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Small research and development activity

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prepared by	Associate Professor Christie Chang, University of New England
co-authors/ contributors/ collaborators	Mr Anton Mais, Ms Miriam Simin, Ms Isidora Ramita and Dr Joel Waramboi, National Institute for Agricultural Research, PNG
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Executive summary

This project was a pilot study aimed at assisting community groups and entrepreneurs in Papua New Guinea (PNG) to identify and assess product and market development opportunities for processed sweetpotato products.

Food processing using local materials has the potential to add value, reduce freight costs, and increase the shelf life of fresh produce, and create employment and income-generating opportunities for smallholder farmers and rural communities. More importantly, in the longer term a well-functioning food processing sector is crucial to farming sector sustainability, since the demand for value-added and processed products increases along with economic development. However, it has been difficult for the government and industry to develop an efficient food processing sector from a very low base. In this project, we sought to develop and test a framework from which commercially viable home-grown small-scale processing enterprises can be established. Sweetpotato processing was chosen as the pilot case because it is the major food crop in PNG, and opportunities exist for enterprise diversification to increase and stabilise farm household income through value-adding and processing.

Previous ACIAR research (ASEM/2008/035 and ASEM/2012/046) showed that processed sweetpotato products had a marketing advantage, especially when they were produced with locally available materials. However, adoption of processing technology by farm households and women's groups was found to be low. This was due to lack of access to equipment (milling machines, baking ovens, kitchen utensils, etc), ingredients (milk, sugar, butter, eggs, etc), and basic services (transport, clean water, electricity, credit, technical support, etc). Additionally, a review of the Food Processing and Preservation Unit (FPPU) at Unitech (in operation from 1984 to 2007) showed that failure to develop a food processing sector was due to FPPU itself being improperly managed, and trainees being inadequately equipped with the business and entrepreneurial skills required to access markets and support services. Given that previous research on food processing and training in PNG has tended to focus on addressing technical issues, in this project we focused on addressing the capacity and marketing issues facing small-scale food processors. The project involved four main activities: on-station research to improve flour processing efficiency; village-level product and market development to improve marketing; training workshops to build marketing and business skills; and working with primary schools to raise awareness and promote sweetpotato processing to the wider community.

Key results:

1. the quality of flour was robust under different treatments (chipping vs grating, sun-drying vs oven-drying, single vs mixed variety, or peeling vs non-peeling);
2. demand for products made from sweetpotato existed but on a small scale;
3. training workshops in costing and gross margin analysis were effective in enhancing market-orientation and profit motive; however, monitoring and continuing technical assistance over a sufficient period of time would be required to develop the skills and to obtain accurate and meaningful quantitative results; and
4. working through the education system and educating school teachers and students could be a good starting point to raise awareness of food processing and to encourage innovation and entrepreneurship in young people – often lacking in PNG rural areas due to limited exposure to new ideas.

Key recommendations:

- The farmer business school approach can be employed to improve small business management/entrepreneurial skills of enterprising farmers and young entrepreneurs.
- To promote agroenterpprise development on a large scale, business development support services need to be improved and made readily available to farmers at a reasonable cost.

1 Introduction

Developing an agri-food processing sector has the potential to speed up the process of rural development and industrialisation of an economy. This has been a key development strategy used by governments worldwide, especially in developing countries. In recent years it has also been applied by international development agencies such as the Food and Agriculture Organisation, the United Nations Industrial Development Organisation, and the International Fund for Agricultural Development (Konig et al., 2013). The demand for value-added food and agricultural products has been increasing, and will continue to increase as a result of growing per capita incomes, higher urbanisation, and changing socio-demographics (da Silva et al., 2009). This growth prospect constitutes a push for increased attention to agro-industries development within the context of economic growth, food security and poverty-fighting strategies. 'Agro-industries for development' is broader in scope than 'Agriculture for development', since the former has the potential to provide employment for the rural population not only in farming, but also in off-farm activities such as handling, packaging, processing, transporting and marketing of food and agricultural products.

The development of a food processing and preservation industry was identified by the Papua New Guinea (PNG) government as one of the priority programs in the National Agricultural Development Plan 2007-2016 (Ministry of Agriculture and Livestock, 2006). The objective was to develop commercial and cottage industries for food processing and preservation to increase farm profitability, create employment, reduce freight costs, and increase shelf life. Five development strategies were outlined:

- Strategy 1: Conduct feasibility study;
- Strategy 2: Long term research and development;
- Strategy 3: Development of new products;
- Strategy 4: Training and information dissemination; and
- Strategy 5: Product testing.

Strategies 1-2 have been implemented by Chang and Mais (2014), with the support of ACIAR (ASEM/2012/046). The results from the feasibility study showed that sweetpotato flour was not cost competitive compared with wheat flour. However, processed sweetpotato products had a marketing advantage, especially when they were produced with locally available materials. Despite this, there was little awareness of sweetpotato or food processing in PNG, including its potential and benefits. In this project, we aimed to implement Strategies 3, 4 and 5 and address the issues of product development, market development and promotion. Furthermore, given that this project was effectively a follow-up on the previous study, we strived to improve on what have been done so far based on lessons learned and recommendations made, especially in regards to on-station research (and report writing) and product development.

The main objectives and activities of this project were:

- On-station trials to improve the quality of sweetpotato flour and flour yields;
- Training workshops to improve business acumen of potential entrepreneurs;
- A School Project to raise awareness and promote food processing in the wider community; and
- Product competition to encourage entrepreneurship and innovation among students.

The research was based on participatory action research, which enabled us to work closely with our collaborators to identify and address issues that were important to them. In the following sections, we outline the main project activities, and then present and discuss the results. The report concludes with recommendations for further research, development and extension activity (RD&E).

2 On-station sweetpotato flour production trials

2.1 Sweetpotato processing

Sweetpotato flour processing involves a number of steps (Figure 1).

Fresh sweetpotato roots
|
Weighing*
|
Trimming*
|
Washing
|
Peeling
|
Slicing/shredding
|
Soaking (bleaching/blanching)*
|
Pressing*
|
Spreading
|
Drying
|
Grinding
|
Sifting*
|
Weighing*
|
Packaging

Figure 1. Flowchart of sweetpotato flour processing

Source: Van Hal (2000).

This is not a complex process, and can be completed without sophisticated equipment or significant capital investment. However, each of these steps has some bearing on the final quality and processing cost of the flour, with regard to the selection of fresh roots, peeling, soaking, drying, and packaging. These steps are discussed in the following sub-sections.

2.1.1 Factors affecting flour quality

Selection of fresh sweetpotato roots

Sweetpotato roots are classified into two general types in terms of dry matter content and colour: dry-fleshed cultivars with mealy, light yellow or white flesh; and moist-fleshed cultivars with soft, gelatinous, bright orange flesh. Choice of variety has the most significant effect on the conversion rate of root to flour, or flour yield. Gakonyo (1993) estimated the maximum flour yield of sweetpotato to be 37.7%, assuming a moisture content of 70% for fresh roots, a desired moisture content of 12% for flour, and a 10% wastage rate. At a conversion rate of 37.7%, it takes 2.65 kg of unpeeled roots to produce one kg of flour. At a conversion rate of 25%, it takes one kilogram of unpeeled roots to produce one kilogram of flour. Yields reported in the literature range from 17 to 38%, but they are most likely to be in the range of 25 to 29% (see Figure 2). Dry matter content and flour yield are the most important factors influencing processing cost. Careful consideration must be given to the selection of raw sweetpotato roots, as dry matter content can vary from 65-81%, depending on variety.

To achieve a white flour colour, the ideal variety will be low in total sugar, reducing sugar (not exceeding 2% on a dry weight basis), amylase activity, and polyphenol oxidase to limit discolouration during processing (Lizado and Guzman, 1982).

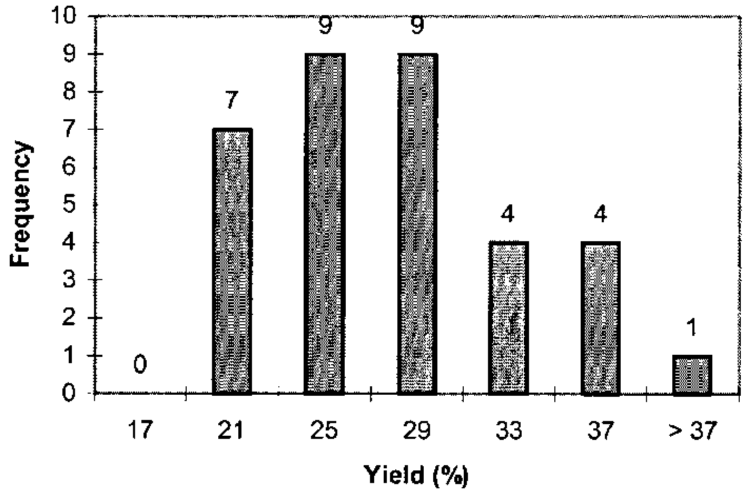

Figure 2. Distribution of yield of flour of different sweetpotato varieties

Source: Van Hal (2000).

In addition to choosing the right variety, the physical characteristics of fresh roots are also important. For any given variety, sweetpotato roots must be selected based their size and shape, while also minimising rotting, insect damage, excessive mechanical damage, and excessive soil or other foreign materials. Peeling takes more time when the roots are too big, too small, or irregularly shaped. Excessive culling and trimming to remove undesirable parts of roots will increase wastage, reduce yield, and increase labour costs (Gakonyo, 1993). For industrial production, sorting and grading are essential and must be carried out on farm rather than at the processing site, to reduce transport costs and to avoid disease transmission during transit.

Once good quality roots have been selected, critical points during sweetpotato flour processing include peeling, soaking, and drying. Significant changes to flour yield and the nutritional value of sweetpotato roots can occur during each of these stages.

Peeling

Peeling removes the skin from the root, and can be carried out manually or mechanically. Peeling is sometimes included in the process to increase the quality of the flour, but it can lead to product loss, and reduced flour yields (Gakonyo, 1993). The wastage rate from peeling depends on the form and irregularity of the roots, but an average wastage rate of 10% of root weight is common. In addition, peeled sweetpotato roots must be submerged in water to avoid browning. Since the peel of the root is thin, it does not pose problems if it is not removed before processing. Elimination of the peeling step cuts down on processing time, since peeling is time-consuming work in addition to contributing to a degree of wastage. However, using unpeeled roots requires the washing step to be especially thorough. Flours from peeled and unpeeled roots are different in composition, since flour from the latter is higher in ash and crude fibre (Gakonyo, 1993). The decision to peel or not to peel is therefore largely dependent on consumer's willingness to accept a slightly browner flour, caused by the colour of the skin.

Soaking (Bleaching/Blanching)

Discolouration of sweetpotato slices/shreds can also produce a browner flour, due to the action of oxidase enzymes, and can be enhanced by mechanical or heat treatment (Silva,1990). Soaking or dipping sweetpotato slices or shreds in water (cold or boiling) or in solutions which may contain sodium sulphite, sodium meta-bisulphite, citric acid, acetic acid or potassium for 3 to 10 minutes decreases oxidase activity and thus prevents browning. In addition to preventing browning and helping to whiten the final product, soaking also preserves the natural flavour of the sweetpotato, and prevents microbiological contamination (Lizado and Guzman, 1982; Gakonyo, 1993). However, it can decrease yield by: reducing solubles; increasing the final moisture content of the flour where the solution sodium bisulphite reduces evaporation; decreasing total sugar, starch, amylose and ash content; and result in shrinkage of the slices due to plasmolysis (Widowati and Damardjati, 1992).

Drying

Drying is the most critical step in processing sweetpotato for its impact on final flour quality and processing cost. Excessive drying can reduce yield and increase cost. Different drying methods exist. Solar drying is the cheapest since it uses free, non-polluting energy with a minimum investment in equipment. However, solar drying has a number of disadvantages, including: poor control of energy input and product quality; interruptions to drying caused by cloud, rain, and nightfall; and frequent contamination of food by microorganisms, dust, and insects.

