there have been some identified barriers within the processing of the nut it is the supply chains that represent the more significant barrier to the upscaling of the industry from the point of view of the smallholder. Within the processing facility there are some identified bottlenecks. The cracking of NIS and testa removal is labour intensive and relatively slow, although there are continual improvements and with better processes and demand for canarium, further improvements and mechanised processes may evolve.

It is, however, primarily the supply of nuts and more importantly the knowledge of the market, for suppliers, that is currently restricting upscaling. There have been several announcements made in local markets and a word of mouth campaign spreading awareness that NARI was buying nuts. There are several ideas that local staff (government officer, Feb 2015) suggested would be utilised to spread this information including newspapers, radio announcements, information sessions and public announcements in marketplaces. These methods could potentially spread the understanding that there was a market for the canarium nuts that might otherwise go to waste, although as mentioned previously this is not a step that can be taken without a careful consideration of the sustainability and capacity of the market, else risk raising farmer's expectations unrealistically.

Currently the supply of nuts is co-ordinated by NARI staff utilising phones to contact an area to spread the word that they will be buying nuts. They then drive to the area on a particular day and buy nuts in pulp and conduct their own quality control at this point. This system is not providing a consistent supply nor is it representative of the whole region and will require refinement for the upscaling of the project. There are established buying points for cocoa and copra throughout the region, operated by some of the larger cocoa and copra exporters, that could be utilised through a partnership or understanding with one of these entities. This would provide the ability to draw supply from across the region and at a rate that would facilitate upscaling. Another solution, identified through discussions (government staff, Feb 2015), was approaching a range of middleman style ventures that also exist across the region where entrepreneurial buyers advertise their buying prices by displaying them from on roadside stalls. These buyers could still ensure quality control at the buying point and could enable a pickup run across several of these collection points and would require training in quality control.

The capacity of the public institution to meet project and market requirements

Operating an industry in East New Britain presents its own challenges, and operating from within a public institution under the current fiscal climate can further escalate these challenges. As a remote setting with the majority of supplies arriving by boat there are challenges in readily obtaining equipment and the availability of incidental supplies and spare parts. There were cases identified where the factory was still awaiting delivery of a new more suitable commercial oven that was explained as being stuck in customs as there had been some mix-up with paperwork (government staff, March 2016). There is a ten seater van awaiting a gearbox that has been ordered for over a month and was exorbitantly priced given the transport required to get it to East New Britain (government staff, March 2016). There were some difficulties in obtaining packaging materials locally which saw temporary changes away from the more popular smaller packaging to the larger 250gram packages just to adequately store the nuts that were not in demand. These factors are all challenging to the upscaling of the industry, though with the other examples of businesses operating successfully from the region they cannot be seen as insurmountable.

Papua New Guinea is currently experiencing the downturn in commodities and energy markets, particularly given its reliance on these as revenue. This has impacted upon all public institutions.

There is a greater need for public organisations to demonstrate economic efficiencies and potentially generate income. At a local level this sees the NARI factory often waiting for approvals on equipment and other factory needs that effectively slow down the operations and ability to upscale. There were some storage issues, that have since been resolved, that impacted on the capacity to store the nuts without degradation that could have been avoided had there been the ability to purchase equipment directly. There is limited capacity at the factory for vehicle transport with several vehicles that are out of service awaiting parts, and a permit system that only sees a handful of staff able to drive company vehicles. There is pressure around the hiring of new staff, with factory workers only being reassigned from other areas of the NARI operation rather than specifically identifying staff for some positions. These challenges represent a barrier to upscaling of processing that could potentially be averted with a private partner operating the factory.

There is a range of other expectations that are being placed on the factory through the project itself. For example, there were initial expectations around the capacity to monitor, evaluate and report efficiencies with the processing chain that have seen the limited staff devoted to reporting rather than development. These requirements would be seen as commonplace within the private sector, from an Australian understanding, and are essential in developing a model that could be adopted by such. Workplace practices and approach were summed up by one individual who suggested that our, Australian/private sector, approach and expectations was at one end of the scale and that their, PNG/public sector, was at the other end. They elaborated on this suggesting that *there was capacity for their end to move to the middle, though he also suggested that our expectations and approach could also move towards this middle ground* (government staff, March 2016). The progress that the factory has made in developing local domestic markets and a demand for product has assisted in the improvements in the factories approach.

This development of industry sales generated from within the public organisation and may be a response to the pressures they face in the economic rationalisation of the public sector. It was identified that the *sales of nuts into local markets has subsidised some costs of running the factory* (government staff, March 2016) and that this has alleviated concerns around project expenditure. Whilst this may be the driver of these developments it still represents a bottom up approach to the development of the industry that has been informed at a local level and has seen self-development and implementation of improvements in procedures and processing throughout the processing chain. This could only be seen as a positive process, from a community development approach, it also can be seen as a barrier to the upscaling of the industry from an economic development approach. There is enormous economic potential with the factory developing and supplying a domestic market that could expand into further markets in years to come, however, there is an expressed need from the private sector for a several tonnes of nuts to be used in product trialling that has been difficult to obtain as product continues to be sold into domestic markets (industry representative, March 2016). This presents a significant challenge to the direction for the factory as they currently are selling at 50 kina/kg as opposed to the private sector trials which they will sell at 5 kina/kg. Whilst large private sector interest and product trialling could see the development of a larger demand in a shorter period this needs to be weighed carefully against the extension benefits of the current progress that has been made.

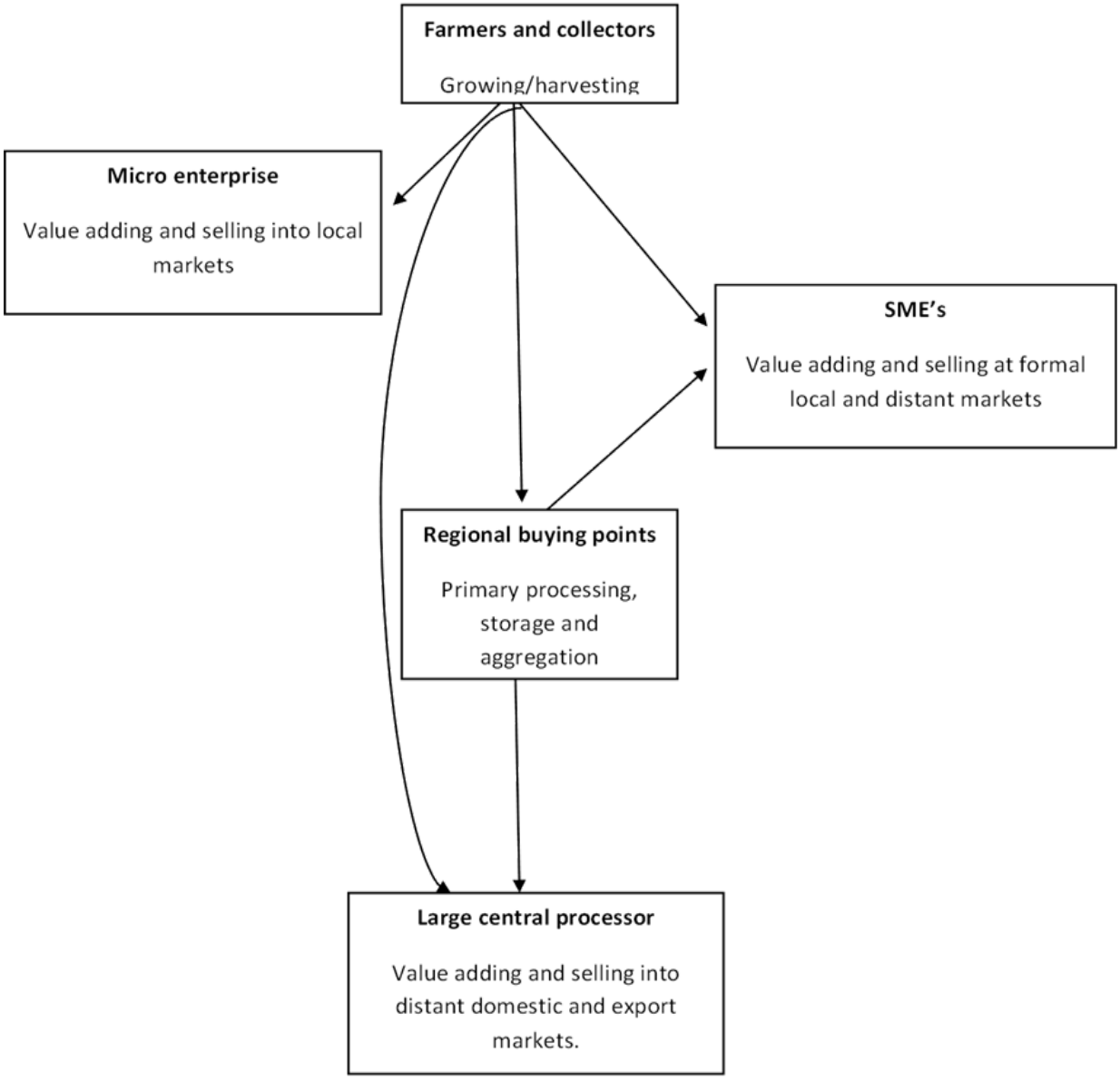
11.3 Enhancing private sector led development of canarium industry in PNG – A roadmap for success

