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Final report

Small research and development activity

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1 Acknowledgments

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In particular we wish to acknowledge Dr Lois Englberger, founder, inspiration behind and spiritual leader of the **Go Local** movement.

2 Executive summary

The objectives of this project were to 1) identify and analyse leafy vegetables with the potential to improve human nutrition, 2) investigate and document the reasons for acceptability (or non-acceptability) of different leafy vegetables, and 3) recommend a strategy for further research and raising awareness of their health benefits.

Since the 1940s the consumption of high-energy, low-nutrient foods, including white flour, sugar, polished rice, turkey tails and mutton rib flaps by Pacific Islanders and indigenous Australians, combined with reduced exercise, has resulted in alarming rates of obesity, heart disease, diabetes and certain cancers. These conditions were not present when traditional diets and lifestyles predominated. Many leafy vegetables are grown and eaten in the Pacific region; however, they are sometimes regarded as "low status" foods.

During this 15-month project, leaf samples were collected from Solomon Islands, Samoa, Tonga, Kiribati, Torres Strait Islands and Northern Queensland to analyse minerals, protein and carotenoids, and assess genotype-environment interactions. Surveys were conducted in all project countries to collect knowledge and opinions of leafy vegetables. These revealed that although certain leafy vegetables were popular in some countries, particularly Solomon Islands and Tonga, there was a lack of widespread knowledge of their considerable health benefits.

The data obtained were used to produce 500 sets of factsheets which featured the top ten vegetables for nutritional value and popularity, and these were distributed in the participating countries. The factsheets, which were very well received, included information on plant traits, propagation, harvesting and storage methods, common pests and diseases, and nutritional value (see www.aciar.gov.au/News2013July). Outstanding species included *Abelmoschus manihot* (aibika), *Polyscias spp.* (ete), *Sauropus androgynus* (sweetleaf) and *Moringa oleifera* (drumstick tree). Sweetleaf, for example, was high in iron, zinc, calcium, magnesium, manganese, sulphur, lutein, b-carotene and protein; ete was high in zinc and calcium, and grows well on alkaline coral soils, and the drumstick tree was particularly high in b-carotene, sulphur and selenium.

Addressing the need to strengthen supply of nutrient-rich foods and at the same time ensuring effective delivery of nutrients to the consumer requires consideration of what happens between production and consumption and how the various steps along this chain can affect the availability, affordability, acceptability and nutritional quality of foods for the consumer. A value chain approach would enable analysis of the nutritional value at each step of the chain to include production, storage, distribution, processing, retailing, preparation and consumption.

The project was successful in 1) documenting knowledge and opinions of local people on the growing and consumption of leafy vegetables; 2) producing and distributing information factsheets (as above); 3) promoting local leafy vegetables via the media in the participating countries; 4) supporting outstanding programs in Solomon Islands (Rosemary Kafa's Ministry of Health nutrition awareness program), Samoa (organic farming, conducted by Women in Business Development) and in the Torres Strait (the *Lift for Life* nutrition/fitness study conducted by Queensland Health Community Nutritionist Natalie Orero, and the community horticulture demonstration project conducted by TAFE Lecturer George Ernst); 5) building the capacity of local collaborators in terms of agronomic/plant nutrition and human nutrition knowledge and plant sample collection methods; 6) providing information on optimal propagation methods for the popular vegetable, aibika, from a field trial conducted in Samoa; and 7) providing guidelines for further research/promotion of the production and consumption of healthy local food crops in the Pacific and Northern Australia.

3. Background

Since the 1940s the consumption of high-energy, low-nutrient foods, including white flour, sugar, polished rice, turkey tails and mutton rib flaps by Pacific Islanders and indigenous Australians, combined with reduced exercise, has resulted in alarming rates of obesity, heart disease, diabetes and certain cancers. These conditions were not present when traditional diets and lifestyles predominated.

Many different types of leafy vegetables are grown and eaten in the Pacific region. When available, local vegetables are usually inexpensive and thus affordable to most people in both urban and rural areas; despite this, they can be overlooked, being sometimes regarded as “low status foods”. Circumstantial evidence suggests that this is largely due to lack of knowledge of their food value (an assumption that will be explored further in this SRA). Research has shown most leafy vegetables are valuable foods: they are nutritious and rich in protein, minerals, vitamins (e.g. A, B, C, K), beneficial phyto (plant) chemicals and fibre (for example, aibika/bele, drumstick tree, Ceylon spinach, kangkong).

Most leafy vegetables can be easily grown in home gardens, providing leaves daily for meals. Some crops usually grown for their corms/tubers/storage roots, for example, taro, sweetpotato and cassava, also have nutritious edible leaves. The leaves usually have higher concentrations of vitamins, minerals, fibre and other beneficial compounds than the roots, which are higher in carbohydrate/energy. Some leafy vegetables are found growing in the wild, sometimes as weeds or wayside plants.

The *'Go Local'* campaign in Pohnpei, Federated States of Micronesia (which encourages the production and consumption of high beta-carotene traditional foods including 'karat' bananas), a project to investigate and encourage the consumption of carotenoid-rich orange-fleshed sweetpotato varieties in Solomon Islands and Papua New Guinea (ACIAR SRA PC/2006/106), a project which promoted interest in native plant food production in Samoa and Cape York, Australia (ACIAR PHT/2001/023) and another in Tonga which had as one of its objectives “promoting local production systems and consumption of locally produced fruit and fruit products” (ACIAR HORT/2006/173) provide evidence that tropical vegetables and fruits can be highly nutritious and that their consumption can be promoted successfully if culturally appropriate methods are used.

In addition to the obvious health benefits of traditional diets, local food crop (including “wild food”) biodiversity strengthens the resilience of food systems through increasing the crop species richness and therefore enhances food security. This study is further justified on economic grounds. Growing food to improve nutrition, such as leafy greens, sweetpotato, taro and cassava assists to reduce trade deficits associated with high consumption of imported foods in the Pacific.

This scoping study proposes a review of existing literature on the nutritional benefits of leafy vegetables, and on behavioural analysis and the factors affecting the consumption (or not) of particular foods. Nutritional analysis will be carried out on specific crops and varieties, selected for their potential nutritional value and their acceptability. The project will work with communities to see whether, on a pilot scale, promotional and educational strategies and approaches can change/influence attitudes to food consumption.

4. Objectives

Overall aim:

To develop a strategy for increasing access to, and consumption of, nutritionally rich leafy vegetables among indigenous communities in Samoa, Solomon Islands and Northern Australia.

Objective 1

To identify and analyse leafy vegetables with the potential to improve human nutrition.

Objective 2

To investigate and document the reasons for acceptability (or non-acceptability) of different leafy vegetables.

Objective 3

To recommend a strategy for further research and raising awareness of their health benefits.

5. Methodology

5a Objective 1

To identify and analyse leafy vegetables with the potential to improve human nutrition.

A literature survey/review was conducted by Mary Taylor, titled *Green leafy vegetables and nutrition* (**Appendix 1**). In addition, Ms Alicea Garcia, a student in Environmental Policy and Management at the University of Adelaide, undertaking work experience, wrote a supplementary/complementary literature review titled *Introduction to the sustainable agriculture of leafy vegetables: smallholders in the Pacific* (**Appendix 2**).

(a) Solomon Islands

In June/July 2012, Graham Lyons, assisted by Pita Tikai (AVRDC Honiara) and Rosemary Kafa (SI Ministry of Health and Medical Services) , collected 80 leaf samples from these areas:

1.Burns Creek, in the outskirts of Honiara, representing a peri-urban community, the Falo Local Farmer Association (ex Malaita). Samples were also collected from the Kastom Gaden Association (KGA)'s headquarters at Burns Creek.

2.Marau Sound, at the eastern end of Guadalcanal, representing rural communities. Samples were collected from communities at Porokokore, Legalawa, Nunura and Alite (Tawa'ahi Island), and also from Makina Catholic Mission and adjacent to Marau airfield. We were assisted by Willie Loufeli, the local APHEDA coordinator.

3.Aruliho, West Guadalcanal: Vatukulau village. This site provided a low pH (pH H_2O of 5.0) soil for comparison with most of the other sites. Aibika plants growing on the same soil, but some under full sun and some shaded, were sampled to test for differences in minerals and carotenoids, as it had been observed that insect pests strongly favour Aibika plants in the sun.

4.Ysabel Island (several villages sampled later by Pita Tikai), providing further examples of rural communities.

In order to examine genotype-environment interaction (GxE), an effort was made to sample a range of species growing on the same soil type, and also the same species (e.g. Aibika, sweetpotato, cassava, Ete) growing on several different soil types.

To enable valid comparison between plant species, the 3rd to 6th youngest leaves were sampled where possible. Leaves growing close to the ground or near dusty roads were washed with rainwater to reduce soil/dust contamination (which greatly increases Al and Fe levels).

To limit degradation of the three carotenoids we analysed (beta-carotene, alpha-carotene and lutein), samples were dried in a microwave oven as soon as practicable after collection, usually the same night. Care was taken to ensure that all water was removed from the samples to prevent mould growth.