However, drying sweetpotato root slices in direct sunlight and open air (sun-drying) or in an enclosed, greenhouse-type apparatus (solar-drying) is frequently carried out. Various drying times from 4, 6–7, 8, 12–15 hours, up to 1, 2, and as much as 5 days have been recorded, depending on climatic conditions (Winarno, 1982). Normally, slices were dried until they reached a moisture content of about 6–10%. Both white and coloured varieties have been found to be suitable for solar drying (Winarno, 1982). In many countries, solar drying is used as a simple and cheap method. It requires very few purchased inputs and is suitable for home and small-scale use, as well as at a commercial scale. Lizado and Guzman (1982) observed that the point at which the sweetpotato slices become brittle corresponds with reaching constant moisture content, and as such this could be used as an empirical criterion for completing the drying process. However, the quality of food dried in direct sunlight is often considered inferior to that of food dried using other methods, such as drum or spray drying (Woolfe, 1992).

Drum or spray drying is often used in commercial-scale enterprises. These are highly technical processes, and use large amounts of energy. Therefore, drum or spray drying may not be suitable for many developing countries (Martin, 1984). The final flour obtained from drum or spray drying is different to that where solar drying is used, since the flour leaves the drum dryer, or leaves the sprayer pre-cooked. However, heat processing treatments can have a negative influence on protein quantity and quality, depending on the period and intensity (temperature) of heat exposure (Martin, 1984).

Packaging/storage

Sweetpotato flour can be packaged and sealed in different forms of packaging material, including porcelain and glass jars, tin cans, paper ‘‘craft’’ bags, polypropylene bags, polyethylene bags, cotton bags, or a combination of two different materials, for example polyethylene and cotton bags together. Although flour is less vulnerable to spoilage during storage than fresh roots, it still has a capacity to absorb moisture. Orbase and Autos (1995) studied the effect of different packaging materials (polyethylene, muslin cloth, and polyethylene/muslin cloth) on the microbiological quality of sweetpotato flour. They found that the microbial count (bacteria, moulds, and yeasts) did not change over 5-7 months or with different packaging materials.

Dried sweetpotato products have a higher sugar content, which can favour microorganism growth and can also attract insects (Woolfe, 1992). For prolonged storage, sweetpotato flour must be stored in sealed containers or packaging with a low initial moisture content (no more than 10%). The packaging material must be impermeable to vapour and gas, resist tearing, protect against environmental contamination, be easy to handle, and preferably be inexpensive. Sweetpotato flour can maintain its quality for 5 to 7 months, as long as it is stored in cool, dry, dark places using appropriate packaging such as polypropylene or polyethylene bags.

2.1.2 Quality standards for sweetpotato flour

The most important quality characteristics of sweetpotato flour are moisture content, protein and β-carotene content, microbiological quality, colour, taste, and odour.

The quality of sweetpotato flour is defined in the African Standard CD-ARS 827:2012(E) (ARSO, 2012). This Standard covers requirements regarding raw material quality, the colour, odour and particle size of flour, nutritional contents and microbiological limits, the presence of micro-organisms, food additives and contaminants (pesticide residues, heavy metals, mycotoxin, chemicals, and other contaminants), and packaging and labelling standards.

African nutrient composition and hygienic and food safety requirements are presented in Tables 1 and 2, respectively.

Table 1. Compositional requirements for sweetpotato flour in Africa

Parameter	Requirement (In % on dry matter basis)	Method of test
Total ash	< 3.0	ISO 2171
Moisture	< 12.0	ISO 712
Crude fibre	< 5.0	ISO 5498
Acid insoluble ash	< 0.15	
Total sugar (as sucrose)	> 6.0	ISO 2173
Starch	> 60.0	ISO 15914
pH of aqueous extract	4.5-7.0	ISO 1842
Cold water solubles	< 12.0	ISO 941

Source: African Organisation for Standardisation (ARSO; 2012).

Table 2. Microbiological limits for sweetpotato flour in Africa

Micro-organisms	Requirement	Method of test
Escherichia coli, cfu/g	< 1	ISO 7251
Salmonella, 25g	Absent	ISO 6579
Yeasts and moulds, cfu/g	$< 10^4$	ISO 21527-1

Source: African Organisation for Standardisation (ARSO; 2012).

A variety of data show that, using existing technology, flour of a desirable quality can be made even at the household/village level (Wheatley et al., 1995; Van Hal, 2000).

2.1.3 Producing high quality sweetpotato flour

To produce high quality sweetpotato flour, due consideration must be given to the quality of the raw material, processing, and storage. The preceding section suggests that various factors are involved:

- Ideally, the roots should be high in dry matter content and low in polyphenolic compounds.

- If a white coloured flour is desirable, peeling is necessary. However, not peeling increases yield.
- Soaking, with or without sodium meta-bisulphite or citric acids, can prevent browning and discolouration, as well as microbial contamination.
- Heat treatment with high heat intensity during drying can cause damage to the protein and the β-carotene contents of the slices.
- Using solar drying is cheap, but it requires considerable attention to hygiene.
- The initial moisture content should be low (< 10%) for storing sweetpotato flour, and levels of moisture uptake can be limited using appropriate packaging.

Angue and Inocencio (1992) observed that studies in the area of sweetpotato processing tend to focus on chemical analysis of the flour, while research to improve sweetpotato processing technologies was rarely carried out. This is an important oversight, since processing costs depend on the type of technology used, and can be reduced by using inexpensive technology. Furthermore, for this technology to be of the greatest benefit to smallholder farmers, rural processors and the local community, it must be easy to use, be available from local manufacturers at an affordable price, and have multiple uses for those periods when sweetpotato processing is not possible. Angue and Inocencio (1992) recommended that more emphasis on these potential benefits is needed to raise awareness and interest in improving flour processing technologies and processes – this was what we strived to achieve in this project.

2.2 Workplan for on-station flour processing trials

In the previous project (ASEM/2012/046) (see Chang and Mais 2014), research on flour processing was mostly carried out in the lab using modern equipment (for example chipper and electric ovens for drying, and milling machines), as much as possible to set a benchmark for flour processing at the village-level, where the majority of processing activities would be carried out by hand, using the most basic equipment and bush materials because of lack of access to funds and electricity. We were also interested in finding ways by which sweetpotato processing could be simplified for farmers who do not have access to modern equipment and electricity, without compromising the quality of the flour. The main research on flour processing is outlined in Table 3.

Table 3. Work plan for on-station sweetpotato flour production trials

Treatment	Activity	How, who and by when
1. Drying	Literature review and consultation on sun and solar drying	What has been carried out elsewhere regarding drying of SP or Cassava and costs, (a) using traditional materials by villagers, and (b) using modern materials, results and lessons learned. Consult with Baker (Taiwan Technical Mission, ROC) for details of the type dryer which was introduced to Swaziland by Dr Wu (Pingtung University, Taiwan), as well as ATDCI (Unitech) for alternative ways of drying roots and tuber chips, and their work on cardamom drier development which was carried out in 1980s in Highlands.

	Construction of sun and solar dryers	The construction of the drier should be based on the recommendations from the literature review. Whilst the plan for the construction is discussed, materials will be collected and at the same time the construction site (opposite Biotech, NARI) will be prepared. Check with Thomas Omot for the land at which the construction would be completed. The solar drier should be covered with clear plastic sheet and have black stones at the bottom for absorbing heat. The cost of construction and operation should be determined. The drier should be thoroughly tested and then demonstrated to farmers and other operators. This task will require at least 2 weeks to be completed.
	Compare sun-drying, solar-drying and oven-drying	We will want comparisons of all three different drying methods in terms of (a) flour yields and quality, (b) time required to reach a given level of moisture (10-12%), and (c) cost assessment of the amount of inputs needed to obtain a given quantity of flour. Data loggers will be inserted for temperature and relative humidity measurement. Develop protocols and templates for sweetpotato flour processing using solar drying and sun drying, and the workplan for demonstration at Sibi village. This task should take 7-8 weeks.
2. Variety evaluation	Select low-land varieties for trials	Select 3 different varieties for initial trials. Sourcing fresh roots from farmers in the villages and NARI-Bubia. A farm survey will be made to identify farmers and varieties from sites. This will take 3 days to complete, beginning by end of May. Once survey is finished, we will ask Priscilla to provide us fresh Sweetpotato roots on a 2-weekly interval.
	Assessing and compare root and flour quality	One variety at a time over a 6-week period to test for varietal differences. While producing the flour, SP will be sorted according to standards. Once the flour is produced, it will be sent to Mainland Holding for proximate analysis, and delivered to Sibi for product development and marketing. The evaluation studies will be completed on the following: • colour, cortex thickness, root shape, latex production, total soluble solids, dry matter; • flour solids yields, starch contents; • proximate contents; • water indices; • pasting properties; • particle size distribution; and • gelation.

		The following are also important but we need to buy some simple equipment and reagents to do: • total starch; • water absorption; and • water solubility. For 6 weeks, we will make sweetpotato flour and collect data.
	Compare flour quality from a single variety vs mixed variety	Formulate various recipes for biscuits, cookies and muffins based on single variety and mixed variety flour, and compare the quality of end products made from these.
3. Peeling	Compare peeled and unpeeled roots	Peeled and unpeeled roots will be compared in the Lab: (a) normal peeling using peelers vs (b) no peeling. The content after drying and milling will be analysed for proximate analysis and flour yield. If everything works out on a dry-matter basis, we should be able to obtain a precise measure of the peeling efficiency with which the flour is extracted (including differences in water usage, additional time for washing, and time saved from non-peeling).
4. Chipping	Grating vs chipping	We want better ways of pulverising sweetpotatoes, particularly for places where electricity for using machines is not available. Produce home-made graters using flat metal sheet and pinch holes with nails. These are of better quality than what is currently sold at the shops. Isidora has been using it for the EU-ARD project. Assess the cost of making it and compare methods of trimming using: (a) the traditional grating method; (b) EU-ARD type of grating; (c) a plane tool to slice the root in thin sheets. For flour yields, assess physical appearance and storage potential. This task would require one day for making the boards and 2 weeks for testing and collection data.
5. Packaging	Packaging materials for biscuits, cookies, buns and muffin	Contact suppliers of packaging materials in PNG/Singapore/Korea for cost and specifications. Order two thousand pieces of different packages first. Packaged products will be studied for storage stability under different packaging and storage conditions. Joel’s input in this activity will be less than 2 weeks.
6. Product development	Compare the quality of baked products made from sweetpotato flour vs cooked mashed sweetpotato	

7. Data collection and analysis	Assess and compare costs and flour quality from different treatments	At least 3 sets of data will be collected regarding: (1) the time taken for each step from weighing, sorting, cleaning, etc to the final product; (2) extraction rates, and input costs; and (3) to identify areas where efficiency can be improved. • Proximate analysis • Processing costs • Cost share of various inputs (labour vs raw material)

2.3 Results and discussion

Three experimental trials were conducted according to the following treatments:

1. Chipping: home-made grater (Treatment A) vs multi-purpose slicer (Treatment B);
2. Drying: Sun-dried (Treatment a) vs Oven-dried (Treatment b); and
3. Peeling: Peeled (Treatment 1) vs Non-peeled (Treatment 2).

Eight experimental trials were evaluated according to the following treatments, to help determine the cost of processing (Table 4).

Table 4. Experimental design and treatments

Sample code	Treatment	Variety	No. of replications
Aa1	Grated, sun-dried, peeled	SI-85	3
Aa2	Grated, sun-dried, non-peeled	W.besta	3
Ab1	Grated, oven-dried, peeled	SI-85	3
Ab2	Grated, oven-dried, non-peeled	W.besta	3
Ba1	Sliced, sun-dried, peeled	RAB-36	3
Ba2	Sliced, sun-dried, non-peeled	W.besta	3
Bb1	Sliced, oven-dried, peeled	RAB-36	3
Bb2	Sliced, oven-dried, non-peeled	W.besta	3

2.3.1 Yields and proximate analysis

Overall results from the experiment are summarized in Table 5, with the yield figures indicating processing efficiency, and proximate analysis of flour indicating the quality of the end product. Proximate analyses were carried out at the PNG University of Technology, Applied Science Department.