Kim Jones, Prof. Helen Wallace, Tio Nevenimo, Dr. Shahla Hosseini-Bai, Theo Simos

Vision Statement: A profitable and sustainable Galip industry with diverse domestic and export markets.

This road map has been developed with input from stakeholders and potential stakeholders at workshops and from targeted interviews. The potential structure proposed in Figure 1 is based on the expectations and foresight of participants and will utilise experiences and networks already existing in the cocoa industry.

Figure 1. A schematic view of product flow through the future PNG Galip industry



Vision: A profitable and sustainable canarium industry with diverse domestic and export markets.

11.1.1 Action plan

Objective	Tasks	Resources required	Responsibility	Time line
Harvesters and collectors delivering quality NIP to the NARI factory	Develop minimum specifications for NIP. Develop differential pricing scheme for different quality standards based on kernel recovery/nut size Train farmers in quality standards. A mechanism for assessing standards on delivery is required.	R&D	ACIAR/NARI/private partners	2019-2022
Skilled farmers delivering quality canarium nuts to nut buyers located in the growing regions	Develop and publish GAP guidelines including post-harvest handling Communicate and train nut buyers to implement minimum standards	funds to update and publish quality guideline booklet. distribution in training for nut buyers and farmers	ACIAR and NARI project team	2019-2022
	Train extension officers (train the trainer) to deliver GAP for Canarium course	Extension officers in each province available and resourced to conduct Canarium training Gov't funding to support the extension officers	DPI	2015-2022
	Conduct farmer training	Trained and resourced extension officers	DPI/PPAP/ACIAR	2015-2022

		Partner with PPAP project		
An expanding plantation sector	Develop confidence in the industry and information packages suitable for the larger scale plantation sector	Research on cost/benefit of inter-planting canarium and cocoa Research on pest control (weevil) Access to elite planting stock NARI factory operating in conjunction with private partners demonstrating the commercial viability of mechanical large scale processing	ACIAR/PPAP/NARI NARI NARI/PPAP/private sector ACIAR/NARI/Private partners	2015-2022
Develop large scale handling and primary processing technologies for plantation operations	Machinery, dehuskers knowledge on post-harvest quality management for large scale operators Refine economic analysis including sensitivity analysis with improving kernel recovery.	Further R&D into post-harvest quality management, effects on shelf life and reject levels, develop financial info on cost/benefit	ACIAR/NARI	2019-2022
Micro enterprises value adding at the village level and selling KIT to SME's	Hand crackers available at an affordable price. Participants trained in food	Minimum standards to be established and, documented. SME trained in risk analysis and food safety.	ACIAR/NARI/SME	2020-2022

	safety and good hygiene practices	SME's empowered to engage with their supply chain and implement quality control measures		
Micro enterprises selling packaged canarium in local markets. A range of canarium products available outside traditional harvest season	Train extension officers Train women in small scale processing packaging and food safety.	Trained extension officers Information booklet detailing simple step for processing and food safety Affordable hand crackers produced in PNG. Examples of packaging and local suppliers available	ACIAR/NARI	2016-2022
Economically viable SME's trading in niche markets at a local and national level DMS, Niugini Organics GNC	Survey current structures, resources and networks of women's co-ops Market study to determine products, market segments etc Produce generic business model that can be adapted by a range of SME's. Resource SME's, Co-ops with appropriate equipment and training to produce commercial products within	Donor funding for private/public partnerships project Government subsidies Extension or project officers for training in Canarium processing, packaging, food safety and marketing Financial data and small scale processing technologies available Small scale equipment available in PNG (solar drier,	ACIAR/EU NARI, WYIA, DPI ACIAR	2015-2022 2017-2022 2017-2022

	their business model Develop generic food safety protocols based on HACCP principles Train SME's and co-ops in production including food safety, processing, and marketing Register all canarium buyers for food safety and traceability	hand crackers, packaging equipment)		
A working mechanised model factory producing a range of value added products that have been test marketed. Market potential documented and financial analysis available.	Design and Equip NARI factory with appropriate machinery to produce high quality commercial products. R&D on large scale mechanized processing R&D on testa removal R&D on mechanical pulp removal Document and implement a	Improved water bath for separating kernel and shell. Improved flash drier to remove excess water immediately following the water bath. Vertical form fill packer ($20,000) R&D into improved methodology for testa removal Further R&D into purpose built de-pulpers	ACIAR, Donor, NARI, Government grant	2019-2022

	food safety program based on HACCP principles Produce sufficient quantities of commercial products to test the market Economic analysis of cost of production			
Engagement with potential large scale investors; Equanut ENDBC	Knowledge of current resource base. Demonstrate mechanised cost effective processing technologies Develop financial and market potential prospectus	NARI staff, vehicle and time. GPS tablet computers and software Working model factory at NARI	NARI staff to conduct the survey, ACIAR to provide tablets and software and training in it use.	2016-17
Establish and maintain a national canarium development program with support from all levels of government.	Prepare submission to National Government Prepare submissions to provincial, district, LLG's governments.	Sufficient funding to employ, train and resource extension officers in the Dept Ag. Funding package to support the development of Women's co-ops and other SME's	NARI to prepare submission to National Government National, Provincial, District, LLG's Governments	By 3 Oct 2014 2015-2020

		Subsidies for freight from remote provinces Subsidies for packaging Innovation grants to help purchase equipment Gov't support for healthy snack initiative in schools and local markets		
A steering committee made up of existing industry participants (small and large scale)	Re-establish the Canarium Industry Association Elect members and office bearers Develop and publish a constitution	Assistance with initial meetings Inviting participants, secretarial assistance, etc	NARI/Dept Ag	ASAP 2014-2015
A national Canarium R&D program for Canarium, including a cultivar improvement program.	Prepare submission to National Government	NARI with sufficient resources to conduct R&D in high priority areas as determined by NARI in consultation with the industry	NARI, Industry Association	2015-2035 (20yrs)
Market development including distribution channels and wholesalers and retailers. CPL/Prouds				