It should be noted that the surveys of the composition of leafy vegetables and opinions of local people about them (see below) were by no means comprehensive. The Solomon Islands, for example, has rich diversity in edible leaves and this survey sampled just a few of the (usually) better known species in a few areas.

The samples were taken to Australia under a DAFF/AQIS dried plant sample permit held by Waite Analytical Services, University of Adelaide (Waite Campus). On arrival in Australia, the samples were taken by DAFF for irradiation and then sent to the Waite Campus.

Most of the samples were subjected to the extraction method described in Wheal et al (2011), then analysed for a range of mineral nutrients (Fe, Mn, B, Cu, Mo, Ni, Zn, Ca, Mg, Na, K, P and S) and also Al, Ti and Cr (for quality control purposes to detect soil contamination) using inductively coupled plasma (ICP) optical emission spectrometry; and a small sub-sample was analysed for Se using ICP mass spectrometry; N (from which crude protein can be estimated) by the combustion method (using an Elementar instrument). For leaves, a conversion factor of 4.4 is considered more accurate than the traditional 6.25, which was developed for animal protein sources and which will overestimate leaf protein (Milton and Dintzis, 1981; Mariotti et al, 2008). Thus multiply leaf N% by 4.4 to give leaf protein %. The leaves were also analysed for b-carotene, a-carotene and lutein by high pressure liquid chromatography (HPLC) by the laboratory of Associate Professor Daryl Mares, Waite Campus (Soriano et al, 2007, using methanol/tetra hydrofuran/butylated hydroxyl toluene extraction and HPLC method modified from Breithaupt et al, 2002).

In addition, a sub-sample (n=28) was sent to the biochemist, Dr Shahidul Islam at the Department of Biochemistry, School of Life Sciences, University of KwaZulu Natal (Westville Campus), Durban, South Africa. Dr Islam is renowned for his studies on phytocompounds and their human health benefits. Dr Islam was assisted by Mohammed Auwal Ibrahim. Each powdered leaf sample was defatted with hexane, then extracted both in ethanol and water. The total phenolic content of each extract was determined (as gallic acid equivalent) according to the method of McDonald et al (2001). The absorbance values were determined at 765nm on a Shimadzu spectrophotometer. All measurements were done in triplicate.

The eight highest samples for total phenolics were then tested for radical scavenging activity, using the popular DPPH antioxidant assay.1,1-Diphenyl-2-picryl-hydrazyl (DPPH) is a stable free radical which has an unpaired valence electron at one atom of nitrogen bridge. In addition IC50 was determined for each sample. IC50 is a measure of the half maximal inhibitory concentration, or the concentration of a drug that is required for 50% inhibition *in vitro*. Units are g/mL. In this case it is a measure of the effectiveness of a sample in removing free radicals that cause oxidative stress. Thus the lower, the better.

(b) Torres Strait Islands

Due to time/budget constraints, leaf sampling was limited to Thursday and Horn Islands in the southern Torres Strait Islands. A special DAFF permit for collecting plants from this area was obtained prior to Graham Lyons and our horticulture consultant, Roger Goebel travelling there in September 2012. Our Thursday Island collaborators, Natalie Orero (Queensland Health Community Nutritionist) and George Ernst (TAFE horticulture/agriculture lecturer) assisted with the collection and drying of the samples (by microwave oven). Samples of *Moringa* were split to test a dehydrator v microwave oven for sample drying. We found the microwaved sample had twice the b-carotene concentration and 81% of the lutein, so this method appears effective, especially for preserving b-carotene. The dried samples (n=44 from 14 main sites) were inspected by DAFF officers on Thursday Island, then handed to a DAFF officer on arrival back in Cairns. After irradiation, they were forwarded to the Waite Campus, Adelaide.

(c) Cairns

Roger Goebel sampled several leafy crops (n=12) growing at his farm at Etty Bay, Mourilyan, south of Cairns, microwave-dried and sent to Adelaide.

(d) Tonga

During his trip to Tonga in October 2012 (on another project), Roger collected 22 samples, dried and sent to Adelaide, via DAFF.

(e) Samoa

Mary Taylor, assisted by researchers from Samoan Women in Business Development, collected 31 samples of a range of leafy vegetable species during her December 2012 trip, and 18 taro leaf samples during her March 2013 trip, to enable a GxE study of different taro cultivars which were being trialled at 5 sites. On both trips, the leaves were dried in a microwave oven, as above, and sent to Australia.

(e) Kiribati

Ms Takena Redfern (Coordinator, Soil Health Project, Centre for Excellence for Atoll Agriculture Research and Development, Agriculture Division, Tarawa, Kiribati) sent samples of several breadfruit cultivars (n=10) grown at several sites on Tarawa, for ICP and N analysis.

(f) Fiji and Vanuatu

Due to time and budget constraints, surveys were not conducted in Fiji and Vanuatu. However, the survey conducted in Tonga and the samples collected in Tonga and Cairns (courtesy of Roger Goebel) and in Kiribati (courtesy of Takena Redfern) were in addition to the project proposal.

(g) Factsheet production

Using the ICP, N and HPLC data, together with information gathered during the surveys (below), consultation with collaborators, and existing knowledge of leafy vegetable crops in the South Pacific and Northern Australia, a ***top ten*** list of leafy vegetable crops for these regions was compiled, and a 2-sided, A4 sized colour factsheet produced for each one by Roger Goebel, Mary Taylor and Graham Lyons. The factsheets included information on plant traits, uses, best propagation methods, common pests, harvesting methods, storage and nutritional value. For the latter, an effort was made to present data of the featured species growing at a representative site, along with another leafy vegetable (or two) growing at the same site (on the same soil type) - in order to highlight the nutritional strengths of the featured species – and also a comparison with English cabbage, an introduced vegetable now commonly available at markets in the countries studied (and which was usually inferior to the featured species in most minerals, protein and carotenoids.

Each factsheet includes around 5 high-quality photographs, mostly supplied by Roger. In addition to the factsheets featuring the *top ten*, an introductory sheet (describing the project, background, personnel, references, etc) and a sheet describing George Ernst's community horticulture program on Thursday Island (an outstanding example of what can be achieved by using the right species and agronomic methods, working with a poor soil base) were also produced. Mr Simi Tukidia, Suva assisted with graphic design, and the sheets were printed and (half) laminated in Suva in May 2013 (500 sets for a total of 6000 sheets), then couriered/taken to Samoa, Tonga, Solomon Islands, Torres Strait, Darwin and to the project manager in Suva.

5b Objective 2

To investigate and document the reasons for acceptability (or non-acceptability) of different leafy vegetables.

After consultation with our collaborators and numerous drafts, a questionnaire was finalised (**Appendix 3**) to try to obtain information which would provide us with people's genuine opinions on cultivating and eating local leafy vegetables and wild-collected leaves. Key questions included:

- Which leafy vegetables/edible leaves do you grow in your garden or close to your house?
- Which do you collect from the wild?
- Which do you eat most often?
- Which leafy vegetables do you not like to eat? Why not?
- What kinds of pests and diseases do you see on them?
- Do you think leafy vegetables are good for you? Why?
- Is nutrition/diet taught at the local school?
- Does the school have a food garden? If so, what crops are grown?
- What do you think could prevent people from growing their own leafy vegetables (e.g. taboos; lack of garden space in towns).

Flexibility was required in the implementation of the survey of local opinions on leafy vegetables. In the case of Arnhem Land and Torres Strait, it was not possible to conduct community workshops. Although the project was able to obtain human ethics clearance from the University of Adelaide, on the advice of our collaborators in these areas, *viz* that the process of obtaining the necessary permissions to conduct social research (in the form of a survey using a questionnaire) would be too protracted for a short project like this, along with issues relating to intellectual property and the use of traditional knowledge, we instead based our findings on information from key informants, colleague interviews (including agricultural, health, nutrition officers) and third party sources. We found that this approach provided an insightful view of the situation re growing and consumption of leafy vegetables in the Top End and Torres Strait (see Tania Paul's report: **Appendix 4**).

In Solomon Islands, mini-workshops were held at the villages/sites where leaf samples were obtained (in Honiara, Burns Creek, Marau Sound and Aruliho) (see G Lyons's report of Solomons trip May/June 2012: **Appendix 5**).

In Tonga, Roger Goebel collected samples and conducted interviews and a market survey (see his report: **Appendix 6**).

In Samoa, Mary Taylor collected samples and conducted interviews. In addition, interviews were conducted at the WIBD Workshop (see Kalais-Jade Stanley's report: **Appendix 7**). For Kalais-Jade's report on the pele propagation trial, see **Appendix 8**.

Common themes derived from the data we obtained were then used to inform Objective 3, a strategy for further research.

Local media were engaged (e.g. in Solomon Islands: *The Solomon Star*; *Vois Blong Mere*) to publicise the project and the nutritious local leafy vegetable message.

5c Objective 3

To recommend a strategy for further research and raising awareness of their health benefits.

Based on the data obtained by using the methods described above, the project leaders, in consultation with our collaborators, have determined a strategy which we consider should be effective in ultimately producing the outcome of improved nutrition and health in South Pacific Island countries and in Northern Australia.