As shown in Table 5, flour yield ranged from 17.30% to 24.47%, with an average of 21.67%. These results were better than those achieved from the previous study in which the yields were between 17-20%. Average readings were 2.75% for protein, 1.56 % for fat, 10.07% for moisture, 3.06% for ash, and 2.53% for fibre. All readings were within the parameters of the sweetpotato flour standards defined in the African Standards. The differences between samples can be attributed to differences in variety[1], moisture content of flour, and

[1] Three sweetpotato varieties, SI-85 and RAB-36 from the NARI Agriculture farm and Waghi Besta from Sibi Kasuaka Coop, Nawaeh District, were used in this experiment. However, they were not used consistently across

measurement error occurred in various places along the process, including the lab work at Unitech. The moisture content was more reasonable and acceptable than previous study where it ranged from 2.85% to 8.25%. Over-drying increases cost and reduce flour yield unnecessarily.

Table 5. Yields and proximate analysis results (%)

Sample	Protein	Fat	Moisture	Ash	Fibre	Yield
Aa1	2.20	0.50	9.37	2.50	2.50	22.14
Aa2	3.24	1.00	11.62	3.00	2.00	24.47
Ab1	1.70	1.00	8.50	2.50	2.50	17.30
Ab2	3.15	1.00	8.75	3.00	2.75	22.84
Ba1	2.80	2.50	10.50	3.50	2.50	18.27
Ba2	3.30	1.50	10.30	3.00	2.50	22.39
Bb1	2.80	2.50	11.00	3.50	2.50	23.02
Bb2	2.80	2.50	10.50	3.00	2.00	22.93
Average	*2.75*	*1.56*	*10.07*	*3.06*	*2.53*	*21.67*
African Standards	--	*< 12%*	--	*< 3%*	*< 5%*	--

2.3.2 Cost analysis

The main costs associated with sweetptoato flour processing are summarised in Table 6. More details are presented in Appendices 1-4.

Average total costs of producing one kilogram of sweetpotato were found to be ranging from K11.53/kg to K27.84/kg, with an average of K16.32/kg (last row of Table 6). These were much higher than the retail prices of rice and wheat flour sold at the supermarkets in Lae, indicating that sweetpotato flour was price uncompetitive.

Table 6. Average total cost of processing SP flour

	Aa1	Aa2	Ab1	Ab2	Ba1	Ba2	Bb1	Bb2
Raw material (kg)	28.00	38.00	60.70	16.20	60.20	40.20	40.40	15.70
Total Processing costs (K)	97.1	119.54	121.04	86.71	133.73	123.49	124.24	100.21
Flour produced (kg)	6.2	9.3	10.5	3.7	11	9	9.3	3.6
Cost/kg (K)	15.66	12.85	11.53	23.44	12.16	13.72	13.36	27.84

different treatments, which was an error in the experimental design. Therefore, comparisons across samples should be made with caution.

However, these figures could be overstated as the total costs included small equipment which was used in all treatments. Purchasing of small equipment may be necessary for someone who takes on processing the first time, but it is not applicable when the tools can be used over a significant period of time, say at least 3-6 months. When the later cost was removed, the figures looked more reasonable as the average total costs were reduced to raging from K10.08/kg to K23.26/kg, with an average of K13.87/kg (Table 7). If we were to ignore the results from Aa1, Ab2 and Bb2 where the volumes of sweetpotato were too small to be useful (28, 16.20 and 15.5 kg, respectively), the average total cost was between K10-12/kg.

Table 7. Average cost of processing SP flour (without small equipment costs)

	Aa1	Aa2	Ab1	Ab2	Ba1	Ba2	Bb1	Bb2
Raw material (kg)	28.00	38.00	60.70	16.20	60.20	40.20	40.40	15.7
Total variable costs (K)	84.25	104.78	108.19	72.06	110.88	98.84	111.39	83.73
Flour produced (kg)	6.2	9.3	10.5	3.7	11	9	9.3	3.6
Cost/kg (K)	13.59	11.27	10.30	19.48	10.08	10.98	11.98	23.26

When we analysed the processing costs in more details, we found that the raw material cost account for on average nearly 20% of total cost while labour accounted for nearly 60%. Drying, which accounted for 68% of labour cost, has potential for further improvement.

Table 8. Total costs of sweetpotato flour processing (in Kina)

	RM	Labour (Drying)	Labour (Other)	Total labour	Total utility[a]	Small tools[b]	Total cost	RM (%)	Labour (%)
Aa1	16.80	45.60	13.28	58.88	8.57	12.85	97.10	17.30	60.64
Aa2	22.80	55.20	19.88	68.20	6.90	14.65	119.43	19.09	57.10
Ab1	36.42	42.24	25.96	68.20	3.57	12.85	121.04	30.09	56.35
Ab2	9.72	39.60	15.84	55.44	6.90	14.65	86.71	11.21	63.94
Ba1	36.12	42.48	23.71	66.18	8.57	22.85	133.73	27.01	49.49
Ba2	24.12	52.80	15.02	67.82	6.90	24.65	123.49	19.53	54.92
Bb1	24.24	43.92	39.66	83.58	3.57	12.85	124.24	19.51	67.27
Bb2	9.42	42.00	25.88	67.88	6.43	16.48	100.21	9.40	67.74
Avg	*22.46*	*45.48*	*22.40*	*67.02*	*6.43*	*16.48*	*113.24*	*19.14*	*59.68*

[a] utility costs include water, electricity, fuel, etc; [b] Small tools include peelers, slicers, graters, brush, and bags used in processing.

Significant variations existed from treatment to treatment, affecting by the size of the bag processed and the quality of roots and record keeping, as well as the people who participated in the experiment (ie whether they were diligent and work conscientiously or not). However, the latter reflected the reality in the village, and perhaps the work ethics in PNG in general. Clearly, business-minded entrepreneurs who value their time and with a profit motive would have much lower cost structures than those who are not. In any case, it was disappointing that it happened during the experiments. Clear experimental designs and protocols, and adequate supervision, would have prevented the problems from happening.

2.3.3 Weight loss and its impact on yield

Weight loss in roots occurred at each step of flour processing shown in Figure 1. Some of these losses could be either avoided or reduced. In Tables 9 and 10, we showed where the losses occurred and discuss how they could be either avoided or reduced. Using experiment Aa1 as an illustration, it can be seen that initially we had a small bag of sweetpotato roots of 28kg, after sorting, 0.60kg was lost as poor quality roots had been removed. This loss reduced the potential yield from 22.63% to 22.14%. There was no loss from washing because the roots were clean (or they might have been washed before). After washing, 5.4kg were lost to peeling, which reduced the potential yield from 28.18 to 22.63%. There were further losses to grating of 2.6kg. The most significant loss occurred during drying, as 19.4kg of fresh roots was reduced to 6.2 kg of flour when approximately 90% of moisture was removed. There was also a small loss from milling where dry chips were ground into flour. On average (based on eight experiments), purchasing good quality roots had the potential to improve yield by 2-3%.

Table 9. Weight loss and potential yields, using hand-made graters

	Aa1		Aa2		Ab1		Ab2		Average	
	Kg	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
RM	28.00	22.14	38.00	24.47	60.70	17.30	16.20	22.84	35.73	20.78
Af sorting	27.40	22.63	35.00	26.57	51.10	20.55	13.20	28.03	31.68	23.44
Af washing	27.40	22.63	34.20	27.19	50.30	20.87	12.20	30.33	31.03	23.93
Af peeling	22.00	28.18	34.20	27.19	43.30	24.25	12.20	30.33	27.93	26.59
Af grating	19.40	31.96	23.00	40.43	38.50	27.27	11.10	33.33	23.00	32.28
Af drying	6.60	93.94	9.80	94.90	11.40	92.11	4.00	92.50	7.95	93.40
Af grinding	6.20		9.30		10.50		3.70		7.43	

Table 10. Weight loss and potential yields, using multi-purpose slicers

	Ba1		Ba2		Bb1		Bb2		Average	
	Kg	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*	*Kg*	*%*
Raw materials	60.20	18.27	40.20	22.39	40.40	23.02	15.70	22.93	39.13	21.02
Af sorting	57.60	19.10	34.20	26.32	37.00	25.14	14.00	25.71	35.70	23.04
Af washing	57.10	19.26	33.40	26.95	36.40	25.55	12.30	29.27	34.80	23.64
Af peeling	50.10	21.96	33.40	26.95	33.10	28.10	12.30	29.27	32.23	25.52
Af slicing	47.00	23.40	32.00	28.13	31.20	29.81	12.10	29.75	30.58	26.90
Af drying	11.70	94.02	9.90	90.91	9.80	94.90	3.90	92.31	8.83	93.20
Af grinding	11.00		9.00		9.30		3.60		8.23	

2.3.4 Other results

Root size

Sweetpotato roots were collected from the farm, and came in varying sizes and shapes because sorting and grading were not practiced on the farm. However, sorting and grading are an important first step in ensuring good quality end products and high level of flour yields. Table 11 shows the time cost and weight loss as a result of inappropriate root size. In particular, weight loss accounted for 16.74%, 27.27% and 32.35% of the original weight of large (average weight of 213g, with a diameter of 5.6cm in the middle section), medium (average weight of 150g, with a diameter of 4.7cm in the middle section) and small-sized (average weight of 105g, with a diameter of 3.4cm in the middle section) roots, respectively. There was also time loss of 1.31, 2.07 and 3.21 minutes associated with peeling one kilogram of large-, medium- and small-sized roots, respectively.

Table 11. The impact of size on yields

Size	Fresh wt (kg)	Peel wt (kg)	Wt after peeling (kg)	Wt loss (%)	Yield (%)	Peeling time (min)	Peeling time/kg
Large	2.33	0.39	1.94	16.74	83.26	3.06	1.31
Medium	2.09	0.57	1.52	27.27	72.73	4.33	2.07
Small	2.04	0.66	1.38	32.35	67.65	6.55	3.21

Washing of SP roots

Normally women wash sweetpotato with their bare hands, but now they are using a hand brush to clean the sweetpotato more thoroughly (Figure 3). This operation comes before peeling. Water availability can be a constraint in the village, as water is obtained from streams that are some distance away from the homes, and often it takes some time to walk to the nearest creek to fetch water. Using a brush not only helps to remove the soil and dirt more effectively, but also helps to reduce water usage, and produces cleaner roots. This in turn reduces the time spent in additional washing after peeling.

Figure 3. Hand brush used in the experiments

Peeling of roots

Sweetpotatoes are peeled by hand using an ordinary vegetable peeler (Figure 4). The task is not difficult but it is tedious, and requires a lot of patience. As noted in earlier work, peeling is the most time consuming task, but when it takes too long it gradually becomes a social activity for women who tend to chat and do not hurry to finish the job. To overcome this constraint, a potato peeler (Figure 5) was recommended due to its lower waste rates. This particular peeler was tested in the experiments, and showed much better results in terms of the percentage of peel waste. Between 1.30 min and 3.20 min was required to peel one kilo of sweetpotato by one person, depending on the sizes.

Figure 4. Vegetable peeler used in the experiments

Figure 5. Potato peeler used in the experiments

Chipping of sweetpotato roots

In this experiment, chipping was completed manually using home-made graters and multi-purpose vegetable slicers. The two techniques tested are illustrated in Figure 6 below. On average, 24 kg of chips can be produced from the grater and 30kg of chips can be produced from the multi-purpose slicer for the same amount of time. Moreover, the home-made grater resulted in more sweetpotato off-cuts being discarded.

Figure 6. Hand-made grater (A) and multi-purpose slicer (B) used in the experiments

Soaking

All experiments were carried out without soaking. Although soaking is helpful for retaining chip colour and stops rapid browning, when dipped in the soaking solution extra water is absorbed by chips, causing later problems in drying and flour yield. Issues of browning were noted and assessed.

Spreading

Spreading is a very critical aspect of the drying process. To avoid rapid browning, chips have to be spread thinly on the drying racks in order to accelerate the drying process.

Drying

Generally between 17 and 24 hours are required to dry the chips, depending on chip sizes, the mode of drying, and the thickness of the drying layer. Sun drying and oven drying can be combined to reduce this time further, especially for commercial operations.

Chips produced by grating peeled and non-peeled sweetpotato roots, as well as those prepared by slicing, were tested in the drying experiments. Chips were also tested by oven drying (at the NARI Biotech Lab) to compare with sun-drying results. Chips were spread in a single layer on the drying racks for sun-drying and oven-drying tests (Figure 7). The results from sun-drying are shown in Table 12.