Export market developed through private partners (Equanut, ENDBC and others)	Private partners develop products and volumes to fill niche export markets.	Technical support and further R&D from NARI Two way information exchange	ACIAR/NARI/private partners	2021

Summary:

The galip industry is showing encouraging signs of growth and interest from commercial enterprises. At least three companies are now selling packaged product in local supermarkets and through the duty-free shops at Jackson International airport. The interest and involvement from private companies is an important step in establishing a viable industry, however there are still many gaps in knowledge, equipment and capabilities. The various sectors of the developing canarium industry require information and assistance that is specific to their individual circumstances.

a) Small-scale farmers and collectors require information and training on product specification and quality control. They also require local buying points as transport is difficult and expensive.
b) Farmers and collectors have recently begun value adding at the village level by cracking the nuts and selling KIT to processing companies. This supply chain has many risks in food safety and product quality. Research in quality control and training needs to be completed for this sector.
c) Large-scale farmers need financial data, access to elite planting material and markets for large volumes of nut in shell.
d) Micro enterprises need information and training in food safety, value adding (roasting, salting etc), packaging and marketing at the local level.
e) SME's require information on the current resource base and predicted production, mechanical processing, market potential and financial analysis.
f) There is a lack of knowledge around pest threats (weevil) and control measures.

Interest has been shown from two large scale enterprises who will need assistance in the initial stages for handling, processing, quality management and product development. Much of the action plan is aimed at developing the knowledge and financial data that this sector requires. The economic data and trial products and market intelligence, developed from operating the NARI factory should be used as a vehicle to engage these larger enterprises.

The micro enterprises, mainly women who sell in the local markets, need further support to develop their businesses. Support will include one on one mentoring to provide advice on developing products, packaging, food safety, shelf life.

Small-scale farmers and collectors have been supplying the factory at NARI and their knowledge of quality specifications has been improving. As the industry develops the quality standards will need to be refined to pay for kernel recovery. A bonus scheme needs to be developed to appropriately reward farmers supplying high kernel recovery (elite) varieties. Some entrepreneurs have entered the industry as regional buyers. This sector needs further development and training in quality control.

The large-scale farmers and plantation sector require access to elite planting material, financial information, information on tree management including pest and disease control, and cost/benefits from inter-planting with cocoa, reliable information on market potential.

12 Objective 2 Appendices

12.1 Barriers to small holder participation

Female smallholders and small-scale entrepreneurs face a wide range of barriers to their participation and will benefit from their research, training and extension needs being addressed; through running a series of focus workshops identifying the specific needs of these groups, further training in agricultural and post-harvest best practice with value adding opportunities, and opportunity to engage in a range of programs developing basic literacy through to entrepreneur mentorship and governance. The research that is required amongst female smallholders and small-scale entrepreneurs is to identify the needs specific to this group through a series of focus sessions around their vision, expectations and concerns for the future. With some training in solar drying having already been delivered, there is a need for this to continue across the region to differing groups and for this to expand to cover a range of identified agricultural and value adding opportunities for improvement. The extension needs identified are drawn from several levels of participation and focus on issues for co-operatives, smallholders and entrepreneurs each with their own barriers to participation.

The diverse and fragmented nature of the East New Britain smallholder and small-scale entrepreneur populations presents significant barriers to successful engagement representative of the region. This would normally be overcome through co-operative and farmer groups representing this diversity, though there are several challenges that limit the effectiveness of this approach. Rather than utilising these structures alone as a means to engage with the target populations their needs will be addressed at three levels; the East New Britain Women and Youth in Agriculture (WIYIA) Co-operative, several family groups within smallholder communities and the women whom regularly sell canarium nuts in the markets around Kokopo, Rabaul and Kerevat. Each of these groups requires tailored training opportunities to address their specific needs in conjunction with some generic extension needs that present challenges across these groups.

Identified Research Needs across all organisational structures

The priority research needs for women smallholders and small-scale entrepreneurs have only been identified through individual interviews and conversations which have been taken as representative of these populations. It is suggested that each of the identified groups Women in Agriculture Co-operative, smallholder families and small-scale entrepreneurs from local markets be engaged in a series of workshops to elicit their expressed priority needs. These workshops would differ with each group depending on size, with family groups working in a more intimate setting. Working specifically to better understand; the vision and expectations they have for the future of their families and livelihoods; the challenges that they currently face and those they see as potentially challenging; and sustainable solutions that are achievable from their perspective. It would be expected that the results from this engagement will inform the resultant needs of these groups.

Training Needs across three organisational structures

WYIA

The WYIA co-operative require a range of training opportunities to further their capacity to engage in market activity and opportunity. The co-operative is facing issues of economic viability with only three members having met their financial responsibilities to 2015 with many being several years behind. There is a lack of past records around this financial status and the co-operative does not have the strong financial position required to engage in opportunities that may present. The leadership structure is in a transition period with a new president coming in the next few months as the sitting president finishes her maximum term. The New Zealand Volunteer has also currently resigned from her position citing that the women "*needed basic training in working in cooperatives, time management, governance, communication skills, literacy and presentation skills before they were ready for me role*" (May 2016).

It is suggested that training packages that could directly improve the co-operatives ability to participate in economic development in the region will focus on capacity building around co-operatives, governance and entrepreneurship. This training should consider the advice of several members and representatives of the organisation that these approaches should specifically work to incorporate all members equally and not create any imbalances within the existing structure. It was self-identified early in the project that the ENBWYIA did not have the capacity to run the canarium processing factory, though this was an opportunity to actively participate in the economic development process in the region. This training should assist WYIA in developing the capacity to engage in the next opportunity.

Smallholder Family Groups & Market Stallholders

Small holders whom attended the first solar drying workshop indicated that they would like further training in solar drier construction and operation. Feedback from participants identified that the cost outlay was prohibitive to most smallholders and co-operatives at 500 KINA per drier, though there was a consensus that they enjoyed the training and the potential that this could have in prolonging the shelf life of not only canarium but a range of other seasonal crops. There were some concerns raised around the travel required to access the drier in situ at Kerevat and their reluctance to leave food unattended during the drying process. "*I am unsure if people would come to NARI to use it and they would not want to leave food in it in case it was stolen" (co-operative member Nov,2015).* Even staff from the centre often relying on local transport options are left with a long walk to Kerevat or waiting for several hours (government worker Feb, 2016). Some participants have since suggested that if they could source the material and work from a plan they could build it cheaper, and suggested that any further training could be around construction. It was also noted that the first workshop was focused on women and several men of their district expressed interest in attending future training (smallholders, Nov 2015). After the initial training several small holders identified that their hygiene practices had improved and that they were already starting to dry produce in their own traditional ovens because of the training (smallholders, Nov 2015). One young smallholder announced that *"I have been washing hands and teaching others as well"* (Nov 2015).

The value adding process is one that most of the participants could readily understand and resulted in some follow up visits to small holders experimenting with baked goods incorporating canarium. One smallholder who runs a small catering company cooked several batches of biscuits, in her woodfired backyard oven, to differing recipes using locally sourced goods trying to ascertain the best option in promoting the canarium flavour. This smallholder and small-scale

entrepreneur was excited that she had incorporated this local product that she had known for so long in a new and interesting product (smallholder Feb, 2016).