6. Key results and discussion

a. Objective 1

Factsheets

The factsheets were the main outcome (of all surveys and analyses) under Objective 1 and because of this we have placed them at the head of this section. See:

www.aciar.gov.au/News2013July

The data obtained from analysing the leaf samples and information from previous studies showed that there were plenty of species in addition to the ten featured in the factsheets which warrant promotion due to their nutritional value, taste and suitability for the target countries, e.g. ferns, sweetpotato leaves, cassava leaves: see Table 1 below and appendices featuring mineral and carotenoid data. It would be worthwhile, if resources were available, to cover these species, especially those of interest for specific countries.

Table 1. Comparison of nutritional traits in sweetpotato leaves, cassava leaves and English cabbage. Summarised data for minerals and carotenoids. Units are parts per million (mg/kg) for all minerals (except nitrogen, in %) and carotenoids

				Mineral nutrients							Carotenoids		
	Mn	**B**	**Cu**	**Zn**	**Ca**	**Mg**	**K**	**P**	**S**	**N %**	**Lutein**	**Alpha-carot**	**Beta-carot**
Sweet potato	83	39	13	29	6700	4200	28000	3500	3000	4.2	332	8	265
Cassava	170	41	8	88	12000	5400	16000	3100	2800	4.3	319	4	269
English cabbage	23	12	23	20	5700	1450	29000	3750	3750	2.8	5	0	2

Sweetpotato samples: n=9 from Samoa, Solomon Islands and Torres Strait Islands. Cassava samples: n=13 from Samoa, Solomon Islands, Torres Strait Islands and Cairns. English cabbage samples: n=2 from Tonga and Solomon Islands

Cassava leaves are considered to be particularly nutritious, including being high in protein. This study suggests that sweetpotato leaves are similar to cassava leaves for B, P, S and N (equivalent to 18% protein) and the three carotenoids tested. Sweetpotato leaves are higher than cassava leaves for Cu and K, and lower for Mn, Zn, Ca and Mg. Cabbage is generally of lower nutritional content than leaves of sweetpotato and cassava (and indeed most of the local leafy vegetables we tested), except for Cu, K and S.

The factsheets were well received by all who have seen them: Luseane Taufa (Ministry of Agriculture, Food, Fisheries and Forests, Tonga) and the researchers at Samoan Women in Business Development, led by Kalais-Jane Stanley, were particularly enthusiastic. They were also very well received at the WIBD Workshop (report below). On the second/follow-up trip to Solomon Islands, factsheet distribution commenced at the communities visited previously, and also provided (during the trip and later, by Pita Tikai, AVRDC Honiara) to *inter alia* Kastom Gaden Association, Ministry of Health and Medical Services, Ministry of Education and Training, Ministry of Agriculture and Livestock, the SDA's Adventist Development and Relief Agency and print and radio media.

In Australia, factsheets were provided to Tania Paul (Charles Darwin University), Roger Goebel (Mourilyan, for distribution during his busy horticultural consulting activities), Natalie Orero (Queensland Health), George Ernst (TI TAFE) and Eddie Sailor (Torres Shire Council) and print media.

(a) Solomon Islands

The samples collected in Solomon Islands in June/July 2012 are listed in **Appendix 9**, followed by the data in **Appendix 10**. The sample numbers on the data sheets correspond with the master list. Carotenoid data are in **Appendix. 11**. See **Appendix 5** for a detailed report of this trip. In addition, Pita Tikai collected samples from two villages on Santa Ysabel in December 2012.

Summary

Minerals

The mineral analyses of the 85 leaf samples collected on this trip revealed large genotypic variability in mineral nutrient accumulation (shown by sampling and analysing different species growing on the same soil) as well as showing the influence of soil type (by analysing the same species across several sites). There were species that appeared to be very good at accumulating particular nutrients/micronutrients, e.g.:

Fe: Moringa (Drumstick tree), Ete, yardlong bean, Boneo (note that some leaf samples were not included in plant Fe assessment due to soil/dust contamination. In my experience, such contamination, as long as not severe, affects only Al, Fe and titanium levels)

Zn: Ete, Boneo, watercress

S: Drumstick tree, watercress, cabbage

Mg: Ofenga

Ca: Ofenga

P: Ofenga

K: Pumpkin tips, soursop, chilli

Ni: Bohore fern

Se: Drumstick tree

N/protein: Boneo, local kabis (at KGA), Moringa, cassava.

And "good all rounders" included Boneo, Ofenga, Ete, Aibika and Drumstick.

Other notable mineral findings/elaboration include:

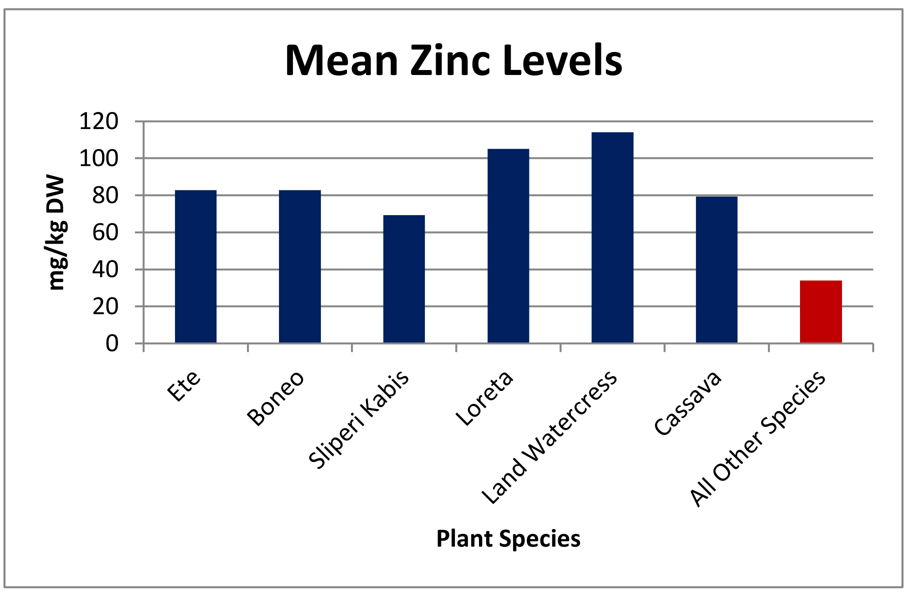
- Drumstick tree (*Moringa oleifera*) is particularly efficient at accumulating sulphur and selenium in leaves, around 4x and 11x that of most other plants, respectively, grown on the same soil. This trait would be especially valuable in Sub-Saharan Africa, where these minerals are deficient in soils in many areas. Their deficiency is considered by some scientists to be a risk factor for HIV/AIDS.

- Ete (*Polyscias spp.*) grows very well (showing no Fe or other deficiency symptoms) on high pH, coralline soils, while other plants such as cassava and sweetpotato usually grow poorly (and exhibit pale, chlorotic leaves) on these soils. Hence, Ete should be a valuable plant for atolls, with this iron-efficient trait, together with its excellent overall nutrition, outstanding flavour and lactation-enhancing ability.
- Tree ferns (samples 44 from Marau and sample 7 from Ysabel) were very high in aluminium: 5300 and 400 mg/kg, respectively. The levels of iron and titanium in these samples indicate that the Al is not due to soil contamination in these samples. This finding is unusual as most plants do not take up Al into their leaves. It is suggested that this type of tree fern not be included in the diet, or only in small amounts.

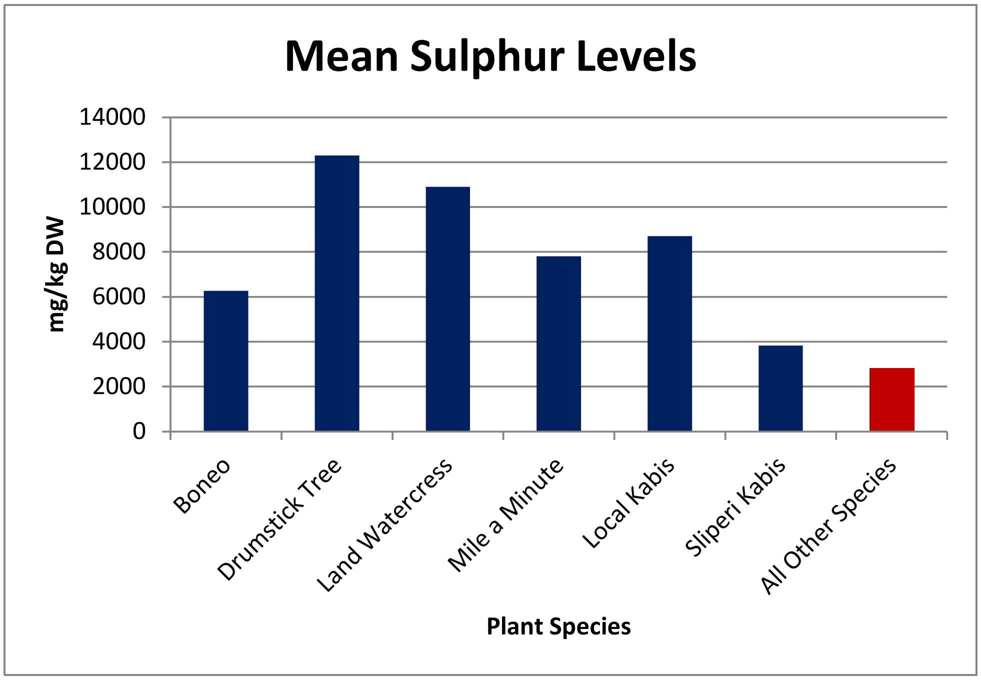
Figure 1, prepared by Alicea Garcia, University of Adelaide, shows the highest leafy species for zinc and sulphur concentration, and, using *Sliperi kabis* as an example, shows the variation in leaf concentration of two minerals (zinc and manganese) at different sites. This variation is due mostly to differences in plant-available levels of these minerals in the soil. See **Appendix 12** for further graphs, including the best accumulators of nitrogen (protein),calcium, magnesium and manganese, and GxE graphs of zinc and magnesium in *Sliperi kabis* and zinc in *Ete.*