Figure 7. A – home-made grater and B - multi-purpose slicer

From our observation, sliced-chips dried appreciably faster than the grated-chips. This results are opposite of what was found by Seidu et al. (2012) where grated sweetpotato dried considerably faster (2- 3 days vs 5-7 days in solar dryers and 3 vs 7 days in open air, sun-drying) than chipped sweetpotato. More research is needed to reconcile these differences.

Table 12. Sun-drying of sweetpotato chips

Time	Temp (°C)	RH (%)	Slicer, non-peeled chips: Sample A wt g	Grater, non-peeled: Sample A wt g	Av. M.C % Sample A	Av. M.C% Sample B
9.10	27	82	33.2	43.2	1.52	1.44
10.10	28	84	32.9	45.5	1.28	1.44
11.13	29	79	32.6	43.5	1.15	1.34
12.12	31	74	31.0	41.2	0.90	1.23

1.10	29	76	28.3	37.3	0.83	1.17
2.10	28	80	24.2	32.2	0.71	1.09
3.10	31	67	20.0	31.6	0.59	1.05
3.40	29	67	17.8	30.2	0.41	0.99
4.10	28	68	17.5	29.5	0.17	0.98
Average	*29*	*72*	*14.4*	*15.5*		

Sun-drying may prove advantageous for providing chips with lower moisture content prior to oven-drying for commercial purpose in large scale operations.

Dried chips (both sun- and oven-dried) were no longer white, having acquired pronounced browning which occurred immediately after grating or slicing, as soon as the tissues came in contact with air.

Labour

Given that there is substitution between labour and capital, the total number of hours spent on flour processing and the number of hours spent on each processing activity were recorded (Table 13). As shown, the total number of hours spent on flour processing ranged from 22.35 to 30.17 hours, depending on the volume and the quality of the raw material to be processed (the second last row of Table 13). When the volume of the raw material was taken into account, the average time spent on producing a kilogram of flour ranged from 0.45 hour for a 60kg bag to 1.42 hours for a 16 kg bag (the last row of Table 13). That larger bags requiring less time per kilogram to process means there are economies of scale in sweetpotato flour processing. It appears that a full bag (60-80kg) would be a good volume to work on. The most time-consuming tasks were found to be the drying of chips -- for oven-drying it accounted for 66.30% of the total processing time and for sun-drying, it was 76.35%. However, women participating in the study complained more about the pains in the arms and fingers associated with grating and slicing that took 2-3 hours continuously than the longer hours it took to dry the chips. In any case, more research is needed to reduce the time required for drying and the drudgery for women working on processing.

Table 13. Total number of hours spent to process one bag of SP flour of varying sizes

	Aa1	Aa2	Ab1	Ab2	Ba1	Ba2	Bb1	Bb2	Avg.	%
Raw material (kg)	28	38	60.7	16.2	60.2	40.2	40.4	15.7	37.4	
Weighing	0.07	0.18	0.18	0.08	0.08	0.10	0.12	0.15	0.12	0.46
Sorting	0.33	0.27	0.10	0.27	0.38	0.17	0.50	0.17	0.27	1.04
Washing	0.20	1.08	0.50	1.00	0.50	1.00	0.50	1.24	0.75	2.85
Peeling	1.66	0.00	4.02	0.00	3.16	0.00	1.66	0.00	2.63	9.96
Slicing	0	0	0	0	4.80	4.80	5.60	2.80	4.50	17.07
Grating	2.66	6.34	5.44	4.80	0	0	0	0	4.81	18.25
First Spreading	0.10	0.04	0.10	0.08	0.10	0.03	0.02	0.10	0.07	0.27

Second Spreading	0.08	0.02	0.10	0.06	0.05	0.05	0.08	0.10	0.07	0.26
Third Spreading	0.12	0.04	0.05	0.05	0.11	0.08	0.04	0.09	0.07	0.28
Oven-drying	0.00	0.00	17.60	16.50	0.00	0.00	18.30	17.50	17.48	66.30
First Drying	8.00	8.00	0.00	0.00	8.00	8.00	0.00	0.00	8.00	30.35
Second Drying	8.00	9.00	0.00	0.00	6.00	9.00	0.00	0.00	8.00	30.35
Third Drying	3.00	5.00	0.00	0.00	3.50	5.00	0.00	0.00	4.13	15.65
Milling	0.22	0.20	0.30	0.20	0.25	0.25	0.24	0.20	0.23	0.88
Packing	0.10	0.10	0.10	0.10	0.30	0.30	0.10	0.30	0.18	0.66
Total	24.44	30.17	28.39	23.04	26.93	28.48	27.06	22.35	26.36	
Average/kg	0.87	0.79	0.47	1.42	0.45	0.71	0.67	1.42	0.85	

2.4 Summary of results

- Average flour yield was 21.67%.
- The quality of sweetpotato flour, based on proximate analyses, was robust and within acceptable standards under different methods.
- There is economies of scale in sweetpotato flour processing.
- Average total cost was between K10-12/kg when the volume of fresh roots processed was between 40-60kg.
- At 60kg, the average time spent was 0.40 hr/kg, and at 16kg, it was a little less than 1.3 hr/kg.
- Raw material cost accounted for 20% of total cost while labour accounted for 60%.
- Among all processing activities, drying was the most time-consuming, accounting for 70% of total labour cost.
- Sun-drying took about the same time (23-24 hours) as oven-drying to arrive at similar moisture contents (8.5% for oven-drying and 10.50% for solar-drying). However, there was a trade-off between labour cost and power cost (and initial capital investment).
- Sliced-chips took less time to chip and dried appreciably faster than the grated-chips. However, they would be more difficult to mill if it is done manually. In this study, milling was carried out by a milling machine.
- The quality of raw material was important as flour yield could be reduced by 3-4 % after removing poor quality roots. Similarly, peeling could lower flour yield by 3-4%.

These results mean that sweetpotato flour can be produced at the village level using basic equipment and simple methods while meeting quality standards. However, although general conclusion can be made, caution must be exercised when making references as the experimental designs did not allow for direct comparisons between treatments -- there was no control, and treatments were combined rather than being distinct and separated.

More research is needed to develop simple and low cost solar dryers to cut costs and to improve processing efficiency. This research on drying technology is important drying, as one of the oldest methods of processing and preserving food for later use, is an effective way to improve food security and manage production risks resulting from climate change. The technology is applicable to other root and tuber crops and fruit and vegetable.

3 Village-level product and market development

3.1 Sibi village

Collaboration for the village-level sweetpotato processing centred on Sibi village, based in the Wain-Erap Local Level Government (LLG), Morobe province. Participants were members of the Kasuka Cooperative from seven villages located in the Middle Erap (Kwerebo, Kawalang, Barawang, Bayang, Sibi, Sawana and Kwaleng) with a population of approximately 5,000 people. The resource centre of the Cooperative is based in Sibi village, where community meetings and training take place. Sibi village is an hour's drive away from Lae, in a mountainous area 600 meters above sea level. The roads are treacherous, and can become impassable after heavy rainfalls. In 2013, the Cooperative received a 3-tonne truck from the district office. This daily service to Lae provides a reliable transport for villagers and for their produce.

Although access to market was difficult, a major enabling factor in the Middle Erap community was the presence of the PNG Volunteer Service Officer (VSO), Ms Priscilla Lillih, whose role was to facilitate and keep records of development interventions in the community, and to ensure the community benefited from the various projects. Priscilla resided in the Sibi village where the resource centre was located, and worked closely with community leaders, as well as outside R&D organisations. Community leaders and R&D organisations were involved in inland aquaculture, rice production, fresh produce production, coffee and cocoa production and processing, and sweetpotato processing (with Trukai, ADRA (the Healthy Island Concept), FPDA (the Fresh Produce Development Agency), and the district office). The community also had a link to the urban supermarkets in Lae, supplying fresh fruit and vegetables to Papindo, Anderson, and Foodmart on a weekly basis. The Evangelical Lutheran Church was also a major player in the community, with several livelihood projects and community events.

Over time, Priscilla had developed a strong rapport with the community and with outside development organisations alike. Projects would not have progressed without her persistence, and the community had become dependent on her for getting things moving. Priscilla was the main driver for the initial success in promoting sweetpotato processing to Sibi village. Her contribution to the project also included the various communication and dissemination activities that she had done for us through her involvement in various community events where she explained her work in sweetpotato processing and showcased various sweetpotato products. They included: Sweetpotato Fairs, the NARI Agricultural Innovation Show, Trukai Open Days, Lutheran church functions and training of women's groups in Madang and Morobe provinces.

When her contract expired after 3 years, Priscilla left Sibi village in December 2014. Her departure created delays in implementing project activities, since the person who took over was not as capable or enthusiastic as Priscilla. Losing key collaborators in the middle of the project is nothing new in PNG, however, and this is a significant factor that makes it a challenging place to work. Despite the additional challenges that this departure posed, we pressed on and achieved as much as possible in the areas of product and market development, business skills training, and communication and dissemination.

Previous research on sweetpotato processing in PNG has found that earlier research and development activities conducted by research organisations such as NDAL, FPDA, and NARI, has been relatively ineffective, producing few tangible results (Chang and Mais 2004). One reason for this was that in each of these projects there was an attempt to imitate wheat flour based on Western recipes, rather than developing unique products based on the unique characteristics of sweetpotato. Furthermore, these projects did not consider consumer acceptability and preferences, and the financial viability of the associated technology before promoting their approaches to the public, who in most cases were unaware of the potential for sweetpotato processing. Extension also did not take into account the social and economic constraints faced by rural households. Cegumalua (2007) also reported that there was little uptake of the processing technology by entrepreneurs or trainees, because they often lacked sufficient technical know-how and management skills to set up a processing enterprise, or to expand. As a result, most of them continued to operate as a cottage industry and sell their products through informal markets.

The aim of this activity was to assist two community groups in Morobe province – Sibi in the Nawaeh district, and Gebansis in the Huon district – to identify and assess product and market development opportunities for processed sweetpotato products, as well as building the capacity of these communities in technical and business skills.

3.2 Workplan for working with Sibi village

Table 14. Workplan for partnership with Sibi village

1. Product and market development	Provide fresh flour samples, along with product specs (bun/cookies) to SV for their product development and marketing, and follow ups	Communicate with Priscilla to discuss work plans proposed under this activity to focus on: (a) sweetpotato flour making and sweetpotato products, quality assurance, marketing and costing for her processing team; (b) planning for field visits on technologies (drying, improved recipes and trainings) to be completed by NARI processing team, during which time we work out the data we need to collect for the technologies; and (c) 23-27th September display. For that to happen, the flour specifications and drying technology must be developed. **Whilst this is happening, Isidora should provide update to Anton and Christie**. For 3 months, 3 batches of sweetpotato flour will be delivered to Sibi Village for market testing and product testing. The first batch will be produced in June. The second batch will produce during the next trip to Sibi on July, and the third batch will produce in September.
2. Capacity building	Conduct training of small food processors on the fundamentals of food processing at NARI (Lae)	Participants will be selected from Sibi, Gebansis and other potential partners. One week of training in the principles of food processing and practical aspects (including hygiene, costing, marketing, etc) will be provided. The training venue will be NARI, with not more than 10 participants. Follow ups with the participants periodically will be completed to determine how the training has been used. A formal assessment should be carried out, based on the evaluation sheet developed.
3. Communication and dissemination	Boanan District for the ELC PNG conference	Boana station is the site for the ELC PNG women's conference. We will prepare printed materials and products for display. The purpose of the display is to support the Sibi group in promoting the processing work.
	Sweetpotato Fair in Jiwaka province; Trukai Open Day	During these events, team members prepared and distributed information sheets on the project and receipts for food processing while Priscilla and her processing group made sweetpotato products and put them on display.

	Training of women's and community groups on food processing	Both team members and Priscilla received requests for processing training from different communities. It would be interesting to see how they went since the training.

3.3 Product and market development

This activity was a progression of the same activity which was first initiated by the ACIAR project, AESM/2012/046 (Chang and Mais 2014). In the previous project, flour samples were distributed to two collaborating communities, Gebansis and Sibi, after a training workshop was held on sweetpotato flour processing and baking, and recipes distributed. Each recipient was given 500g or 1kg of sweetpotato flour and encouraged to "make something out of it". The results were good, with the Gebansis group coming up with simple products such as cakes, cookies, and sweetpotato balls. The Sibi group developed more than a dozen interesting new products, using ingredients that were available in the village. These products were showcased at the NARI Agricultural Innovation show in June 2013, and at community events. When these events were held in the village, the products were well-received and generated good profits.