It is proposed that the training for these groups could continue around the solar drier workshops and the opportunities they present. This engagement would provide a platform to provide other value adding opportunities and deliver extension needs. The training should engage those within these groups who express interest, including young people and men. The workshops can be modified to incorporate construction techniques, plans and alternative material options. Further value adding and storage ideas could also be introduced within these workshops providing opportunity for the small-scale entrepreneurs to diversify and develop their livelihoods. This training will provide smallholders and small-scale entrepreneur's opportunity to invest in technologies that can add value to the canarium they harvest. Importantly it will provide additional food security to their families as they can effectively store a range of the bountiful, yet seasonal, produce available to them for longer periods of time, either for sale or consumption. The flow on benefits are already evident from this initial workshop with the dissemination of better hygiene practices around food handling and it could be assumed that there are other positive impacts that have yet to be reported.

Identified Extension Needs across three organisational structures

Market Stallholders

Engagement with this group has been restricted through language barriers and limited access to date. From the initial conversations and informal interviews it would be difficult to accurately assess the priority extension needs of this group. It could be assumed that their needs may mirror those of smallholders and co-operative members, though a clear direction for their requirements will only be available after research in this area, through focus groups discussed earlier.

Smallholder families and WYIA

The WYIA co-operative have an extensive history of engagement with development programs and subsequent training opportunities that has accompanied them. They have recently participated in a range of extension training opportunities through 2015-16. Some of these have been delivered through the, World Bank funded, Productive Partnerships in Agriculture Project (PPAP) designed to revive the cocoa industry in East New Britain, and includes basic bookkeeping, HIV awareness and Sustainable Livelihoods. Others were delivered through ACIAR projects including and the solar drier workshop with this project. There is training in budgeting and money management delivered by banks in the area, though this is often seen as a customer building exercise for these institutions. Despite the wealth of extension training opportunities, women from the co-operative and smallholders, all identified areas that had not been addressed in their experiences, including drug/ alcohol awareness and domestic violence. The overwhelming need identified from both smallholders and WIYA members was for real opportunities for the younger generation. Multiple members of the co-operative identified, on several occasions, that "*they wish for opportunity, not for themselves, but for their daughters and granddaughters… something to give them a future"* (WYIA member, November 2016). This was prompted through concerns of the changing nature of family values, the introduction of new technologies (mobile phones) and the identified linkage between boredom, lack of opportunity and unsociable behaviours. The great granddaughter of a smallholder identified a "*get up to no good… I spend most days on my phone when I can get credit … I don't have much more to do''* (March 2016).

To complement the range of opportunities that have already been afforded to these groups packages covering the identified areas can be delivered. Though specifically a program of engagement with young people building their capacity to engage in opportunities and develop their own livelihoods with the resources available to them is what is required. Dependent on the group's needs, this could include a range of targeted training modules. It was identified through WYIA members that to enable the poorest of the poor groups to access employment or opportunity that basic English was a priority (March,2016). Many of the young people from this group have limited schooling, due to limited income for school fees, and hence limited English, which is seen as a prerequisite for many paid positions in the region. The programming could incorporate an entrepreneurship skills development component that would provide participants with the knowledge of small business and achievable money making ventures where they could build a sustainable business from resources they have available to them. "*Young people need the skills to be able to grow a business from a bag of cocoa, which they can go out and achieve through sweat" (WYIA Executive March, 2016)*. Further investigation is required to see how much of this training is already available in the area to ensure there is no duplication of services, feasibility of running such a program, the logistical considerations and the linkages that could be established within the private sector in the region.

12.2 Solar drying training workshop

COURSE TITLE: **Canarium nut: Best practices for harvesting, processing and packaging on a small scale.**

General objective of the training:

- To introduce best practices for control of quality and food safety during small scale canarium nut processing, from tree to consumer.

Specific objectives of the training are to:

- To enhance participants knowledge about basic principles for control of aflatoxin formation in canarium nut
- To enhance participants knowledge on their responsibility to control quality and safety of food
- To enhance participants awareness and knowledge on best practices for handling of canarium, specifically drying at farm and village trader level
- To train participants in quality assessment and quality grading of canarium
- To introduce and train participants in application of financial incentives for quality

Participants:

- The course is aimed at people who harvest, process and sell canarium nut at a local or village level
- People who collect or harvest canarium nuts to sell to a buyer (such as NARI)
- Other village traders or buyers serving individual farmers or farmer groups and acting as a middleman to supply a buyer/value adder

12.3 Training packages

Contributed by Emma Kill, Brett Hodges, Simaima Kapi and Shahla Hosseini Bai, based on original training developed by Kim Jones, Elektra Grant and Helen Wallace

Sorting galip fruit

Immature, mouldy and spoiled fruits can be separated from healthy and fresh fruit before fruit processing. The galip fruit sorting can be done both visually and using floating method.

Visual separation

In the visual separation, the mature fruits have dark purple color and can be visually identified and separated from immature (green fruit), mouldy and spoiled fruit (Figure 1).

Figure 1: Visual separation of mature (purple fruit), immature (green fruit) and mouldy fruit

Floating separation

The floating method can separate the bad galip nuts when it is not possible to detect them visually. In this method, the fruits are added to a bucket of water. The fruits, which sink, are fresh and mature whereas the floated fruits are either immature or spoiled (Figure 2).

Figure 2: The bad or immature galip fruit float on the water

11.1.2 Depuling training

De-pulping training includes

- Boil water to 100 °C.
- Remove the boiled water from fire or stove.
- Soak the galip fruit into the hot water for 90 seconds to soften the pulp (Figure 3).
- Remove the fruit from the water and squeeze the fruit by hand, the pulp should now be easily separated from galip shell (Figure 4).

Figure 3: soaking fruit into hot water for 90 second to soften pulp

Figure 4: Squeezing the pulp after being soften in the hot water to remove it from nut in shell.

11.1.3 Galip kernel drying methods

Kernel drying over fire, electric stove, gas stove or electric ovens

Drying using open fire/electric stove

- Place the fresh galip nuts into the pan over open fire//electric stove for 30 to 35 minutes.
- Keep stirring the nuts while they are heating, otherwise the nuts will be burnt (Figure 5)
- Do a snap test, if the nuts do not snap, increase the time of drying.

It should be highlighted that

- Peanut and other nuts can also be dried using this method.
- The galip nuts without skin are fragile and during over fire or stove will be resulted in breaking the nuts into pieces. However, drying will increase the shelf life of the nuts.

A household electric oven is another equipment item that can be used to dry and roast galip nuts as given below

- Place the fresh galip nuts into a tray and place it into the preheated oven at 120°C for 30 to 35 minutes.
- Do a snap test, if the nuts do not snap, increase the time of drying. However, keep checking your nuts for the first time. The duration of drying in the oven differs using different brands of electric ovens.

Figure 5: Placing galip with salt and sugar, fried and roasted in the electric oven (left), drying over gas stove (right).

Kernel drying with solar drier

Solar drier is constructed using materials available from local providers by NARI staff. A drying demonstration is undertaken and participants are given a chance to try dehydrated nut and fruit with discussions around the adaptability of other fruits and vegetables to the process. All interested parties can contact NARI staff who are happy to assist for solar dryer construction (Figure 6).

To dry galip nuts in the solar dryer

- The fresh galip nuts are places in trays with holes to allow airflow (e.g. plastic sieves) in only one layer (Figure 7).
- The trays are placed in the solar dryer.
- In a sunny day, if the trays are placed in the solar dryer in the morning (e.g. 8 am) by 3 pm (please see Annual report 2016), the galip nuts will be dried to optimal moisture content. The moisture content of the galip nuts can be examined using snap test.
- The dried nuts then can be collected and stored.