Figure 1. Highest Zn (a) and highest sulphur (b) in leafy vegetable samples, and levels of zinc and manganese in *Abelmoschus manihot* from different sites (c). All samples collected on Guadalcanal, Solomon Islands in June 2012

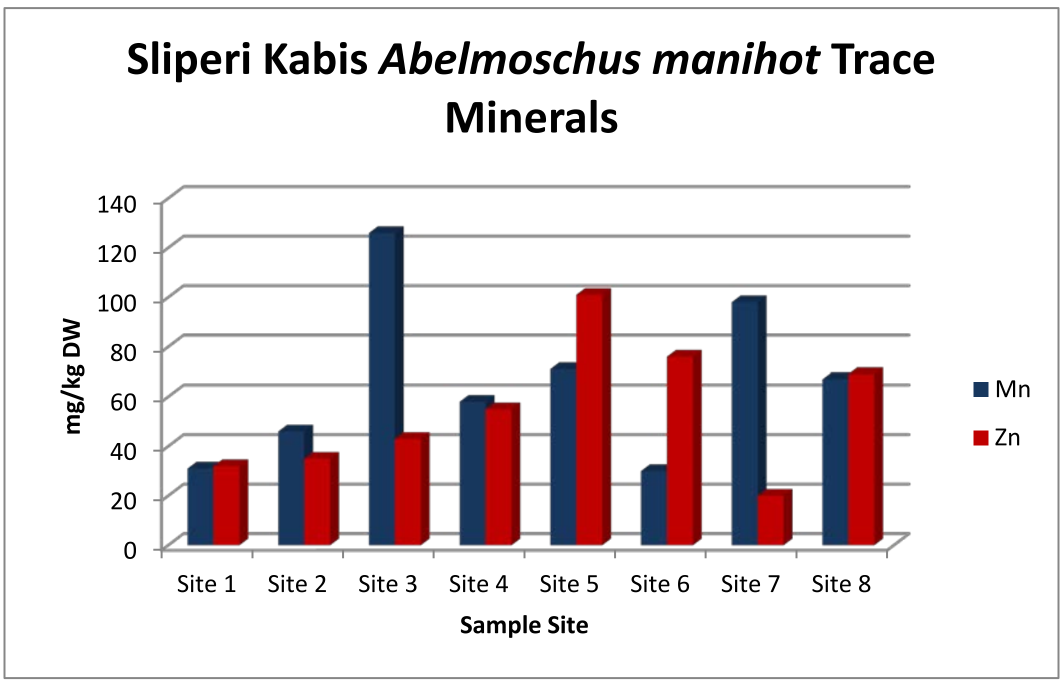
(a)



(b)


Mean Sulphur Levels
14000
12000
10000
8000
6000
4000
2000
0
mg/kg DW
Boneo
Drumstick Tree
Land Watercress
Mile a Minute
Local Kabis
Sliperi Kabis
All Other Species
Plant Species

(c)


Sliperi Kabis *Abelmoschus manihot* Trace Minerals
140
120
100
80
60
40
20
0
mg/kg DW
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 8
Sample Site
Mn
Zn

Aibika-*Nisotra* study

As part of this study, we investigated Aibika samples grown in sun and shade. It is well known that Aibika (sliperi kabis, bele) is susceptible to insect attack. In addition it is often observed that Aibika growing in full sunlight can be heavily infested with *Nisotra basselae* (the “Aibika flea beetle”) while plants of the same variety growing nearby on the same soil but in the shade are insect-free. Researchers have found that previously shaded, insect-free Aibika plants, when transferred to a sunlit position, remain insect-free for around two days. In this study we found differences in certain minerals, carotenoids and polyphenols between the plants growing in the two locations. Table 2 summarises these. Further study is warranted. See **Appendix 13** for full report.

Table 2. Concentrations of selected minerals and carotenoids in Aibika leaves from plants grown near to each other either in full sunlight or shade at Aruligo, Solomon Islands

	Minerals (mg/kg dry wt)						**Carotenoids (mg/kg dry wt)**		
	K	**Zn**	**Mg**	**S**	**Cu**		**lutein**	**alpha-carotene**	**beta-carotene**
Sun	34000	69	6200	3400	9		511	11	173
Shade	34000	95	11900	4700	12		850	20	288
Change in shade (%)	0	+38	+92	+38	+33		+66	+82	+66

Carotenoids

Carotenoids are an important class of plant compounds, with over 600 forms identified. The most important for human health are the pro-vitamin A carotenoids, of which beta-carotene is the most efficient in conversion to vitamin A once it enters the body. It is also involved in eye health and has anticancer effects. The xanthophyll carotenoids (lutein, zeaxanthin) are important for eye health (in reducing risk of macular degeneration and cataracts). These carotenoids are also involved in bone health. Alpha-carotene, which is usually present at much lower levels in these samples, is also a pro-vitamin A carotenoid (with around half the vitamin A conversion efficiency of b-carotene), and is a precursor of lutein.

Table 3 shows that leafy crops in the tropics provide relatively high levels of lutein and b-carotene (for human nutrition, the higher the levels of these the better). For comparison, a high b-carotene orange-fleshed sweetpotato variety (Beauregard) has a level of around 225 mg/kg DW b-carotene and almost no lutein in its tubers. The English cabbage (purchased from the Honiara market) was almost devoid of the carotenoids we analysed, well below all of the samples of local leafy plants we tested. More data are provided below, under (c) Cairns.

Table 3. Carotenoid levels in a selection of leaf samples collected on Guadalcanal, Solomon Islands in June 2012. For the full report see **Appendix 11**.

			Carotenoid mg/kg DW)	
Sample no.	**Name**	**lutein**	**b-carotene**	**a-carotene**
3	Cassava	563	233	5
5	Sweetleaf	773	289	32
8	Ofenga	401	130	39
14	Aibika	1024	356	38
16	King tree	737	116	122
32	Drumstick tree	773	427	0
33	Sandpaper kabis	554	57	159
36	Ete	156	62	18
48	Taro	437	177	0
74	Pumpkin tips	905	276	11
81	English cabbage	5	0	2

Note: The lutein form reported here is the sum of trans lutein and 3'-epi lutein (HPLC peak 446nm), which constitute the bulk of biologically active lutein

b-carotene analysed peak 451nm; a-carotene 446nm.

Phenolics

Total phenolics is usually associated with total antioxidant activity and various health and medicinal benefits: generally, the higher, the better. The data are presented in Table 4. **The standout species was Ceylon spinach, featured on Factsheet 9, with a level of 76 mg/g GE equivalent (ethanol extract).** Other high-rating leaves included breadfruit, Ofenga (featured on factsheet 4) and climbing fern. Butterfly tree and *Cyathea* fern had low levels (around 2 for both forms of extract).

The eight highest samples for total phenolics were tested for radical scavenging activity (see Table 8a), and ***Alternanthera* (redleaf) and *Basella alba* (Ceylon spinach) had the lowest IC50 values (the lower the more effective).** *Alternanthera* has been found to have effects against fever, inflammation, pain and diabetes, while *Basella* has effects against inflammation, high blood pressure, dysentery, viruses, fungi and cancer. **The ethanolic extract of *Basella* was by far the most effective of all the samples studied for DPPH radical scavenging activity** (see Figure 2a (1), compared with the climbing swamp fern, which had the lowest activity against free radicals in this sample set), thus in accord with the total phenolics finding for Ceylon spinach (above).