In this project, the main focus was to develop markets in Lae, as well as continuing to improve the quality and processing efficiency of existing products, replacing sweetpotato flour that is time-consuming to make, with cooked mashed sweetpotato.

3.4 Business skills training

Previous ACIAR research (ASEM/2008/035 and ASEM/2012/046) showed that processed sweetpotato products had a marketing advantage, especially when they were produced with locally available materials. However, adoption of processing technology by farm households and women's groups was found to be low. This was due to lack of access to equipment (milling machines, baking ovens, kitchen utensils, etc), ingredients (milk, sugar, butter, eggs, etc), and basic services (transport, clean water, electricity, credit, technical support, etc). The review of the Food Processing and Preservation Unit (FPPU) at Unitech (in operation from 1984 to 2007) also showed that FPPU's failure to develop a food processing sector was due to FPPU itself not being properly managed and trainees not being adequately equipped with the business and entrepreneurial skills required to access markets and support services (Cegumalua, 2007). Given that previous research on food processing and training in PNG has tended to focus on addressing technical issues, in this project we focused on addressing the capacity and marketing issues facing small-scale food processors.

Participants for business skills training were selected from Sibi, Gebansis and other operators who had some experience in food processing. A one-week training activity on the principles of food processing and practical business management (including hygiene, costing, marketing, etc) was held at NARI, for farmers or entrepreneurs who had been undertaking food processing.

The business skills training workshop was held on 21-24 July, 2014. There were a total of ten workshop participants. Five topics were covered (Table 15).

Table 15. Training workshop agenda

Date	Topic/trainer
21/7	1. Understanding the products and the process/Anton Mais • Why food they prepare is important: what are principles behind food processing: How are they described • Trainees to know what factors cause food to spoil • Group discussion on correct procedures to handling food to prevent food spoilage 2. Product Quality Assurance/Joel Waramboi • How to manage quality assurance? Emphasis should be placed on: o Source of contamination o Effect of contamination on the process o Probability of micro-organisms surviving the process and growing in the product Trainees to discuss issues and problems in relation to their own work Group discussion on health and safety, hygiene and sanitation practices
22/7	3. Marketing principles and gross margin analysis/ Christie Chang In the morning session, basic marketing principles, marketing planning and cost components of food processing and marketing were briefly introduced. In the afternoon, participants were asked to do a costing exercise based on the product they have produced and sold with the help of team members. The results were reviewed and comments provided.
23/7	4. Drying and Processing Quality Dried Products/ Isidora Ramita and Joel Waramboi In the morning, trainees to gain knowledge on drying of root crops: how to protect their dried sweetpotato products under local conditions, and to identify the advantage and disadvantage of drying and storage: kind of practices must be done to produce quality dried products: which of those practices are important? In the afternoon, trainees to discuss how dried sweet potato produced can be stored in good (quality) form and why drying and preservation is important: o Trainees to make a list of the ways they prepares the dried chips. o Trainees to learn methods of drying, milling into flour o Discuss problem experienced during milling and storage, what did they do about them?
24/7	5. Baking and Practise of Baking/Anton Mais and Miriam Simen • understand how wheat flour from store differs from homemade SP flour: • Trainees to learn methods of baking into bread and muffin: what are the purpose of each of equipment, tools and ingredients used • Trainees to use the loaves of bread that they have made, to examine them for any of the problem. • Discuss what they already Know about root crops flour and what they want to Know Revision and review – food processing presentations, marketing/costing exercises. • Any final points • Any other course issues

Feedback on the processing and business training was positive. We managed to take workshop participant through simple costing exercise and helped them arrive at a gross margin for something they sold. One workshop participant, a community leader, commented that if he had done this business training earlier, he would have taken a different approach to helping his community. Previously when his community faced a problem, they always looked to government for assistance, which in most case did not come. Now with this business approach to product and market development, he realised that they as a community must strive to be self-reliant, learning new skills and trying new things to come up with solutions themselves, rather than waiting for assistance from others.

We were pleased with the result. However, to ensure that the participants understood and practiced what they learned, their progress must be monitored continuously and further technical assistance provided when necessary. Furthermore, to promote sweetpotato processing to the wider community, we must find a way to get the messages out. The normal channel would be the agricultural extension systems. Unfortunately, the PNG extension system has not been working for decades, and despite our effort to work with the provincial and district offices, nothing came through. Financial and capacity constraints were main reasons for lack of response and actions. But we also noticed that although development plans have been developed and documented both at the provincial and district levels, they were not in sufficient details or practical to be operational. It appears that provincial and district administrators could benefit from training and capacity building in strategic planning and project management. The alternative for our project was to work through the education system.

4 The School Project

Processed sweetpotato products have a distinct marketing advantage, especially when they are produced with locally available materials. However, there is no food processing culture in Papua New Guinea, and little awareness of the potential benefits of food processing. The objective of this project was to raise awareness of food processing in the wider community through the Making-A-Living (MAL) program of the primary school curriculum that focused on developing practical life skills. We worked with two primary schools in the Houn District, Morobe province, to promote food processing. Key activities for the School Project included:

- Stakeholder consultations;
- Planning workshop
- Train teachers in sweetpotato processing;
- Develop unit of work with teachers of MAL;
- Train students in sweetpotato processing;
- Student group project on product development; and
- Product competition.

4.1 Work plan for the School Project

Table 16. Workplan for the School Project

Date	Activity
Dec 2014 - Jan 2015	1. Stakeholder consultations
5-6 March	2. Planning workshop
23-24 April	3. Training of teachers Time frame for this training was 2 days. Teacher training was conducted at NARI MPH for teachers at Bubia and Gebansis. Our focus was on Grade 7 and 8 students, and the teachers were from those grades. Bubia is a level 7 school and has 4 classes in each grade; therefore 4 classes in Grade 7 were selected. Gebansis has 2 classes in each grade, so they combined the two grades into 4 classes. Altogether, there were 8 classes from both schools. Anton and Miriam conducted teacher training from 23-24 April 2015. In the morning of the first day, they focused on teaching the basic principles of processing technology that the teachers used as teaching aids, providing professional development and application opportunities to help other teachers to teach food processing as part of the MAL curriculum. In the afternoon of the first day they worked with the teachers to develop teaching aids and training manuals for each lesson, to be implemented within the given time frame. On the second day the teachers were given basic hands-on training on baking sweetpotato buns, cookies, muffins and bread, as well as ingredients and equipment required.
The week of 25 May	4. Training of students Training focused on teaching and learning activities and was conducted by MAL teachers with the NARI team assisting. Five lessons were conducted concurrently and 8 classes altogether were involved, both from Bubia and Gebansis. The time frame for this activity/program was 5 days. The total time allocation for those lessons was 360 minutes, including practical tasks and marketing of products. The topics were as follows: (1) “What is food processing?” By end of the lesson the students were able to define and understand what processing and food preparation is. This was the objective that students should have achieved after the first lesson. The lesson was comprised of an

	introduction (5min), body (30mins) and conclusion (5 min), and a key technique of the lesson was brain storming. The teacher gave a brief explanation on food processing technology. Then the students split into groups (5 groups according to the topics; food safety, food handling, quality, nutrition, etc). These topics were addressed via roundtable discussion. Teaching aids were placed on the table, and the students used the teaching aids to assist them in knowing what each topic was all about. Students also answered questions set by the teacher on those particular topics. At the end of the lesson a class discussion was held on the answers, arriving at a clear definition and purpose of the lesson. (2) “Safety practices of handling food, tools and equipment”. By end of the lesson students were able to (i) understand the types of materials used in the processing of food, (ii) understand the safety rules of handling food and equipment. The lesson comprised of an introduction, body and conclusion. Students read notes and handouts provided by the teacher, after which the teacher explained the activity. Students worked in groups, writing down different types of food and equipment and explain their uses. (iii) Students drew and labelled different types of tools. By completing activities (ii) and (iii), students were able to become familiar with the tools and equipment for the experiment. (iv) Listing the safety rules for food and equipment handling. Students also answered questions set by the teacher on that topic. At the end of the lesson, a class discussion was held on the answers and allowing the class to identify clear safety measures for handling and preparation of food. (3) “What is costing and marketing?” The time frame for this lesson was 40min. By end of the lesson, students were able to calculate the cost of products, sale price, and estimated profit. The teacher provided notes on business approach, and basic principles of how to make money from marketing. Templates for calculating cost were also provided to students for practice in calculation of costs and profits. In this way, the students learnt the basic skills of the food handling business. (4) “Prepare sweet potato food products”. The time frame for this lesson was 120 minutes because it was a practical lesson. By end of the lesson students were able to apply different procedures to cooking methods and how to prepare sweetpotato products. The lesson introduction was 15min, body 50min, and the conclusion 15min. The teacher (i) stressed the importance of the preparing sweetpotato products, (ii) highlighted the importance of checking the materials and ingredients for processing, and iii) highlighted the methods of how to prepare and cook sweetpotato products. In the practical component of the lesson, the teacher demonstrated while students observe, and then organised students into groups who followed the steps the teacher had demonstrated to the students. The teacher provided supervision, assistance and encouragement to students. At the end of the practical lesson, students displayed their processed products. The teacher evaluated students’ work by assessing their products using the criteria for tasting. (5) “Marketing of sweetpotato products”. The time frame was 40min for this practical task. Students were asked to sell products at the school market with appropriate packaging materials. This helped students to understand and determine whether the food had any value, or if it could be marketed with a high margin. By end of the task, students were able to calculate their selling price and estimated profit, and keep a good record of sale. The teacher evaluated student learnings and outputs. We sought to challenge the teachers (schools) to come up with their own recipes. In that way, they would be able to (i) identify different methods of cooking sweetpotato flour, (ii) acquire knowledge of how to cook sweetpotato flour, and (iii) apply the knowledge that they had identified and acquired in real-life situations to make good money. Every student who participated in this program had the opportunity to learn more about what they could do to improve their livelihoods and create wealth for themselves.
1-30 June	5. Student group project
2 July	6. Product competition

4.2 Results and discussion

In this section, we outline our work in promoting sweetpotato processing to two primary schools in the Houn District, Morobe province. We then present the results and lessons learned from the planning workshop and group discussion with the head teacher and teachers who were involved in the MAL curriculum. This is followed by presenting the outcomes of the processing training for teachers, the product development trial with students, and the product competition.

4.2.1 Stakeholder consultation

We first commenced discussion in December 2014 with the Headmaster (Mr Issac Dau) of Gebansis PS in Wampar LLG, Huon District, about the proposal of the introducing food processing technology to the school curriculum, which would fit in with the food preparation and processing component that was already included in the MAL curriculum under the "Better living" sub-strand. Mr Dau then organised a meeting for the project team and the teachers who were teaching the MAL lessons, as well as other teachers within the school, to discuss the proposal. At the start of the 2015 school year we approached the teachers at Bubia PS, determining that they were also interested in the proposal, and were therefore also included in the discussion. A planning workshop was subsequently organised for teachers from both schools. Personnel who were involved in the School Project are named in Appendix 5.

4.2.2 Planning workshop

A two-day planning workshop with teachers was held on 5-6th March 2015 (Figure 8). On the first day, the background of the ACIAR project and the purpose of the school project were presented by the team member. This was followed by the Headmaster, Mr Isaac Dau, who took the group through the background of the MAL curriculum and the syllabus, and its relationship with the proposed school project. In the afternoon, teachers shared their experiences in teaching the MAL curriculum, and issues they have encountered. On the second day, participants worked together to develop the Unit of Work that detailed the objectives, learning outcomes, activities and assessment for the school project, as well as the knowledge, skills, and resources required for different lessons. An example of Unit of Work developed by the teachers at the planning workshop is shown in Figure 9.

Knowledge identified to be acquired by students included:

- Food preparation;
- Food safety and quality;
- Nutrition;
- Steps and procedures in processing;
- Sweetpotato products recipes; and
- Costing and marketing.