The participants are also trained to use solar dryer to dry banana, mango, pineapple and pawpaw.

- The fruit and vegetables need to be cut to fine and thin pieces.
- The thin pieces are placed in the trays and then in the solar dryer.
- The duration for fruit drying may vary depending on the thickness of the fruit.
- If the fruits are not dried sufficiently, the trays can be removed from solar dryer overnight and place back into the solar drier in the next day.

Figure 6 & 7: Tio Nevenimo from NARI demonstrating solar drier principles (L), Placing galip nuts into a tray which allows airflow before putting into the solar dryer (R)

Snap test training

Snap test is one of important assessment methods to prolong the shelf life of galip nuts. thus, the participants are trained to examine the moisture of their product after drying using snap tests. This training allows them to store their dried and processed fruit and nuts with optimal moisture, and increase the shelf life of their products (Figure 9)

Hold the galip nut with two hands and snap it (Figure 10). If the nut breaks and makes a snapping sounds, it indicates that the galip nut has been sufficiently dried and can be removed and stored.

Figure 9: Demonstration of snap test to workshop participants.

Figure 10: Indicating how to snap a galip nut

11.1.4 Value adding methods Baking bread, cakes or cookies using galip nuts

Hands-on baking demonstrations using a wood fired oven and incorporating galip into breads and biscuits have been included in our training packages (Figure 11).

Carolyne Misiel from the Josein co-operative of the Women and Youth in Agriculture Co-operative Society Association (WYiACSA) attended and demonstrated the techniques and recipes that she follows to bake breads and biscuits which she sells in East New Britain.

Figure 11: Female participant baking cakes and biscuits in the wood fired oven

11.1.5 Food preservation

Hands-on demonstrations for preservation of surplus fruits and vegetables into jams, cordials and pickles are undertaken. This allowed participants to produce their own preserved products utilising locally grown products, including pineapples, chokos, paw paw, and ginger. This resulted in a wide

range of products that were tested and taken home as a new addition to the diets of participants. Cordial is made from the waste fruit products for ice blocks (Figure 13). Discussions are held regarding preservatives and healthy diets.

Figure 13: Mother with child tasting homemade ice block made using cordial produced from pineapple skin which would be otherwise wasted.

11.1.6 Packaging and labelling

Figure 14: Anna roasted her galip nuts over open fire at her home.

A presentation is given to participants to increase their knowledge of accessing to diverse markets followed by a practical workshop for packaging and labelling. All participants are encouraged to use locally available material.

For example, they can use the ziplock bags and recycled containers (e.g. jam container) (Figure 14).

Preparing labels is the next step in the training. They are trained to use simple and inexpensive methods to prepare the labels. For example, typing the labels using a computer and printing them out in black and white. The information on labels include:

- The brand name.
- Ingredients used to value add the products.
- The expiry date.

11.1.7 Factory open day tours

Many factory open days are organised by Galip team for farmers and sellers in the market throughout the year (Figure 15). All participants experience a day of factory tour, and receive some basic training for:

- Food safety and hygiene
- Food processing
- De-pulping
- Drying
- Cracking
- Value adding

Figure 15: Participants shown galip products at the factory open day

Food safety and hygiene

A short presentation is undertaken to familiarise the participants to the concept of the food safety and hygiene (Figure 16). This presentation aims to increase awareness about the ways to prevent food poisoning and prolong galip shelf life, the PowerPoint slides are available upon the request.

A leaflet for the food safety and hygiene have been prepared in Tok Pisin.

Figure 16: Kim Jones giving a presentation of food hygiene

11.1.8 Farm day training

In this one-day training, the importance of spacing regimes for trees to decrease competition among trees for soil nutrients are discussed. We also talk about sustainable farm management to ensure soil nutrients are not limited over time (Figure 17).

In this workshop, the results of our cocoa-galip farming studies are shared (please see Bai, S.H., Trueman, S.J., Nevenimo, T., Hannett, G., Bapiwai, P., Poienou, M. and Wallace, H.M., 2017. Effects of shade-tree species and spacing on soil and leaf nutrient concentrations in cocoa plantations at 8 years after establishment. *Agriculture, Ecosystems & Environment*, *246*, pp.134-143.) to

- Increase the capacity of participants to design their agroforestry systems
- Provide them resources that they can contact and ask for help (e.g. NARI staff).

The workshop is usually concluded with an open discussion between participants and research group (Figure 18).

Figure 17: A farm visit at Dorothy Luana's place, Rum Jungle Warangoi

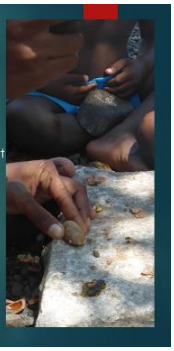
Figure 18: Godfrey Hannett discuss farm issues with participants in the farm day training workshop

11.1.9 Training to access new markets

The slides presented in this package include:

How can we build on what we are already doing?

- We are not suggesting changing what you already do and have done for a long time.
- Things around us are changing and we may need to adapt



Packaging & Storage

- Karamap only lasts one day, maybe two (Dries out and mould)
- Drying and roasting increases shelf life
- Pan roasting, Solar Driers, Ovens, Dehydrators
- Different Packaging can improve shelf life (Vacuum Sealer)

Labelling

- Provides details of what the product is and the procedures
- Ingredients, Date packaged, Expiry Date
- Makes a product more attractive
- Will sometimes allow for import through Customs
- Flowers on the stall
- Competitive advantage

Wholesaling

- We all understand profit
- Retail stores buy from wholesalers and mark up products
- What do Retailers want?

- Safe Product
- Attractive Product
- Date packaged or Date of expiry
- To make money


Different
Products


New Ventures
HOTELS & RESORTS
Store

11.1.10 Food recipe leaflet for workshops

Contributed by Simaima Kapi Ling

Carolyn's galip bread recipe

Ingridiens:

12pla kap plain flawa 6pla tbsp. yeast

1pla kap suga

½ kap cooking oil

2pla kap kernel cake (Yu ken usim Almond cake sapos inogat Galip)

3pla kap kiln Wom wara

1pla kap milk

Wei blong beikim

- Addim Plain flawa igo insait lo bowl
- Addim suga na yeast na mixim gut
- Addim kernel na mixim gut ken
- Mekim hol namel lo mix blo yu na addim cooking oil na mixim
- Bihain addim 3pla kap wom wara na 1pla kap milk na mixim gut tru inap emi kamap dough.
- Bihain larim na waitim bai dough isolap gut
- Bihain putim mix igo insait long baking tray na redim lo beikim.

Galip cookies

Ingridiens:

125 g Bata
1pla na ½ Self raising flawa 1pla kiau
1pla kap suga 1pla kap Galip nut

Wei blong bakim

- Hotim oven inap lo 180oC pastaim
- Mixim suga na bata bai i creamy pastaim bihain addim kiau
- Mixim olgeta insait lo flawa bihain addim galip nuts na bungim olgeta wantaim na mixim gut
- Putim gris lo baking tray gut na bakim long 6 – 10pla minits inap em I brown gut

Painapal na kavavar jam

Ingridiens:

2pla kap painapal (katim liklik)

1pla tbs kavavar (sikirapim)

1pla kap kiln wara

2pla kap suga

3pla tbs wara blo lemon

Wei blo kukim:

Tanim olgeta ingridiens inap suga i mix gut.Bihain kukim/boilim inap lo 30pla minit.