Table 4. Total phenolics content of leaf samples collected on Guadalcanal, Solomon Islands in June 2012

Sample No	Name	Total phenolics (mg/g) GE equivalent	
		Aqueous extract	Ethanol extract
5	*Sauropus androgynous* (Sweetleaf)	6.58 ± 1.43	7.69 ± 0.55
8	*Pseuderanthemum whartonianum* (Ofenga)	4.45 ± 0.25	24.04 ± 0.33
9	*Pseuderanthemum whartonianum*	9.26 ± 2.24	25.67 ± 4.62
10	*Mikania cordata* (Mile a minute)	3.48 ± 0.31	8.82 ± 1.18
11	Malasya	3.26 ± 0.67	4.89 ± 0.17
12	Konare	26.17 ± 4.28	12.94 ± 0.94
15	*Sauropus androgynous* (Sweetleaf)	6.58 ± 0.12	11.09 ± 1.08
32	*Moringa oleifera* (Drumstick tree)	4.95 ± 1.58	10.09 ± 0.69
33	*Ficus copiosa* (Sandpaper cabbage)	6.36 ± 1.82	4.15 ± 0.58
35	*Polyscias spp* (Ete)	2.60 ± 0.13	0.19 ± 0.012
36	*Polyscias spp*	12.28 ± 2.52	14.69 ± 3.21
41	Smol furuti	31.81 ± 0.78	12.39 ± 0.60
42	*Polyscias verticillata* (Pure)	3.81 ± 0.58	15.74 ± 0.67
45	*Cyathea spp* (Kaibohore fern)	1.63 ± 0.69	2.18 ± 0.37
47	*Stenochlaena palustris* (Climbing fern)	17.65 ± 0.78	19.72 ± 0.91
49	*Melicope elleryana* (Butterfly tree)	3.62 ± 0.52	1.54 ± 0.30

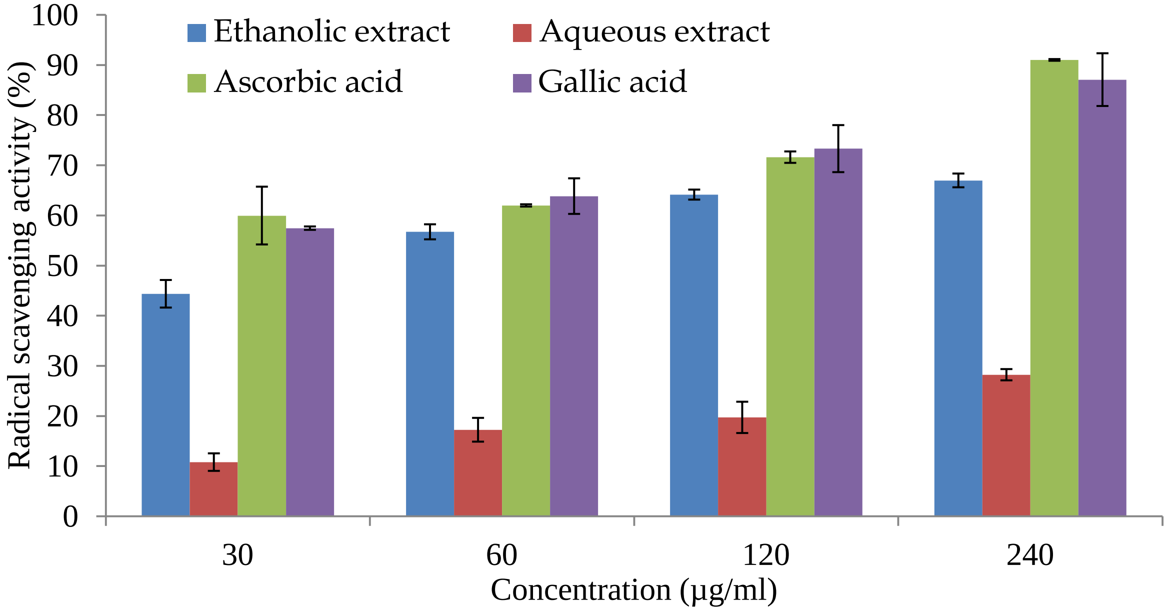
58	Marauvo	17.09 ± 4.20	16.18 ± 0.59
59	*Artocarpus altilis* (Breadfruit)	12.33 ± 1.00	23.93 ± 3.37
61	*Ficus wassa* (Sandpaper cabbage)	6.41 ± 0.62	14.27 ± 1.55
63	*Colocasia esculenta*	7.80 ± 0.66	7.33 ± 0.78
64	*Alternanthera spp. (*Redleaf)	5.39 ± 0.28	25.45 ± 2.60
67	*Basella rubra* (Ceylon spinach)	34.19 ± 5.80	76.24 ± 6.27
68	Aruba	9.63 ± 0.46	13.33 ± 1.94
70	*Carica papaya* (Pawpaw)	10.40 ± 1.58	9.57 ± 0.52
72	Loretta	3.62 ± 1.79	9.84 ± 0.94
79	*Abelmoschus manihot* (Sliperi kabis) growing in sun	11.26 ± 0.58	14.33 ± 0.83
80	*Abelmoschus manihot* growing in shade	4.59 ± 1.04	16.04 ± 1.76

Table 4a. DPPH radical scavenging activity of selected leaf samples from Guadalcanal, Solomon Islands

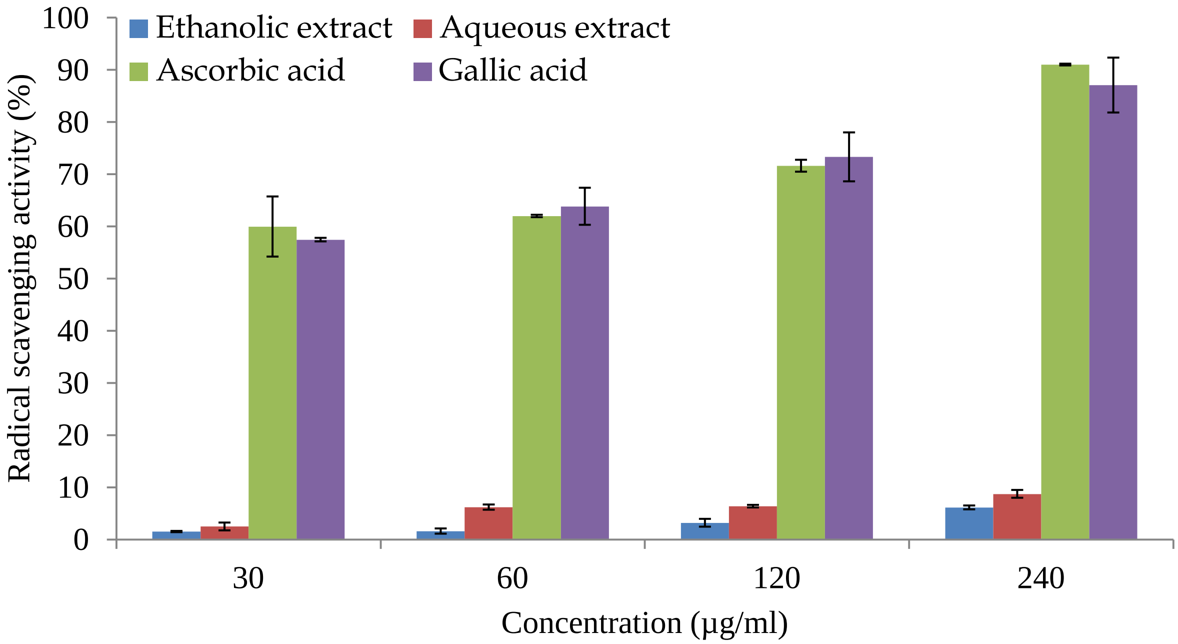
Sample	IC_{50} value	
	Ethanolic	Aqueous
8	977.93 ± 214.61	6930.08 ± 1506.69
9	398.26 ± 95.31	2181.81 ± 1241.89
41	1269.63 ± 1.10*	2945.68 ± 0.27
47	226.99 ± 0.17*	5361.46 ± 210.33
58	204434.0 ± 39362.8	4164.38 ± 261.99
59	738.98 ± 170.42	44.84 ± 14.07
64	11.72 ± 3.31	3.89 ± 0.16
67	41.66 ± 6.24	4004.61 ± 166.07

IC50 is a measure of the half maximal inhibitory concentration, or the concentration of a drug that is required for 50% inhibition *in vitro*. Units are g/mL. In this case it is a measure of the effectiveness of a sample in removing free radicals that cause oxidative stress. Thus the lower, the better.

Figure 2a (1).DPPH radical scavenging activity of ethanol and aqueous extracts of sample 67 *Basella alba* (Ceylon spinach)



(2).DPPH radical scavenging activity of ethanol and aqueous extracts of sample 47 *Stenochlaena palustris* (climbing swamp fern)



(b) Torres Strait Islands

Samples collected on Thursday and Horn Islands included leaves of cassava, sweetpotato, Aibika, chilli, pawpaw, pumpkin, lemon grass, Drumstick tree and sweetleaf. The sample list is attached in **Appendix 14**, together with mineral data.

Minerals

Some dust/soil contamination evident. Some samples were collected from the TAFE horticulture demonstration plots around Thursday Island (see Factsheet 12), which were well mulched and fertilised. For example, sample 21 (pumpkin tips from Blackall St) had 7% N (equating to 31% protein), 3.6% K and 1.1% P, compared with sample 8 (sandpaper cabbage from near the fire station, growing on naturally poor TI soil), which had 2% N (9% protein), 1.3% K and 0.1% P.

Of particular interest was the Drumstick tree, which Roger remembered from a visit when he was a quarantine officer 15 years before, and which was not listed by DAFF on its Thursday Is plant species list. Similarly to the tree at KGA in the Solomons, this one had much higher S and Se levels than other plants growing on the same soil type. In order to promote this nutritious tree, George Ernst collected stem cuttings and grew them in the TAFE nursery, for transplanting into some of the horticulture plots around the island. On the second trip to the TSI (June 2013), Roger and GHL found another Drumstick tree growing near the beach and the *Torres News* office.