The main skills to be acquired by the students included:

- Preparation of sweetpotato products;
- Processing and preservation of sweetpotato flour;
- Different methods of food preparation, processing and preservation;
- Different recipes for cooking sweetpotato products;
- Apply appropriate methods of processing and preserving foods; and

- How to calculate costs and profit.

Figure 8. Teachers working in groups to develop the Unit of Work

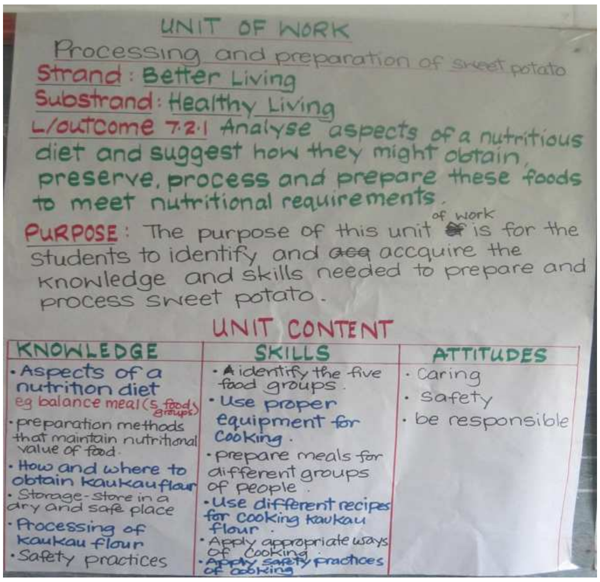

Figure 9. An example of the Unit of Work

4.2.3 Processing training for teachers

Following the planning workshop, a two-day workshop was held on 23-24th April at NARI in Bubia, to provide training to teachers and school administrators on food processing technology so they could later teach their students. There were 19 participants. The training was an important step for preparing the teachers for the school project because most of them were not familiar with basic concepts and methods for sweetpotato processing. The training workshop included the following topics: an overview of the ACIAR project to explain the background and put the school project in context; presentation on purpose and benefits of food processing and preservation; the technical aspects of drying fruit and vegetables; how root crops and tubers are dried and milled into flour, and how flour made from roots tubers differs from wheat flour; basic equipment and tools and techniques for baking; quality and food safety aspects of food processing; and costing and marketing of processed products. On the second day, emphasis was placed on demonstration and practices on baking, as well as developing a workplan for the school project and revising the Unit of Work.

Table 17. Teacher training program, NARI, Bubia, 23-24 April, 2015

Day	Date	Time	Item	Key Person/ Responsibility
Thur	23/04	0830-1000	Participants arrival and Registration	Anton Mais
		0900-1000	Introduction - participants and resource persons	All
		1000-1015	Morning tea	All
		1015-1030	Introduction of training program	Anton Mais
		1030-1130	Session 1 Understanding the products and the process	Anton Mais
		1130-1230	Session 1 (cont.)	
		1230-1330	Lunch	
		1330-1500	Session 2 Practice of Baking	Joel/Isidora/Miriam
		1500-1515	Afternoon tea	
		1515-1700	Session 2 (cont.)	
Fri	24/04	0830-1000	Session 3 Marketing/costing	
		1015-1030	Morning tea	
		1030-1230	Session 4 Developing Curriculum	Issac Dau/Anton
		1230-1330	Lunch	
		1330-1500	Session 4 (cont.)	
		1500-1515	Afternoon tea	
		1515-1700	Closing Ceremony	

It was agreed that the School Project would start in the fourth week of Term 2, commencing with processing training for students, followed by product development by students and product competition for students over the next 5 weeks from 25 May to 2 July. Some participants for the processing workshop are shown in Figure 10. It is worth noting that 2/3 of the participants were male who would not be directly involved in teaching the students how to bake. We ran into trouble later in implementation as female teachers who were supposed to teach students how to bake did not attend the training workshop.

Figure 10. Processing training workshop participants

4.2.4 Processing training for students

Processing training at the schools was provided to all Grade six, seven, and eight students in the first two weeks of the MAL lessons on food preparation. In the third week and fourth week, students began to work in small groups (4–6 students per group) to learn how to bake and later develop their own sweetpotato products. In the fifth week, students learned how to calculate the costs of making muffins, scones and buns based on what they made from the week before.

Student training, which began on the week of 25 May, was conducted by the teachers over a one week period, in accordance with the Unit of Work developed during the teacher planning and training workshops. The training covered the basic concepts of food processing, costing and marketing, as well as practical sessions focusing on baking sweetpotato buns and muffins – two products that were found to be easy to make and therefore suitable for this trial with students. During the practical sessions, the project team conducted a demonstration on how to make muffins and buns, after which students attempted these recipes themselves. Students were eager to learn, and participated enthusiastically in the process of measuring ingredients, mixing, kneading and forming dough, as well as making icing for the muffins. Students were excited about mixing the ingredients themselves, putting the dough in the oven and tasting the finished products. Unfortunately, the Bubia Primary School had only one drum oven and it was not enough to meet demand from 120 students. As a result, baking was completed late in the afternoon, well beyond the normal schooling hours, and as such some students did not get to see or taste the final products. Feedback from the Bubia Primary School is provided in Appendix 6.

4.2.5 Product Development

Due to limited resources, especially baking drum ovens (two baking drum ovens at the Gebansis Primary School and one baking drum oven at the Bubia Primary School, courtesy of the project), product development exercises were limited to few students, selected on the basis of their own interest and potential support from their parents. In Bubia Primary School, students were selected from Grade seven and formed into four small groups (6-10 students each), while in Gebansis one small group of ten students was selected from Grades six, seven and eight. In the case of the Bubia Primary School, sweetpotato flour (20-30kg) was provided by the project team[2], but in the case of the Gebansis Primary School, cooked mashed sweetpotato was used rather than sweetpotato flour.

Initially, the project assisted students to meet the cost of the ingredients, but students were later encouraged to bring their own baking ingredients and supplies where possible, including firewood, dishes, baking trays, spoon and cups. Some students illustrated their resourcefulness by borrowing basic baking utensils from families in the school compound and/or surrounding communities. How students learned to make muffins first time in their lives is shown in Figure 11.

Figure 11. Process and samples of muffins using composite flour at the Bubia Primary School

After initial training, all ingredients and resources other than the sweetpotato flour/mash (yeast, baking powder, salt, sugar, margarine, cooking equipment and firewood) were provided by students themselves. In the following three weeks, students worked in a team to trial different recipes, with the level of supervision from the teachers and the project team reducing over this time. We observed that the students completed a high quality of work, and were able to master the techniques and process of making muffins and buns. Students were able to sell the sweetpotato products to other students, helping to sustain their activities and, in most cases, more than covering the cost of ingredients. Students were able to double their original investment in ingredients when the product was sold, a 100% return on a few hours of their time.

[2] One of the bags contained sweetpotato flour that was processed without peeling. The flour had a browner colour and the buns and muffins made from it had chocolate colour and flavour. It was an unexpected good result as we have been looking for product characteristics that are unique to sweetpotato, and this could be one of them.

4.2.6 Taste panel and sensory evaluation

There were 9 volunteer members on the taste panel, including scientists from NARI and teachers from the Bubia Primary School. Before participating in judging for the product competition, panel members were provided basic training on sensory evaluation, as well as took a trial taste test using buns, biscuits and muffins purchased from the market. The project team also met several times to discuss how the competition should be conducted, including the number of panellists required, presentation of the samples, selection criteria, design of the score sheet and rewards for best products, and training of panellists. An example of the letter of invitation to potential panellists is presented in Table 18 below.

Table 18. Letter of invitation for taste panellist training

From: Anton Mais [mailto:anton.mais@nari.org.pg]
Sent: 25 June, 2015 3:14 PM
To: narilabu@nari.org.pg; naribubia@nari.org.pg; hqnari@nari.org.pg
Subject: IN-HOUSE TRAINING ON TASTE PANELS, TUE 30th June, 2015

Dear Colleagues

We are extending this invitation to interested staff who want to participate in a taste panel training. Sweetpotato processing project has been involved in research, and has been engaging primary schools in sweetpotao product development as part of our school program.

We had several training with teachers from Bubia PS and Gebansis PS to help them prepare well to teach the students as part of the MAL curriculum on food preparation and processing lesson. Students have been making bun, scone, cookies and muffin under this lesson. This in-house training on taste panels is a continuation in preparation towards the school product competition, which is will be held on Thursday 2nd July.

We would like to invite any interest staff who would like to gain skills on product tasting to attend this small training before the actual event on 2nd of July. The venue will be at Food Lab – Biotech Centre. The training is on Tuesday 30th June 2015.

Those interested staff who choose to participate will receive free muffins as a token of appreciation from the project. We also would like to acknowledge their participation and appreciate the time they give to sit with us and go through the steps with us. This training will take between 30-45 minutes.

Thank you.

Regards

Anton

The score sheet and the selection criteria are presented in Table… Key parameters used to evaluate the sweetpotato products included: appearance, texture, size/shape, taste, aroma, and overall quality. Each criterion was rated on a seven-point scale: 1 = Poor; 2 = Not very poor; 3 = Not good; 4 = Acceptable; 5 = Good; 6 = Very good; 7 = Excellent.

Table 19. Score sheet for sensory evaluation of sweetpotato products

Date:							
Name of panellist:							
Product name:							
Instructions: Please rank each attribute from 1-7 using the scale below: 1 – Poor 2 – Not very good 3 – Not good 4 – Acceptable 5 – Good 6 – Very good 7 – Excellent							
	Sample						
Attributes	**1**	**2**	**3**	**5**	**6**	**7**	**8…**
Appearance							
Texture							
Size/shape							
Taste							
Aroma							
Total Score							
Average score							
Additional comments:							

4.2.7 Product Competition

The product competition was held to coincide with the MAL Arts and Craft show of the Bubia Primary School. The aim of the show was to display the skills acquired by the students during the term in the areas of drawing, drama, and dance and cooking. In the morning, teachers and students gathered outside the school ground for the official opening. This was followed by various performances from the Bubia students. Students and some of their parents from the Gebansis Primary School also dressed in their traditional costume and gave two performances. After the performances, students and parents visited painting, drawing, arts and cooking displays. The event was well attended by teachers, students and their families. Most food products at the cooking displays were sold out at the end of the day.

Figure 12. The Bubia Primary School Show and sweetpotato products on display

Eleven entries were received for the product competition: four for cookies, four for muffins, two for buns and one for scones. These samples were coded (see Table 20), cut into appropriate size and placed some distance from one another on tables in the Bubia lab.

Figure 13. Product competition and the taste panel

Table 20. Coded sweetpotato product samples

Test Sample	Code	Product	School
A	C-486	Cookies (rectangle)	Gebansis
B	C-401	Cookies	Bubia 7A
C	C-441	Cookies (round)	Gebansis
D	C-782	Cookies	Bubia 7B
E	M-022	Muffins	Bubia 7B
F	M-654	Muffins	Bubia7A
G	M-248	Muffins	Gebansis
H	M-399	Muffins	Bubia
I	B-967	Buns	Bubia 7A
J	B-169	Buns	Bubia 7B
K	S-64	Scones	Gebansis

Note: All products made from the Bubia Primary School used sweetpotato flour, while Gebansis Primary School used cooked mashed sweetpotato for all their products.

Table 21. Result of sensory evaluation for sweetpotato product competition

	Appearance	Texture	Size/shape	Taste	Aroma	Average*
C-486	3.6	3.6	3.7	3.8	3.6	3.7
C-401	4.7	4.9	5.4	4.6	3.9	4.7
C-441	4.6	4.2	5.5	3.8	3.6	4.4
C-782	5.5	4.8	5.2	4.5	4.4	4.9
M-022	5.6	5.6	5.6	5.9	5.4	5.6
M-654	6.2	5.9	6.1	5.9	5.2	5.9
M-248	3.9	5.1	4.2	4.9	4.9	4.6
M-399	5.9	4.9	5.9	5.9	5.3	5.6
B-967	5.2	3.5	5.5	4.1	4.2	4.5
B-169	5.5	5.1	5.7	4.5	4.8	5.1
S-64	4.2	4.1	4.6	4.8	4.8	4.5

** Overall quality is the average of all the 5 attributes.*

As shown in Table 21, the best product, M-654, muffins by Bubia 7A, received an overall score of 5.9 (out of 7), followed by the second best product, M-022, muffins by Bubia 7B and M-399, Muffins by Bubia, and the third best product, B-169, buns by Bubia 7B. These best products were selected, and prizes awarded.