Mango na kavavar lemon jam

Ingridiens:

6pla mango (katim go liklik tru)

3pla kap suga

1pla na ½ tabs kavavar (sikirapim)

1pla lemon –kisim wara blo em

Wei blo Kukim

Tanim na mixim gut suga gut tru na bihain katim 1pla lemon na rausim skin blo em.Boilim ogeta inap yu lukim isolap na bihain rausim skin blong lemon.

Banana na lemon jam

Ingridiens:

1pla na ½ han mao banana (banana mao imas mao gut tru)

1/3 kap wara blong lemon

½ kap kiln wara

1pla vanilla bin

4pla kap suga

1/3 kap wara blong lemon

Wei blong kukim

- Bungim olgeta mao banana, wara blong lemon,kiln wara,bin/sid blong vanilla na boilim gut na karamapim inap long 10pla minit inap I malumalum gut.
- Bihain addim suga na tanim antap long gutpla paia na bai kuk gut.Kukim gut inap jam isolap.

Popo na kavavar jam

Ingridiens

2pla mao popo

¾ kap wara blong lemon

Kg suga (bikpla suga)

1pla na ½ tbs kavavar (sikirapim gut tru)

1pla tbs kavavar (katim bikpla hap)

Wei blong kukim

- Katim popo, bungim wantaim wara blong lemon na kavavar na boilim inap long 5pla minit. Daunim strong blong paia na addim suga na tanim/mixim gut suga inap l pinis.
- Kukim na mixim klostu klostu bai noken paia na jam bai iken solap.

Cordial/Iceblock

Ingridiens:

Skin blo painapal

Kavavar na lemon

Suga

1pla liklik spun (tispun) Tartaric Acid

Wei blong Kukim

Boilim inap long 1pla hour.Larim bai kol bihain addim citric acid na kapsaitim igo insait long klinpla botol.

11.1.11 Health and hygiene leaflet

Contributed by Simaima Kapi Ling

HANDWASHING (WASIM HAN)

WASIM GUT HAN BIPO NA BIHAIN LONG YU REDIM O HOLIM KAIKAI.

PASIN BLONG LUKAUTIM YU YET LONG OL KAIN SIK TAIM YU REDIM KAIKAI NA HOLIM KAIKAI.

NAMBAWAN NA BIKLA SAMTING BIPO YU HOLIM, REDIM NA KUKIM KAIKAI EM, WASIM HAN WANTAIM SOP.

WASIM HAN EM BIKPLA NA IMPOTENT SAMTING TAIM YUMI RERE LONG REDIM KAIKAI OLGETA TAIM.

WAI NA EMI IMPOTENT TRU LONG WASIM HAN?

- Bai rausim ol deti nogut we yu ken kisim long narapla manmeri,ol animals o long ol wanem ol kainkain samting yu holim lo han.
- Na tu yumi nonap long lukim ol kainkain deti o germs wantain tupla ai blong yumi .Olsem tasol na wasim han tasol bai halivim yumi long noken givim sik na kisim sik ong narapla manmeri.
- Planti manmeri itok olsem yumi ken kisim deti o sik long win yumi pulim tasol nogat bikpla tru deti isave kalap taim yumi holim long han tasol.
- Wasim han tasol ba rausim gut tru ol deti long han taim yumi rinsim gut tru han wantaim sop.Na isave daunim tru ol bikpla sans long ol bikpla germs taim yumi wasim wantaim sop.
- Olsem na emi impotent tru long wasim han wantaim sop na kiln wara bipo yu holim kaikai.

HOW BAI YU WASIM HAN BLONG YU?

- KAPSAITIM WARA SOP O RABIM SOP RAUNIM OL HAND BLO U GUT TRU ANINIT LO GUTLA TAP WARA O INSAIT LO DISH WARA.
- TAIM YU LAIK SAVE OSEM HAND EMI KLIN GUT….YU KEN SINGSING,HEPI BIRTHDAY SONG……EM BAI KISIM 20 SECONDS LO WASIM HAND.
- RINSIM GUT HAND NA DRYIM LO KLIN HAND TOWEL O PEPA TOWEL.

SAMPLA HAP WE DETI I BIKPLA TUMAS LONG EM.(GERMS HOT SPOT)


Mobile

Toilet

Kitchen sink


Dishwashing

Doorknob


Kitchen

GUTPELA HELT NA PASIN BLONG WASIM HAN BIPO YU HOLIM KAIKAI EMI NAMBAWAN INSAIT LONG NARI GALIP FACTORY.

- **WERIM LAB COATS, HAN GLOVES NA HAIR NETS.**
- **WASIM GUT OL HAN NA OL PINGA TU IMAS KLIN GUT TRU PASTAIM BIPO YU HOLIM GALIP.**

TINGIM…..WASIM HAND OLGETA TAIM BIPO NA BIHAIN LONG YU HOLIM KAIKAI!!

EM TASOL NA TENKYU TUMAS……..BY: Simaima Ling Kapi

11.1.12 Food safety booklet for women in markets

Contributed by Dr. Shahla Hosseini Bai and Ms. Simaima Kapi

National Agricultural Research Institute

Food Safety Practices

NARI Kerevat

March 2017

PERSONAL HYGIENE- HANDWASHING

Handwashing is very important and essential law that all food handlers must always do before and after handling food.

WHY IS IT IMPORTANT TO WASH HANDS?

Washing and Cleaning your hands get rid of germs you pick up from other people, from the surfaces you touch and from the animals you come in contact with.
And because germs cannot be seen by naked eyes, handwashing is the best practice we all must do to keep from getting sick and spreading illnesses.
Although people usually think that germs are spread through the air, the fact is that germs are most easily spread through **hand contact.**
Washing hands helps to physically remove germs by friction and to rinse down the drain.
Washing hands reduces the amount of germs present on hands through the use of alcohol based preparations in the form of solutions, gels or foams (bar soap).
It is always important to WASH hands with soap and water anytime they are visibly dirty.

HOW LONG DO YOU WASH YOUR HANDS?

Wet your hands and apply liquid, bar, or powder soap.
Rub hands together vigorously to make a lather and scrub all surfaces.
Continue for 20 seconds! It takes that long for the soap and scrubbing action to dislodge and remove stubborn germs. Need a timer?
Imagine singing "Happy Birthday" all the way through – twice! Rinse hands well under running water.
Dry your hands using a paper towel or air dryer.

WHAT DO WE DO IN THE GALIP FACTORY?
Put on lab coats, hand gloves and hair nets.

Hand washing and personal hygiene is essential when cracking nuts or handling kernel.

FOOD SAFETY

It is law that all food businesses must only produce food that is safe to eat. Unclean surfaces and **not** washing hands can contaminate nuts with germs that make people sick.

Good hygiene is essential.

Good hygiene, clean surfaces, clean clothes, and clean hands are essential when processing food.

- Always wash your hands and any surfaces that will contact the kernels with soap or disinfectant before starting work
- Cracking must be done only in clean hygienic conditions

All tools and surfaces must be washed with soap or disinfectant before cracking

Ensure you use a clean surface for cracking nuts. All surfaces and equipment must be washed with soap or disinfectant before commencing cracking.

Separating bad nuts from good nuts

Identifying bad nut include:

Seeing mouldy nuts can be contaminated with aflatoxin, a poison that can cause cancer and other health effects. Any nuts that have mould **must be thrown** away. Washing off the mould does not get rid of the poison.

Floating test:
Bad nuts will float

Drying methods

To increase shelf-life nuts, you need to dry them.

Electric dryer or dehydrator

Solar Dryer

Fire oven

Over hot stones

Over the fire

Drying time

Break the kernel if it breaks easily so it is dry.