The highest mineral levels in leaves were found in sweetleaf/Boneo, chilli, *Polyscias* (related to Ete in the Solomons, but this one was lower in N), ginger/galangal, pumpkin tips (especially for N), curly-leaf spinach, Bok choi (purchased from the IBIS supermarket…nutritious leafy plants *can* be found in shops). The Boneo plant was growing next to a chain-mesh fence behind the fire station. Erosion of metals from the fence into the soil resulted in high levels of these in the plant, e.g. zinc 2100 ppm, cadmium 13 and lead 14. In the same location but around one metre from the fence, mulberry and pawpaw leaves had normal Zn levels and undetectable Cd and Pb.

Cassava leaf was typically high in Zn. Tamarind was very high in Ca, Mg and Na but very low in P, K and S. The Horn Is Noni leaf was high in Ca and Na. The banana bell (sample 24) was high in nickel, K and P. The two leguminous cover crop species sampled from the same site on Horn Is illustrate genotypic variation in plants' ability to take up and accumulate specific micronutrients: Centro (*Centrosema pubescens*) had 3x the concentration of Mn and Cu, and 2x the Zn of Siratro (*Macroptilium atropurpureum*).

Carotenoids

Carotenoid data reported below, compared with Solomons, Cairns and Samoa, in Tables 5 and 6.

The highest samples for b-carotene were taro/cocoyam, Boneo and pawpaw.

Carotenoid GxE

There was a wide variation in carotenoid levels in different species (as expected), both within the same country and at the same site. However, there was also variation within the same species grown at different sites, within and between countries/regions. For example, the Solomons Drumstick tree had 3 times the lutein and twice the b-carotene of the Thursday Is

Drumstick tree. Such differences are probably due mostly to differences in the soil and climate, but there could also be some varietal differences as well (Table 5).

Table 5. Comparison of carotenoid levels in four species, which were sampled in at least two countries. The data are mean values where samples were collected at multiple sites within each country/region (ppm DW). NS = not sampled

		SI		**TSI**			**Cairns**		**Samoa**	
Species	**lutein**	**b-carot**		**lutein**	**b-carot**		**lutein**	**b-carot**	**lutein**	**b-carot**
Taro	401	163		472	281		650	242	464	213
Cassava	473	239		192	196		564	283	570	392
Drumstick tree	773	427		254	224		NS	NS	NS	NS
Aibika	803	285		328	160		NS	NS	612	335

Notes: SI = Solomon Islands; TSI = Torres Strait Islands (Thursday and Horn Islands)

It can be seen that lutein in taro and cassava is highest in Cairns; and b-carotene in cassava is highest in Samoa and Cairns, while b-carotene in taro is highest in the Torres Strait. Drumstick tree and Aibika are much higher for both carotenoids in the Solomons than in Torres Strait, but b-carotene in Aibika is highest in Samoa. There may be some varietal differences, but in this study it was not possible to determine these.

Table 6. Comparison of highest and lowest concentrations of three carotenoids in leaf samples collected in Solomon Islands, Torres Strait Islands, North Queensland June-Sept 2012, and Samoa in Dec 2012-March 2013 (ppm DW). Some species are reported more than once for a particular country as several different samples were collected.

Place		**Lutein**			**b-carotene**			**a-carotene**	
Solomons	Highest	Name			Name			Name	
		Aibika	1024		Drumstick tree	427		Sandpaper kabis	159
		Aibika	987		Aibika	359		King tree	122
		Pumpkin	905		Aibika	356		Ginger	109
		Pumpkin	869		Chilli	340		Pure	95

	Lowest	Cabbage	5		Cabbage	2		Lettuce	0
		Breadfruit	59		Kaipota fern	19		Sweet basil	0
		Ete	156		Fern	37		Watercress	0
TSI	Highest	Taro	541		Taro	329		Papaya	77
		Boneo	464		Boneo	242		Boneo	36
		Pumpkin	459		Cocoyam	233		Cocoyam	34
		Papaya	405		Drumstick tree	224		Papaya	30
	Lowest	Banana bell	3		Banana bell	2		Sweetpotato	0
		Tamarind	6		Ete	51		Hibiscus	0
		Bok choi	36		Tamarind	53		Drumstick tree	0
Cairns	Highest	Mint	705		Brazilian spinach	319		Malabar spinach	31
		Taro	650		Cassava	283		Tania	8
		Cassava	564		Mint	275		Balsam pear	7
		Tania	489		Taro	242			
	Lowest	Breadfruit	50		Choko	84		Parsley	0
		Malabar spinach	9		Breadfruit	94		Pumpkin	0
		Choko	249		Pumpkin	117		Cassava	0

Samoa	Highest	Aibika	783		Aibika	417		Aibika	37
		Aibika	744		Cassava	401		Aibika	29
		Aibika	637		Taro	393		Aibika	24
		Cassava	588		Cassava	383		Sweetpotato	21
	Lowest	Samoan sage	57		Samoan sage	69		Taro	0
		Taro	223		Pumpkin	76		Kangkong	0
		Pennywort	238		Taro	90		Cassava	0

Of course, this was a relatively limited, opportunistic survey of carotenoids, but it has provided useful information which, along with the mineral nutrient data and people's preferences, can help us choose those leafy vegetables which are most likely to improve human nutrition in the South Pacific and Northern Australia.

(c) Cairns

The 12 samples from Roger Goebel's farm at Etty Bay, Mourilyan, south of Cairns, Queensland are shown in **Appendix 15** (mineral data), and carotenoids are shown in Table 7.

Minerals

Choko tips, followed by pumpkin tips, were highest in protein, in accord with the samples from the Solomons (above) and Samoa (below). There are no obvious deficiencies apparent, although the cassava (which has probably not been fertilised to the extent of the other plants) is quite low in P and K. Usually cassava is higher in Zn than other species, but here it is 65ppm, while others include Brazilian spinach (very high at 189ppm), mint (104) and choko (90). It is likely that these obtained some Zn via fertiliser while the cassava did not. Quite high Na in kangkong (4900ppm) and parsley (2500ppm), but not alarming. Generous fertiliser application is apparent for Brazilian spinach (high K: 70000ppm) and choko/pumpkin/balsam pear (high P: 7400-10000ppm).

Carotenoids

The Cairns samples tend to be higher in b-carotene than for the same species grown in the Solomons and Torres Strait. Cassava leaves were highest for b-carotene, and mint for lutein.

Table 7. Carotenoids in leaves sampled from Etty Bay, Mourilyan, Queensland in October 2012

Sample no.	**Sample**	**Carotenoid concentration (mg/kg DW)**		
		Lutein	b-carotene	a-carotene
1	Parsley	366	165	0
2	Breadfruit	50	94	2
3	Brazilian spinach	398	319	0
4	Mint	705	275	0
5	Pumpkin	288	117	0
6	Choko	249	84	5
7	Balsam pear	325	161	7
8	Cassava	564	283	0
9	Malabar spinach	246	193	31
10	Tannia	489	217	8
11	Taro	650	242	3
12	Kangkong	263	169	0

(d) Tonga

Roger visited Tonga (Tongatapu and Vava'u Islands) from October 12-20, 2012, and his report, including sample list (n=22) appears in **Appendix 6**. Samples included kangkong (aquatic sweetpotato), Ceylon spinach, English cabbage, seaweed, choko, taro/tannia, Aibika and various herbs.

Minerals

The highish N, P and K levels indicate good soil with possible fertilisation in the home gardens where most samples were collected. Basil was high in Zn, Ca, P and Cu, and lettuce was high in Mg (4700ppm). Most samples were quite high in Na, suggesting proximity to the sea. Sample 2 (silverbeet) was particularly high in Na (15,000ppm) and K (71,000ppm). However, I have measured higher Na: 50,000ppm in silverbeet grown on the Adelaide Plains (and bought at an Adelaide supermarket), which is far too high. Choko, as in Cairns, was efficient at accumulating N, P, Cu and Zn. Tannia, a form of taro, was high in K; kangkong high in Ca, Na and Cu; Aibika very high in Ca (20000-30000ppm), Zn, Mg and P, and Ceylon spinach was high in Ca, Mg, K and P.

On the other hand, English cabbage (bought from markets in Tonga and the Solomons) was low in Fe, Cu, Zn, Ca, Mg, protein and carotenoids, compared to most of the local leafy vegetables, and was used in the factsheets as a comparison.

The three seaweed samples (seaweed is eaten by some Tongans and also used to make commercial dietary supplements) were, as expected, very high in Na (50000-65000ppm) and also high in S, Mg, Ni and boron (B), but low in P, Mn, protein and carotenoids. When analysed with the mass spectrometer, the seaweed was found to be high in iodine (I) (10-91ppm) and moderate in Se (53-270ppb).

Carotenoids

A sub-sample was analysed for carotenoids, but the data were not included with those from other countries as no microwave oven was available and a drying oven (commencing at 35C and increasing to 50C; samples took 4 days to fully dry) was used instead. This would explain the relatively low b-carotene levels: a mean of 95ppm for non-seaweed samples.