Although the sweetpotato products submitted for product competition had received good scores from the trained panellists considered the little time students had to prepare we were wondering how good they were compared to what was sold on the market. After the product competition, we used the same protocols to test two muffin products, one was produced by team members using sweetpotato flour (C-116) and the other was bought from a local bakery (C-234). Ten panellists were present for the exercise. The results showed that muffins made from 100% wheat flour by the store was preferred (with a score of 4.7 out of 7) to sweetpotato muffin (3.7 out of 7) (Table 22). This simple exercise indicated that there was room for improvement for both products, sweetpotato products need to be improved more in order to compete effectively with wheat products that have a long history in producing and marketing, and consumers are accustomed to their taste and appearance and use them as benchmarks for evaluating any new products.

Table 22. Sensory evaluation of muffins

	Appearance	Texture	Size/shape	Taste	Aroma	Overall Quality
C-116	3.4	4.1	3.5	4.7	5.3	3.7
C-234	5.5	5.4	4.8	5.6	5.4	4.7

4.2.8 Recipes and costing of sweetpotato products

Table 23. Receipts and costing of making sweetpotato products

Sweetpotato Buns

Ingredients	Quantity	Cost (K)
Sweetpotato Flour	2 cups (400g)	1.00
Wheat Flour	5 cups (781.25g)	3.50
Margarine	15 g	0.38
Sugar	1 cups(200g)	0.80
Salt	1 teaspoon (15g)	0.01
Yeast	10 g	0.28
Water	150 ml	-
Total Cost		5.97
Outputs	1.725 kg Buns 19-22 Buns	K3.461/kg, or K0.27 - 0.31/bun

Sweetpotato Scones

Ingredient	Quantity	Cost (K)
Sweet Potato Flour	4 cups(800g)	2.00
Self-rising Flour	4 cups(625g)	2.80
Margarine	125g	0.94
Baking Powder	2 ½ teaspoons (20g)	0.38
Sugar	¾ cups(150g)	0.68
Salt	$\frac{1}{4}$ teaspoon	0.03
milk	1 cup(250ml)	1.00
Egg	3 eggs	2.50
Vanilla	1 teaspoon	0.10
Total Cost		10.43
Outputs	30~40 Scones	0.26~0.35/scone

Sweetpotato Muffins

Ingredient	Quantity	Cost (K)
Sweet Potato Flour	2 cups(400g)	1.00
Wheat Flour	2 cups(312.5g)	1.41
Margarine	250g	1.80
Baking Powder	2 teaspoons (10g)	0.19
Sugar	1 cup(200g)	0.80
Milk	1/2 cup (125ml)	2.00
Egg	4 eggs	4.00
Vanilla	1 teaspoon	0.1
Total Cost		7.30
Outputs	20~24 Muffins	0.30~0.40/muffin

4.2.9 Stakeholder engagement

Sweetpotato promotion through educational institution linkages has resulted in effective dissemination and adoption of sweetpotato processing technologies. The prospects of the school project being extended to other schools and districts appear promising. With this in mind, we took the school project idea to the provincial government for Morobe, meeting with its agricultural advisors several times. The proposal was well received. However, when it came to putting the project into practice, lack of resources, both human and financial, were a major constraint, in addition to having to determine whether and how the proposal would fit into the existing development program. The project team obtained a copy of the development plan for Morobe, finding that there was nothing to go on as the document did not contain any strategy or action plan into which the proposal could fit. Thus, engaging with the Education Division in the province or even at the national level to revamp the MAL curriculum appears to be our next logical move.

4.3 Outcomes

The school show and community event, organised to showcase the activities of students in the MAL arts and craft lessons, fit in well with the school project. Not only did this event satisfy our goal of holding a product competition, but it also provided an opportunity to promote sweetpotato processing and the ACIAR projects to the wider community, as the event was well attended by students, teachers and parents.

All sweetpotato products were sold out afterwards, providing financial reward and encouragement for participants, as well as an indication of the market potential for sweetpotato products.

- Students learned and worked in a team environment, and gained experience in undertaking a small entrepreneurial endeavour.
- Teachers came to appreciate the commercial potential of sweetpotato as an income-generating activity for the school.
- The project promoted successful linkages of schools with students and families in sharing ideas, which is a promising step towards creating new markets for the crop.

- The project also dramatically raised awareness among students and teachers regarding the importance food processing, and its potential for income generation.

Another good outcome was the conduct of product competition and sensory evaluation. We have tried to conduct product competition to promote sweetpotato processing three times in the past, but failed because of lack of planning. The success this time was owed to all team members working hard and professionally to train the panellists, develop the score sheet, and prepare the samples for the day. This success means we will be able to conduct product competition more regularly as a main means to promote sweetpotato processing to the wider community.

4.4 Lessons learned

We started the school project with the simple objective of raising awareness of sweetpotato processing in the wider community. However, much more has been achieved. In particular, the project introduced a participatory action research approach, which supports the outcome-based teaching model. Both teaching effectiveness and learning outcomes have been improved. In addition, the product competition held as part of the school show was shown to provide the best avenue for promoting sweetpotato processing to the wider community, as well as testing the demand for sweetpotato products.

The pilot trial promoting the use and sale of sweetpotato products by students has shown considerable promise. Future promotional strategies could be geared towards increased buying of sweetpotato flour, and supply of orange fresh root for processing. These strategies are viewed as more appropriate to schools, as they help to address the problem of food security and nutrition. Although these issues are important, the teachers also believe that food security and nutrition may also be addressed and promoted as strategies for healthy living and better wellbeing for children.

Although the trial was successful, there were notable delays and interruptions to the project due to conflicts with other events and activities conducted by school management, and this impacted the program schedule and the duration of teacher training at the May workshop. It also impacted on the momentum created during initial implementation of activities. Even between the schools there were project issues, due to each school having different lesson plans and timetables. At Gebansis, staff teach more than one subject, while at Bubia teachers focus on an individual subject.

Initially a high number of students participated, but this was followed by a later drop in participation rate. This was due to some of the student expectations not being met. Lack of support from school administration was attributed to financial constraints. Despite these constraints, teachers recognised that their processing activity had resulted in marketing opportunities being created for sweetpotato, and also had the potential to enhance technology up-take because teachers want the schools to take advantage of the potential opportunities to profit from processing activity.

Although progress has been made through this pilot project towards promoting processing and utilisation of sweetpotato, at the schools there is a general need to search for more competitive markets for both flour and processed products. Existing opportunities, such as feeding local boarding educational institutions and government offices, have the potential to meet this need to some extent.

The school processing project was trialled at the beginning of second term in two schools in Morobe. The teachers found that sales of sweetptoato products showed considerable promise, although administrative and financial issues were the main constraints to wider student participation. Given these constraints, the teachers focused on one or two of the best possible products.

This research is different to that where research experts arrive at a case study district to carry out research to identify a particular problem and make recommendations. Our approach required students to become more involved in finding out the problem and solving it, working out what needed to be done so that a final product could be marketed effectively. Students found the sweetpotato processing trial to be very useful. Most students involved in the processing lessons used the opportunity to test different recipes. During implementation, teachers monitored students' progress carefully to make sure students completed their assigned tasks properly and in a timely fashion and to achieve the best possible outcomes. The process of research-plan-act-review is the true nature of participatory action research, and it had worked well for the School Project. It is a methodology that can be incorporated into the school system to improve classroom practice and the quality of learning outcomes in schools.

5 Conclusions and recommendations

5.1 Conclusions

Developing an agri-food processing sector has the potential to speed up the process of rural development as well as the industrialisation of an economy. This has been a key development strategy used by governments worldwide, especially in the developing countries, and in recent years has also been applied by international development agencies such as the Food and Agriculture Organisation, the United Nations Industrial Development Organisation, and the International Fund for Agricultural Development. It has been argued that the demand for value-added food and agricultural products has been increasing, and will continue to increase as a result of growing per capita incomes, higher urbanisation, and changing socio-demographics (da Silva et al., 2009). This growth prospect constitutes a push for increased attention to agro-industries development within the context of economic growth, food security and poverty-fighting strategies. ‘Agro-industries for development’ is broader in scope than ‘Agriculture for development’, since agro-industries have the potential to provide employment for the rural population not only in farming, but also in off-farm activities such as handling, packaging, processing, transporting and marketing of food and agricultural products.

This project sought to assist community groups and entrepreneurs in Papua New Guinea to identify and assess product and market development opportunities for processed food products, using sweetpotato as pilot case. The project implemented four main activities: on-station research to improve flour processing efficiency; village-level product and market development to improve marketing; training workshops to build marketing and business skills; and working with primary schools to raise awareness and promote sweetpotato processing to the wider community.

The key findings of the project were as follows:

- Sweetpotato products can be competitive in quality and price using simple technology, and returns to labour are high for people who make the effort. However, few people made the effort, and even they did, the effort was not regular or sustained. The reasons given for lack of enthusiasm or continuity included difficulties in securing the supply of raw materials and basic ingredients, and the laborious nature of the operation when everything was completed manually. Another likely reason, based on our observation, was the local culture of making money only when there was need for cash, rather than making money on a regular basis and saving it for a time when it is needed.
- The business approach to product and market development and business skills training, which focused on costing and gross margin analysis, has had some positive influence on how food processing was perceived as a viable business opportunity. However, there is still some way to go to produce entrepreneurs who are willing to invest the time and resources required to develop a small business, and face the challenge of overcoming many issues of market access and competition. The current business environment in PNG has not made it easy for entrepreneurs to take these first steps.
- There was demand for sweetpotato products because of their novelty, as the majority of PNG consumers did not know such possibilities existed and were curious about what these products were like.
- The School Project was a huge success, both from a methodological perspective and with regard to the outcomes it has produced. In particular, we observed how participatory action research has facilitated learning by doing for the students and implementation of an outcome-based curriculum for teachers. This approach was successful because

sweetpotato processing and product development, being new to the teachers and students, called for continuous learning and improvement until satisfactory outcomes were achieved: in this case, when the product was accepted and paid for by the consumer. It was also successful because it was the teachers and students who decided for themselves how to proceed and what to achieve. The project researchers, as facilitators, were only there to assist when called upon.

- The School Project also helped bring the community together as they used their resources to support the students in product development using locally available materials. Quick selling and high returns from marketing sweetpotato products also provided some evidence of demand and market opportunity for sweetpotato products at the village level. We also found that the School Project was effective in raising awareness of sweetpotato processing amongst the wider community, and the product competition was an excellent way of encouraging innovation and fostering entrepreneurship.

Our conclusion was that developing an agri-food processing sector is necessary for sustainable agricultural development, and it needs to be pursued more aggressively by the PNG government and the agri-food industry with substantial investments in research, development and extension.

5.2 Recommendations

For policymakers:

- A strategic plan for food processing and preservation that coordinates efforts from different departments and at various levels of government.
- Technical assistance to provincial and district governments in formulating and implementing their development plans.
- Recruitment and capacity building of extension personnel and private service providers in food processing and business development services.

For the agri-food industry:

- Stakeholders identifying market opportunities and lobby for government support in RD&E programs for food processing.

For researchers:

- Future food processing research focusing on developing niche products from locally available materials.
- More research in developing simple and low cost solar dryers to cut processing cost and to improve processing efficiency.
- Food processing research focusing on adaptive research based on lessons learned from existing research and experiences from overseas.
- Developing integrated and interdisciplinary research programs aimed at improving the overall cost competitiveness of agricultural commodities that are to be used as inputs for processing.
- Adopt participatory action research and farmer field/business school approaches for capacity building and technology adoption.