Storage

Kernel in Testa or kernel must only be stored in **NE**
bags or **sterilized containers**.

Labelling

You can make your own labels to add value to your product.

For further information contact

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12.4 Minimum standards for raw, blanched and roasted galip nut in PNG

Kim Jones, Dalsie Hannett, Dr. Shahla Hosseini-Bai, Bruce Randall, Prof. Helen Wallace

Minimum Standards for raw, blanched and roasted galip nut

Description of Grades:

Premium

Premium A grade: whole plump kernels, fully mature, with or without testa, measuring greater than 3.0cm long and 1.3cm wide. *Whole kernels* are kernels, which are not split or separated into pieces with not more than 10% of the kernel missing

Figure 1 Premium peeled kernel greater than 3.0cm long and 1.3cm wide

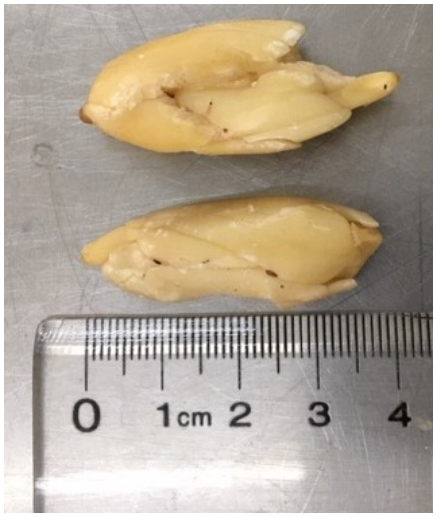

Figure 2 Premium peeled kernel with minor chips. Less than 10% missing greater than 3.0cm long and 1.3cm wide

Figure 3 Premium A grade KIT. Greater than 3.0cm long and 1.3cm wide

Figure 4 Premium A grade KIT with minor chips. Less than 10% missing

Premium B grade: whole plump kernels fully mature, with or without testa measuring less than 3.0cm long and 1.3cm wide. *Whole kernels* are kernels, which are not split or separated into pieces and with not more than 25% of the kernel missing. Premium A grade kernel with between 10 and 25% missing are classed as premium B grade.

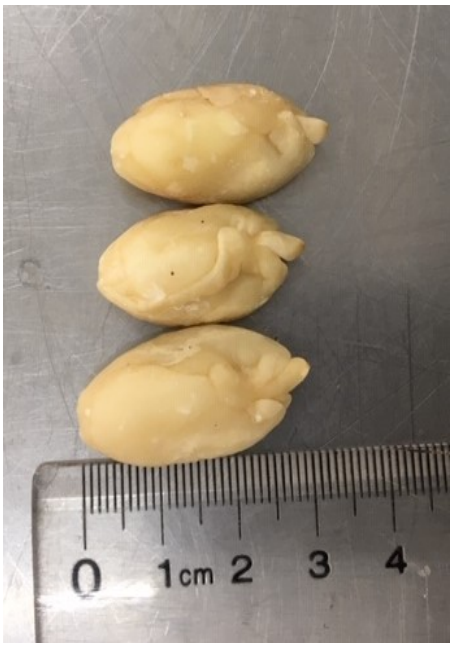

Figure 5 Premium B grade peeled kernel less than 3.0cm long and greater than1.3cm wide

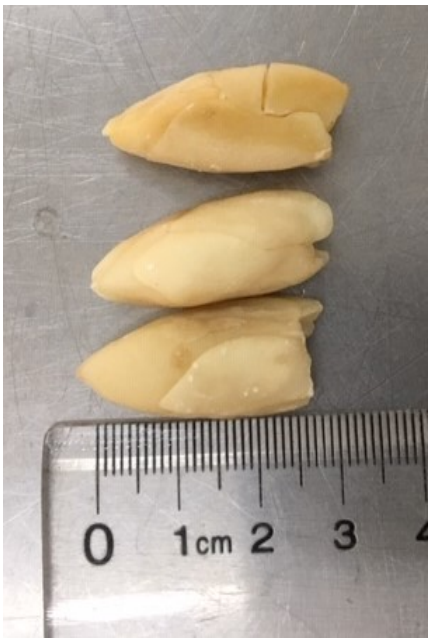

Figure 6 Premium peeled kernel with chips not not greater than 10% and less than 25% missing is classified as B grade

Figure 7 Premium B grade KIT less than 3.0cm long and < 1.3cm wide

Figure 8 Premium KIT with chips not greater than 10% and less than 25% missing is classified as B grade

Premium manufacturing grade:

Is made from premium kernel that are broken with pieces larger than 3mm and is suitable for such products bakery, culinary, ice cream etc..

Figure 9 Premium manufacturing grade. Chips and pieces of premium kernel larger than 3 mm.

Oil stock grade:

Immature kernel and shrivelled as well as small pieces and chips of premium kernel less than 3mm diameter, translucent kernels, immature kernels, and kernels with small defects as well as reject kernel from roasting due to excessive darkening or visible after roast defects. Does not contain any kernel with visible mould.

Figure 10 Kernel with roasting defects classified as oil stock

Reject kernel and KIT

Reject kernel is all kernel with visible mould, sever discolouration, insect damage, or rancidity.

Figure 11 Reject kernel due to brown discolouration. (cause thought to be old nuts)

Figure 12 Reject kernel due to black spot (cause unknown)

Figure 13 Reject KIT due to very small or no kernel inside. (cause unknown)

Minimum Standards

Raw galip kernel in testa (KIT)

Raw galip kernel in testa (KIT) is obtained from nuts of trees of the species *Canarium indicum.* Raw KIT should be fully mature, plump (unshrivelled), kernel surrounded by a brown testa.

Composition

Surface moisture	Nil
Dust[1]	Not more than 0.1%
Foreign matter[2]	Nil
Loose shell[3]	Not more than 1 piece per 1kg
Impacted shell[4]	Not more than 1%
Unsound kernel[5]	Not more than 2%
Insect infestation	Nil
Visible mould	Nil
Kernel moisture	Average of 2% by weight[6]
Microbiological: • Standard Plate Count: • *E. coli*: • *Salmonellae*: • Mould count:	 Less than 30,000 cfu / g Less than 3 *E.coli* / g (using MPN method); or Not Detected in 0.1 g (using Triplicate Tube method) Not Detected in 25 g Less than 20,000 mould colonies / g
Aflatoxin[7] • Total • B_1	Maximum admissible level: 4 μg / kg (i.e. ppb) Maximum admissible level: 2 μg / kg (i.e. ppb) Conforms to importing country's requirements
Peroxide Value[8]	Maximum 3 meq / kg oil
Free Fatty Acid[9]	Maximum 0.5% calculated as oleic acid
Acid Value	1mg KOH/g of Oil
Chemical residues[10]	Not in excess of maximum residue limits as published in the Food Standards Code[11] Conforms to importing country's requirements.

---

1 *Dust is any loose substance, which will pass through a 2 mm square opening.*
2 *Foreign matter is any loose substance other than galip kernel or testa (including loose shell which will not pass through a 2 mm square opening).*
3 *Loose Shell means any loose shell, which will not pass through a 2 mm square opening.*
4 *Impacted Shell means any adhering shell greater than 1 mm in length and width.*
5 *Unsound Kernel is kernel, which is unsuitable for processing and/or sale as raw kernel due to the presence of insect damage, mould, decay, shrivelled, discolouration, or rancidity.*
6 *Unless requested otherwise by the customer.*
7 *Reference: DIR.98/ Commission of European Communities referring to work of WHO and WTO.*
8 *Determined on extracted oil*
9 *Determined on extracted oil*
10 *Chemical Residues are substances specified in Part A14 of the Food Standards Code, which includes residues of pesticides, herbicides, and fungicides.*
11 *Food Standards Code, Australian New Zealand Food Authority (ANZFA), Section A14 Maximum Residues Limits. According to standards set by the importing country.*

Blanched galip kernel (Testa removed)

Blanched galip kernel is obtained from nuts of trees of the species *Canarium indicum*. Blanched galip kernel should be fully mature, plump (unshrivelled) kernel with testa removed. Cracked galip kernel in testa is graded into sound and unsound kernel in testa then blanched and the testa removed by hand.