(e) Samoa

The mixed species sample list (n=29) and mineral data from Mary Taylor's Dec 2012 trip are provided in **Appendix 16** and the taro leaf data (n=18) from her March 2013 trip in **Appendix 17**.

Notable findings (for the mixed species collected on trip 1) include:

- Pele/Aibika/sliperi kabis (samples 1-5 & 17) is an outstanding provider of N (and thus protein) and a range of other mineral nutrients
- Amaranth (10, 23) and Ceylon spinach (27) are also good all-rounders.
- Chilli leaf (19) was high in N and K
- Pumpkin tips (6) high in N…actually higher than most legumes
- There were some very high Zn concentrations found, e.g. in Aibika (250ppm), Indian pennywort (240ppm) and Samoan sage (154ppm). Generally, levels of 70-100ppm are considered excellent in plant leaves (which are well above the levels needed to satisfy the plant's nutritional Zn requirement), and which provide a good level for humans/animals consuming the leaves. High plant-available Zn usually indicates low pH soils, where Mn is often also high, but the soils here are more likely to be of higher pH (see below)
- Guava leaf was high in Cu (20ppm)
- There is plenty of Ca in most samples. Usually this is seen in plants growing on high pH calcareous soils, but a number of the samples have high Zn as well. I suggest that the soils would be mostly of pH (H_2O) 7-8, but also with good levels of plant-available Zn, which is not a common finding.

- The Ca level in leaves of ivy gourd (sample 29) is unusually high, indeed the highest I have ever recorded (97000ppm, almost 10%). I am not sure how bioavailable this Ca would be…if the leaves are also high in citrate it could be quite low.
- As usual, Drumstick tree is high in S (11600-14000ppm) and one sample was high in Se (540ppb, 15x that of the other plants analysed from the same location)
- The plants analysed for iodine (I), a small sub-sample, had levels of 90-370ppb, which is normal, and much lower than the levels found in the Tongan seaweed samples (10-91ppm, or 10000-91000ppb).

Small GxE study of Aibika in Samoa

NB: this is by no means a comprehensive study: we are not using replications of a large number of cultivars at numerous sites…this is an introductory look at the effect of genotype (in this case Aibika cultivar) and environment (mostly soil type) on the concentration of certain mineral nutrients in leaves i.e. findings are indicative only).

Differences mostly due to genotype

Varieties 1 and 3 at Faleasiu

Var 1 higher in B (boron), Zn (although both vg), Ca (both high), K, P, N; much lower in Na: 135ppm v 1770ppm (and the varieties were growing at the same distance to the sea).

Varieties 2 and 4 (sample 5) at Leulumoega–uta

Var 4 higher in Fe, Mn, Zn (both good), Ca, Mg (both high in Ca and Mg…var 4 particularly high in Mg: 20000ppm!), P, S, Na; lower in K, N.

Differences mostly due to environment

Variety 2 grown at two different sites

Both sites similar for Fe, B, Cu, N

Leulumoega-uta (sample 2) higher than Tiavi (sample 17) for K; lower for Mn, Zn (Tiavi Zn a massive 250ppm!), Ca, nickel, Na, P, S.

Variety 4 grown at two different sites

Both sites similar for Fe, Cu, Ca

Leulumoega-uta (sample 5) higher than Matautu (sample 4) for Mn, Zn, Mg, Na; lower for B, K, P, S, N.

Thus we can see that mineral nutrient levels are influenced by both genotype and environment. And we can say that Aibika is highly nutritious.

Carotenoids

Table 8 shows carotenoid data from a sub-sample of the Samoan leaf samples.

Table 8. Concentration of three carotenoids in leaves of leafy vegetables, root crops and herbs grown in Samoa (sampled in Dec 2012)

Comments:

Aibika, cassava, ivy gourd, sweetpotato, amaranth, chilli: high levels.

Sample no.	**Species**	**Carotenoid concentration (mg/kg DW)**		
		lutein	**b-carotene**	**a-carotene**
1	Aibika 1	744	320	29
2	Aibika 2	508	336	16
3	Aibika 3	389	241	16
4	Aibika 4	783	417	37
5	Aibika 4	637	360	24
6	Pumpkin	262	76	5
7	Sweetpotato 1	583	328	21
8	Sweetpotato 2	336	225	6
9	Kangkong	373	226	0
10	Amaranth	472	344	10
11	Cassava	552	401	0
12	Cassava	588	383	6
19	Chilli	533	238	11
23	Amaranth	462	350	8
24	Sweetpotato 3	457	317	10
25	Pennywort	238	172	0
28	Samoan sage	57	69	2
29	Ivy gourd	556	256	17

Different Aibika varieties (identified according to leaf shape) at same sites: Aibika 1 > Aibika 3 for lutein and both carotenes at Ana Epati's; Aibika 4 > Aibika 2 for lutein and both carotenes at Apineru's, and Aibika 4 also high at Falatoese's.

Same site, different species:

Biggest difference: samples 28 & 29 at Christine's. Apineru's: Aibika = cassava =SP > pumpkin.

Taro leaf samples from Trip 2

The taro leaf mineral data (minerals and carotenoids) are included in **Appendix 17**.

The taro cultivars (Samoa 1,2,3,4,5) selected for this survey were the five cultivars identified by the Ministry of Agriculture as suitable for export. The sampling sites appeared to be fertile; no mineral deficiencies were evident in the data. Nickel was quite high (3-14ppm) and sodium (Na) low (<1ppm, unlike the Tongan samples). The samples were remarkably clean, with almost no soil/dust contamination (as shown by the low titanium land aluminium levels of <1ppm and <5ppm, respectively).

Most minerals varied between 1.6- and 4-fold (Mn varied most: 47-186ppm and S least: 2500-3900ppm) between samples, and a significant proportion of this variation appeared to be due to genotypic variation, to the extent that a provisional ranking of the cultivars can be made thus, in decreasing order of mineral nutrient concentration:

Cultivar 4 > 2 > 5 > 1 > 3.

Carotenoid data are presented in Table 9.

Lutein: mean 464ppm (range 223-758ppm), beta-carotene: mean 213ppm (range 90-393ppm); alpha-carotene: 0 (none detected in any of the samples). There appeared to be little stability across sites, i.e. environmental effects outweighed genetic effects in this trial. However (and in contrast to the minerals), it appeared that Cultivar 3 (samples 36, 39, 42, 47) may have higher carotenoid levels than the other cultivars.

Table 9. Carotenoid levels in leaves of taro trialled at 5 sites in Samoa (Upolu) in 2012/13

Sample no.	Cultivar no.	Site	Lutein (mg/kg)	B-carotene (mg/kg)
32	4	Lalonea	427	192
33	2		522	224
34	1		368	238
35	5		539	219
36	3		623	264
37	5	Tanumalala	418	230
38	4		351	198
39	3		461	273
40	1		223	90
41	2		375	140
42	3	Lefaga	758	393
43	1		561	215
44	2		325	170
45	2	Lotofaga	589	180
46	1		699	249
47	3		473	242
48	1	Saleilua	301	179
49	2		342	138

(f) Kiribati

Samples of breadfruit (n=8) and breadfruit leaf (n=2) were provided by Takena Redfern, Agriculture Division from sites on Tarawa in May 2013, and were analysed in Adelaide for minerals (including N). The data are provided in Table 10.

Comments:

The leaves (which we use as a diagnostic…fruits are not usually useful for this purpose) are particularly low in N, K, P, Mn and Zn and quite low in Cu, which is not unusual for an atoll soil. High Ca (good) and Na (not so good, but not dangerously high, and to be expected on an atoll). And the fruit (obviously useful information for human nutrition) is low in all of the minerals analysed (especially S... Drumstick leaves needed to counter this!...and N, indicating only 4.5% protein, whereas the leaves had 14%), except Na. The samples from the Central Nursery were the lowest in mineral nutrients.

Table 10. Selected mineral nutrients in breadfruit and breadfruit leaf samples collected by Takena Redfern on Tarawa, Kiribati in May 2013. Samples 1-8 are fruit, samples 9 & 10 are leaves

No.	Variety	Loc.	Fe mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg	Ca %	Mg %	Na %	K %	P %	S %	N %
1	Bokeke	1	16	2	6	5	0.13	0.19	0.7	1.03	0.18	0.12	1.0
2	Bokeke	2	22	2	6	7	0.13	0.20	0.66	1.04	0.18	0.11	1.2
3	Bokeke	6	16	1	4	3	0.13	0.11	0.23	1.04	0.13	0.07	0.8
4	Pulupu	4	8	1	3	3	0.10	0.10	0.06	1.25	0.15	0.07	1.1
5	Yulley	4	23	1	3	3	0.23	0.11	0.82	0.91	0.15	0.06	0.6
6	Motiniwae	4	6	2	4	5	0.31	0.20	0.24	0.94	0.17	0.09	0.9
7	Maikora	5	17	1	4	4	0.12	0.11	0.27	1.5	0.14	0.08	0.8
8	Maikora	3	26	3	4	11	0.28	0.22	0.37	1.84	0.24	0.14	1.6
9	Pulupu leaf	4	45	4	10	14	2.2	0.54	0.35	3.7	0.25	0.22	2.8
10	Maikora leaf	5	93	13	9	17	2.1	0.55	0.71	1.7	0.24	0.23	3.4

Location key:

1: Good Samaritan Church, Teaoraereke; 2: Roman Catholic Church, Teaoraereke; 3: Atata, Teaoraereke; 4: Central Nursery, Bikenibeu; 5: Quarantine Office, Betio; 6: Roman Catholic Church, Betio.

b. Objective 2

(a) Solomon Islands

Summary

As with Samoa and Tonga, this survey was combined with collection of plant samples (see Report on trip to the Solomon Islands 24/6/12 – 4/7/12: **Appendix 5**). We found that once we explained our objectives to villagers at Burns Creek, Aruliho and Marau Sound, there was much enthusiasm about the project, and the people were keen to provide their opinions on leafy vegetables as well as samples of plants used for food and/or medicines. Information was obtained from village-based workshops, focus groups and individual interviews of government officials (including extension workers), villagers and town-dwellers.