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7 Appendices

Appendix 1. Processing cost analysis: Aa1vs Ba1

Activity	Details	Quantity	Unit price (Kina)	Subtotal (Kina)
GRATED-PEELED-SUN-DRIED CHIPS : [Aa1]				
Fresh roots	Farm gate price	28.0	0.60	16.92
	Weighing	1 person @ 0.07hrs	2.4/person/hr	0.17
	Sorting	1 person @ 0.33 hrs	2.4/person/hr	0.79
	Af sorting	27.67	0.60	
Peeling	Peeling	2 person @ 0.83 hrs	2.4/person/hr	3.98
	Veg. peeler	2 peelers	1.10/peeler	2.2
	Washing	2 person @ 0.2 hrs	2.4/person/hr	0.96
	Water	1.5 buckets (9 Lts)	2.22/buckets	3.33
Grating	Grating	2 person @ 1.33 hrs	2.4/person/hr	6.38
	Homemade grater	2 graters	5.00/grater	10
Spreading	Labour	1 person @ 0.30hrs	2.4/person/hr	0.72
Sun drying	Labour	1 person/19hrs	2.4/person/hr	45.6
Packing	Labour	1 person @ 0.1hr	2.4/person/hr	0.24
	Polythene bag	1	0.65	0.65
Transport	To Bubia	½ bag (6.60 kg)	10.00/bag	5
Total processing cost				94.67
SLICED-PEELED SUN-DRIED CHIPS : [Ba1]				
Fresh roots	Farm gate price	1 bags (60.2kg)	0.60	36.12
	Weighing	1 casual @ 0.08hrs	2.4/person/hr	0.19
	Sorting	1 person @ 0.38 hrs	2.4/person/hr	0.91
Peeling	Peeling	2 person @ 1.58 hrs	2.4/person/hr	7.58
	Peeler	2 peelers	1.10/peeler	2.2
	Washing	2 person @ 0.5 hrs	2.4/person/hr	2.4
	Water	1.5 buckets (9 Lts)	2.22/buckets	3.33
Slicing	Slicing 1 bag	2 person @ 2.4 hrs	2.4/person/hr	11.52
	Multi-purpose veg slicer	2 slicers	10.00	20
Spreading	Labour	1 person/ 0.16hrs	2.4/person/hr	0.38
Sun drying	Labour	1 person/@ 17.7 hr	2.4/person/day	42.48
Packing	Labour	1 person @ 0.3hr	2.4/person/hr	0.73
	Polythene bag	1	0.65	0.65
Transport	To Bubia	½ bag (11.70kg)	10.00/bag	5
Total processing cost				127.72

Appendix 2. Processing cost analysis: Aa2 vs Ba2

Activity	Details	Quantity	Unit price (Kina)	Subtotal (Kina)
GRATED -NON PEELED-SUN-DRIED CHIPS: [(Aa2]				
Fresh roots	Farm gate price	38.0kg	0.60	22.80
	Weighing	1 person @ 0.18hrs	2.4/person/hr	0.43
	Sorting	1 person @ 0.27 hrs	2.4/person/hr	0.65
	Washing	2 person @ 0.54 hrs	2.4/person/hr	2.59
	Water	3 buckets (9 Lts)	2.22/buckets	6.66
	Brushing	2 brush	2.00/brush	4.00
Grating	Grating	2 person @ 3.17 hrs	2.4/person/hr	15.22
	Homemade grater	2 graters	5.00/grater	10.00
Spreading	Labour	1 person/0.1 hr	2.4/person/hr	0.24

Sun drying	Labour	1 person/23 hrs	2.4/person/hr	55.20
Packing	Labour	1 person @ 0.1hr	2.4/person/hr	0.75
	Polythene bag	1	0.65	0.65
Transport	To Bubia			0
Total processing cost	Slicing, drying and delivery of dried chips to Bubia			106.71
SLICED-NON PEELED-SUN-DRIED CHIPS: [Ba2]				
Fresh roots	Farm gate price	1 bags (40.22kg)	0.60	24.12
	Washing	2 person @ 0.5 hrs	2.4/person/hr	2.4
	Water	3 buckets (9 lts)	2.22/buckets	6.66
	Brushing	2 brush	2.00/brush	4.00
Slicing	Slicing 1 bag	2 person @ 2.4 hrs	2.4/person/hr	11.52
	Multi slicer	2 slicers	10.00	20.00
Spreading	Labour	1 person/0.16 hrs	2.4/person/hr	0.38
Sun drying	Labour	1 person/22hrs	2.4/person/hr	52.80
Packing	Labour	1 person @ 0.3hr	2.4/person/hr	0.72
	Polythene bag	1	0.65	0.65
Transport	To Bubia	½ bag (9.9 kg)		0
Total processing cost				104.99

Appendix 3. Processing cost analysis: Ab1vs Bb1

Activity	**Details**	**Quantity**	**Unit price (Kina)**	**Subtotal (Kina)**
GRATED-PEELED-OVEN-DRIED CHIPS: [Ab1]				
Fresh roots	Farm gate price	60.7 kg	0.60	36.42
	Weighing	1 person @ 0.18hrs	2.4/person/hr	0.43
	Sorting	1 person @ 0.10 hrs	2.4/person/hr	0.24
Peeling	Peeling	2 person @ 2.01 hrs	2.4/person/hr	9.45
	Veg. peeler	2 peelers	1.10/peeler	2.20
	Washing	2 person @ 0.5 hrs	2.4/person/hr	2.4
	Water	3 buckets (9 Lts)	2.22/buckets	6.66
Grating	Grating	2 person @ 2.72 hrs	2.4/person/hr	13.2
	Homemade grater	2 graters	5.00/grater	10.00
Spreading	Labour	1 person@ 0.7hrs		
Sun drying	Labour	1 person/17.6 hrs	2.4/person/day	42.24
Packing	Labour	1 person @ 0.1hr	2.4/person/hr	0.24
	Polythene bag	1	0.65	0.65
Transport				
Total processing cost				105.62
SLICED-PEELED-OVEN –DRIED CHIPS :[Bb1]				
Fresh roots	Farm gate price	40.4kg	0.60	24.24
	Weighing	1 person@ 0.12hr	2.4/person/hr	0.29
	Sorting	1 person @ 0.5hrs	2.4/person/hr	1.2
	Peeling	2 person @ 0.83 hrs	2.4/person/hr	1.99
	Veg. peeler	2 peelers	1.10/peeler	2.20
	Washing	2 person @ 0.5 hrs	2.40/person/hr	2.40
	Water	1.5 buckets (9 Lts)	2.22/buckets	3.33
Slicing	Slicing	2 person @ 2.8 hrs	2.40/person/hr	13.44
	Slicer	2 slicers	10.00/slicer	20.00
Spreading	Labour	0.14	2.40/person/hr	0.34

Sun drying	Labour	1 person@18.3hrs	2.40/person/hr	43.92
Packing	Labour	1 person @ 0.1hr	2.40/person/hr	0.24
	Polythene bag	1	0.65	0.65
Transport	To Bubia	½ bag (9.8 kg)		
Total processing cost				104.63

Appendix 4. Processing cost analysis: Ab2 vs Bb2

Activity	Details	Quantity	Unit price (Kina)	Subtotal (Kina)
GRATED--NON PEELED-OVEN-DRIED CHIPS: [Ab2]				
Fresh roots	Farm gate price	1 bags (16.2kg)	0.60	9.72
	Weighing	1 person @0.08hrs	2.4/person/hr	0.19
	Sorting	1 person@0.27hrs	2.4/person/hr	0.65
	Washing	2 person @ 0.5 hrs	2.4/person/hr	2.40
	Water	3 buckets (9 lts)	2.22/buckets	6.66
	Brushing	2 brush	2.00/brush	4.00
Grating	grating 1 bag	2 person @ 2.4 hrs	2.40/person/hr	11.52
	Graters	2 graters	5.00	10.0
Spreading	Labour	1 person @ 0.19hrs	2.40/person/hr	0.46
Oven drying	Labour	1 person/16.5hrs	2.40/person/hr	39.60
Packing	Labour	1 person @ 0.1hrs	2.40/person/hr	0.618
	Polythene bag	1	0.65	0.65
Transport	To Bubia	½ bag (4.00 kg)	10.00/bag	
Total processing cost				67.74
SLICED- NON PEELED- OVEN-DRIED CHIPS: [Bb2]				
Fresh roots	Farm gate price	1 bags (15.7kg)	0.60	9.42
	Weighing	1 person @ 0.15		0.36
	Sorting	1 person @ 0.17		0.41
	Washing	2 person @ 0.62 hrs	2.4/person/hr	2.98
	Water	3 buckets (9 lts)	2.22/buckets	6.66
	Brushing	2 brush	2.00/brush	4.0
Slicing	Slicing 1 bag	2 person @ 1.4 hrs	2.4/person/hr	6.72
	Multi slicer	2 slicers	10.00	20.00
Spreading	Labour	1 person@ 0.19 hrs	2.4/person/hr	0.46
Oven drying	Labour	1 person/17.5 hrs	2.4/person/day	42.00
Packing	Labour	1 person @ 0.3hr	2.4/person/hr	0.618
	Polythene bag	1	0.65	0.65
Transport	To Bubia			0
Total processing cost				84.07

Appendix 5. Personnel who were involved in the School Project

Name	Gender	Primary school	Grade/ Class	Teachers running the school project	People who attended the planning Workshop	People who attended the processing training workshop
Stephanie Trenan	F	Gebansis	5B	✓	✓	✓
Glenis Morris	F	Gebansis	5B	✓	✓	✓
Tienang Bowasae	M	Bubia	6	✓	×	✓
Hatabiang Murakie	M	Gebansis	5A	×	×	✓
Julie Sakarias	F	Bubia	8A	×	×	✓
Irene Mais	F	Bubia	7B	✓	×	✓
Brian Paiferi	M	Gebansis	6B	✓	✓	✓
Mary Toae	F	Gebansis	7B	✓	✓	✓
Raka Peter Uu	F	Bubia	6A	×	×	✓
Damioney Saking	F	Bubia	3A	×	×	✓
Agnes Babaik	F	Gebansis	3C	×	×	✓
Gelam Steven	M	Gebansis		×	×	✓
Edward Babaik	M	Gebansis	3A	×	×	✓
Marie Lekung	F	Bubia	3B	×	×	✓
Mary Marpe	F	Gebansis	4A	×	×	✓
Issac Dau	M	Gebansis	Headmaster	×	✓	✓
Mrs Alex	F	Gebansis	4B	×	×	✓
Mrs Rama	F	Gebansis	7A	×	×	✓
Oathley Omali	M	Bubia	4A	×	✓	✓
Jerry Chepung	M	Gebansis	Board Chairman	×	✓	×
Mr Waranigin	M	Bubia	8B	×	✓	×
Mrs Imanin	F	Bubia	7C	✓	×	×
Mr Masuga	M	Bubia	8B	✓	×	×

Appendix 6. Teacher evaluation of the School Project

Miriam

Report on mal project-baking

Introduction

On week4 Friday- off May 2015 the grade seven (7) classes at Bubia Primary School had their making a living practical lesson on topic food preservation .Students baked to products that are, sweat potatoes bun and sweat potatoes muffin after going through the theory notes on how to bake bun.

Students were asked to bring their own ingredients to help support the NARI staff to meet up all the ingredients required for baking They cooperated very well by contributing money to buy everything that were needed for baking they also brought their own firewood dishes, spoons, and cups for opening fire baking but unfortunately it did not work out way they expected due to less number of oven for baking.

At 1pm the preparation began and everyone gathered at the place where the baking process took place .after listening to the place where the baking process took place. student listening to the instruction and seeking how the officer from NARI –biotech has mixed up the ingredients for baking .the student got back into their little groups and repeated by following instruction given

Strength

Student were very eager to learn that they participated very well throughout the mixed process

They really concentrate in mixing doing it themselves give them a taste, for baking a products they were enjoying seeing their mixture and even tasting their own product like icing.

Weakness

The school doesn't have enough ovens that can evenly divide the student in to group

So that the baking can be done on time we were using only one oven that we were borrowed from a friend.

However good number of the students have not see and tasted their products

Because all the baking was done late in the afternoon, which is beyond the schooling hours

Generally baking product was in rush due to time catching.

Suggestions

The Board of Management of the school should look into this to at least provide ovens and cooking stoves for the student for them to have their practical work done especially, when it comes to Home Economic activities students should go through every process of baking and cooking so that it will help them in near future to earn their living

Compiled by – grade seven teachers

Mrs mais Mrs lemoc Ms imaning

Mr masunga Mr boasae