Composition

Surface moisture	Nil
Dust[12]	Not more than 0.1%
Foreign matter[13]	Nil
Loose shell[14]	Not more than 1 piece per 1 kg
Impacted shell[15]	Not more than 1%
Unsound kernel[16]	Not more than 2%
Insect infestation	Nil
Visible mould	Nil
Kernel moisture	Average of 2% by weight
Microbiological: • Standard Plate Count: • *E. coli*: • *Salmonellae*: • Mould count:	 Less than 3,000 cfu / g Less than 3 *E.coli* / g (using MPN method); or Not Detected in 0.1 g (using Triplicate Tube method) Not Detected in 25 g Less than 20,000 mould colonies / g
Aflatoxin[17] • Total • B_1	 Maximum admissible level: 4 μg / kg (i.e. ppb) Maximum admissible level: 2 μg / kg (i.e. ppb) conforms to importing country's requirements
Peroxide Value[18]	Maximum 5 meq / kg oil
Free Fatty Acid[19]	Maximum 0.5% calculated as oleic acid
Acid Value	1mg KOH/g of Oil
Chemical residues[20]	Not in excess of maximum residue limits as published in the Food Standards Code[21] Conforms to importing country's requirements.

12 *Dust is any loose substance, which will pass through a 2 mm square opening.*

13 *Foreign matter is any loose substance other than canarium kernel or canarium testa (including loose shell which will not pass through a 2 mm square opening).*

14 *Loose Shell means any loose shell, which will not pass through a 2 mm square opening.*

15 *Impacted Shell means any adhering shell greater than 1 mm in length and width.*

16 *Unsound Kernel is kernel, which is unsuitable for processing and/or sale as blanched kernel due to the presence of insect damage, mould, decay, shrivelled, discolouration, or rancidity.*

17 *Reference: DIR.98/ Commission of European Communities referring to work of WHO and WTO.*

18 *Determined on extracted oil*

19 *Determined on extracted oil*

20 *Chemical Residues are substances specified in Part A14 of the Food Standards Code, which includes residues of pesticides, herbicides, and fungicides.*

21 *Food Standards Code, Australian New Zealand Food Authority (ANZFA), Section A14 Maximum Residues Limits. According to standards set by the importing country.*

Roasted galip kernel in testa (KIT)

Roasted galip kernel in testa (KIT) is prepared from nuts obtained from trees of the species *Canarium indicum*. Roasted galip KIT is prepared from fully mature (plump) raw galip kernels which are roasted in air or edible oil, and may be either salted or unsalted, and may contain preservatives and other additives as permitted under the Food Standards Code.

Composition

Foreign matter[22]	Nil
Reject kernel[23]	Not more than 2%
Loose extraneous matter[24]	No more than 0.1%
Loose shell[25].	Not more than 1 piece per 1 kg
Impacted shell	Not more than 1%
Moisture	Average of 2% by weight
Microbiological [26]: • Standard Plate Count: • *E. coli*: • *Salmonellae*: • Mould count:	 Less than 3,000 cfu / g • Less than 3 *E.coli* / g (using MPN method); • or Not Detected in1.0g (using Triplicate Tube method) Not Detected in 250 g Less than 1,000 mould colonies / g
Aflatoxin[27] • Total • B_1	 Maximum admissible level: 4 μg / kg (i.e. ppb) Maximum admissible level: 2 μg / kg (i.e. ppb) Conforms to importing country's requirements.
Peroxide Value[28]	Maximum 5 meq / kg oil
Free Fatty Acid[29]	Maximum 0.5% calculated as oleic acid
Chemical residues[30]	Not in excess of maximum residue limits as published in the Food Standards Code[31] Conforms to importing country's requirements.

---

22 *Foreign matter is any loose substance other than galip kernel or galip testa (including loose shell) which will not pass through a 2 mm square opening.*

23 *Reject kernel is any kernel which is excessively dark (see Standard Colour Chart) and/or inedible due to the presence of insect damage, mould, decay, shrivelled, discoloured, and/or rancidity.*

24 *Loose extraneous matter refers to any kernel pieces, and shell pieces which will pass through a 2 mm square opening.*

25 *Loose shell means any loose shell which will not pass through a 2 mm square opening.*

27 *Reference: DIR.98/ Commission of European Communities referring to work of WHO and WTO.*

28 *Determined on extracted oil*

29 *Determined on extracted oil*

30 *Chemical Residues are substances specified in Part A14 of the Food Standards Code, which includes residues of pesticides, herbicides, and fungicides.*

31 *Food Standards Code, Australian New Zealand Food Authority (ANZFA), Section A14 Maximum Residues Limits.*

Manufacturing grade roasted galip kernel in testa (KIT)

Manufacturing grade roasted galip kernel in testa (KIT) is prepared from nuts obtained from trees of the species *Canarium indicum*. Manufacturing grade roasted galip KIT is prepared from pieces of broken premium KIT and roasted in air.

Composition

Foreign matter[32]	Nil
Reject kernel[33]	Not more than 2%
Loose extraneous matter[34]	No more than 0.1%
Loose shell[35].	Not more than 1 piece per 1 kg
Impacted shell	Not more than 1%
Moisture	Average of 2% by weight
Microbiological [36]: • Standard Plate Count: • *E. coli*: • *Salmonellae*: • Mould count:	 Less than 30,000 cfu / g • Less than 3 *E.coli* / g (using MPN method); • or Not Detected in1.0g (using Triplicate Tube method) Not Detected in 250 g Less than 1,000 mould colonies / g
Aflatoxin[37] • Total • B_1	Maximum admissible level: 4 μg / kg (i.e. ppb) Maximum admissible level: 2 μg / kg (i.e. ppb) Conforms to importing country's requirements.
Peroxide Value[38]	Maximum 5 meq / kg oil
Free Fatty Acid[39]	Maximum 0.5% calculated as oleic acid
Chemical residues[40]	Not in excess of maximum residue limits as published in the Food Standards Code[41] Conforms to importing country's requirements.

[32] *Foreign matter is any loose substance other than galip kernel or galip testa (including loose shell) which will not pass through a 2 mm square opening.*

[33] *Reject kernel is any kernel which is excessively dark (see Standard Colour Chart) and/or inedible due to the presence of insect damage, mould, decay, shrivelled, discoloured, and/or rancidity.*

[34] *Loose extraneous matter refers to any kernel pieces, and shell pieces which will pass through a 2 mm square opening.*

[35] *Loose shell means any loose shell which will not pass through a 2 mm square opening.*

[37] *Reference: DIR.98/ Commission of European Communities referring to work of WHO and WTO.*

[38] *Determined on extracted oil*

[39] *Determined on extracted oil*

[40] *Chemical Residues are substances specified in Part A14 of the Food Standards Code, which includes residues of pesticides, herbicides, and fungicides.*

[41] *Food Standards Code, Australian New Zealand Food Authority (ANZFA), Section A14 Maximum Residues Limits.*