In this survey it was found that leafy vegetables form an important part of the diet of many Solomon Islanders, whether they live in remote or peri-urban settings. A wide variety of leafy vegetables are grown/collected/eaten in both the peri-urban and rural communities, and in the rural areas, wild-collected leaves form a major part of this leafy dietary component.

In all areas, people were eager for more information on their leafy vegetables…which we were able to provide in the form of the factsheets plus additional nutritional information on other species in their areas, during the second trip. In addition, the Ministry of Health and Medical Services conducts an excellent nutrition education program, run my Rosemary Kafa, who accompanied Pita Tikai and G Lyons on this trip, and which includes posters and postcard-sized handouts on the benefits of local foods. The people were very interested in this information.

There was reportedly some nutrition education at local schools, but school food gardens were rare. Nevertheless, it was generally considered that it was important to increase knowledge of these crops, and that school would be the most suitable forum for this. Programs which provide appropriate nutrition education, in particular inclusion in school curricula (and which include a practical element, e.g. sustainable, nutritious school food gardens managed by the students) are likely to lead to positive health outcomes for Solomon Islanders.

Peri-urban

Near Honiara, the major leaves eaten were Aibika/sliperi kabis (the most popular vegetable in the Solomons), taro, sweetleaf/Boneo, pumpkin tips, sandpaper kabis (*Ficus*), ferns, Ofenga and Ete. In the peri-urban communities, there was also cultivation of recently introduced leafy vegetables, including lettuce, English cabbage, bok-choi and Singapore taro, which (along with tomatoes and Aibika) are the vegetables most often marketed. One community used NPK and chemical pesticides for these crops, another did not, considering their organic approach healthier.

Both adults and children liked eating leafy vegetables, especially Aibika and taro leaf. In addition, the leaves of particular species are used to stimulate lactation and for medicinal purposes, e.g. against malaria, diarrhoea, TB, influenza, fever, inflammation, and to stimulate wound healing.

In contrast to the appreciation and knowledge of these medicinal leaves for specific health purposes, there was little or no understanding of the link between “regular” food and health. Leafy crops are grown/eaten mainly because they are easy to grow and taste good. In general, leaves such as Aibika, Boneo, Ete, Ofenga and sandpaper kabis are preferred (because of superior taste) to leaves of SP and cassava. It was considered that there were no barriers to the cultivation and consumption of leafy vegetables in these villages.

Rural

At Marau Sound, leafy vegetables are eaten daily, and often twice daily, and seaweed is occasionally eaten. Sweetpotato leaf, cassava leaf and chilli leaf are not considered to be as appetising as Aibika, watercress, kangkong, fern and pumpkin tips. Like the peri-urban communities, there was more knowledge here of medicinal than nutritional benefits of various leaves. Several species, including Ete (*Polyscias*) and Boneo (*Sauropus*) are used not only as food but also to enhance lactation (thus galactogogues).Rumours of health problems due to particular plant species can be a barrier to their consumption, e.g. at Legalawa Village it was thought that a tree fern could cause “dry blood”, and that taro leaves could “increase spleen size” if eaten to excess.

Aibika may not be planted if insects were a burden in the previous season; pests are not usually a problem with other species.

(b) Northern Territory (Top End)

Tania Paul (Senior Lecturer in Horticulture and Agriculture), Charles Darwin University, Darwin has written an excellent report on leafy vegetable crops/bush tucker in “The Top End”, which includes insights on future activities to promote their use (**Appendix 4**).

Key points/Summary

Edible leafy green plants are not common here due mostly to the long dry season (May to November). Most plants have tough leaves which are adapted to this and to the intense wet season. Indigenous vegetation usually has unpalatable leaves, hence people traditionally obtained nutrients from other food sources.

Most vegetables and fruit in stores are grown in Southern Australia. Generally, people in indigenous communities in the Top End do not grow or buy leafy greens (preferring fruit), although there are market gardens on Melville Island, and Aibika is grown on Croker Is.

Seventy popular species of bush tucker are listed in the report, including the midrib and seeds of pandanus, ferns and the growing tip/cabbage of palms (*Carpentaria, Gronophyllum, Livistona*). Yams are sought after and there are numerous species/varieties. Moreover, melaleuca leaves are used as a flavouring during cooking. People are usually not able to collect bush tucker or hunt on other people’s land, therefore if they are living in towns they will have little access to traditional foods.

(c) Torres Strait Islands

The situation is similar in the southern Torres Strait Islands, although the TAFE/Torres Shire Council’s community horticulture program (driven by George Ernst) is raising awareness of how to grow fruit trees, pawpaw, pumpkin, taro, cassava, chilli leaf and Drumstick trees on the harsh soil of Thursday island, and Agnes Fox’s demonstration food garden at the Horn Island Primary School also provides a valuable demonstration of growing nutritious crops, including curly-leaf spinach, taro and Noni on an unfertile sandy soil. Fruit and vegetables(including the leafies Bok choi and lettuce) are available in the IBIS supermarket and the general store on Thursday Island. Further north in the Torres Strait, where some islands have fertile volcanic soils, more traditional food gardens exist. The Torres Strait Regional Authority is conducting a valuable promotional program (partly funded by Landcare) called *Mekem Garden in the Torres Strait*, managed by George Saveka.

(d) Tonga

See Roger Goebel's report (**Appendix 6**).

Key points/Summary

Roger recorded five interviews and spoke with over 20 people about leafy vegetables. He has seen an increase in leafy vegetables, especially Chinese cabbage varieties and Rocket, in markets during the past four years. There is scope for increased consumption of cassava leaves, ferns and pumpkin/squash tips once their nutritional value is more widely known. Ms Luseane Taufa of the Ministry of Agriculture, Food, Forests and Fisheries is an enthusiastic promoter of local food crops, and was impressed with our factsheets, which have assisted with her education/extension program.

(e) Samoa

The project partner in Samoa is Women in Business Development (WIBD).

Two visits were made to Samoa; December 2012 and March 2013.

During the first visit 31 leaf samples were collected from 20 different plant/crop species Different varieties of pele and sweet potato were included in these samples, and also efforts were made to collect pele, sweetpotato and cassava leaves from different sites to get some indication of genotype and environment interaction. These leaf samples were dried immediately using the project protocol, and then hand-carried to Australia and handed over to AQIS for processing.

The project focal point in WIBD, Pule Elia Toleafoa, had already carried out 29 interviews. During this visit other farmers were surveyed using the project questionnaire. However it was agreed that further interviews would be carried out at a later date with a selection of farmers to try and extract more information than already provided. The questionnaire would be revisited and if necessary revised and other questions added to try and gain more understanding of attitudes to food.

What the interviews did show was that taro leaf and pele were the most common leafy vegetables; pumpkin shoots and chilli leaf were also consumed quite widely. A good proportion of those interviewed said that schools did teach nutrition but it wasn't clear at what level and to what extent. Despite this it appeared that only one school had a garden. All of those interviewed said that more information was needed on nutritional value of leafy vegetables and other traditional food crops such as sweetpotato. Requests were also made for information about "other" leafy vegetables, different varieties and importantly recipes so people know how to cook them. Interestingly food combinations were mentioned – one interviewee said that people used to cook with chilli leaf when turkey tails were available but since these have been banned, people cook less with chilli leaf. Availability of planting material was identified as a constraint, as were roaming pigs in some places! Finally all interviewees stressed the importance of the church and schools spreading the message about healthy eating. All of the interviewees were farmers who were members of the WIBD organic network, and therefore already interested and receptive to the idea of healthy food.

A meeting was held with Christine Quested, Principal Nutritionist of the Ministry of Health, Samoa to provide an update of the project and to discuss the work that the Ministry's nutrition section has done. In the past there have been considerable efforts to promote leafy vegetables, for example, pele, pumpkin tips, chilli leaves, creeping spinach etc., and promotional materials are available in Samoan and English. She also highlighted that in 2007 the School Nutrition Standards were developed, pilot tested in selected schools from 2008-2010 and endorsed for use in schools by the Ministry of Health and the Ministry of Education, Sports and Culture in 2011. She was very supportive of the project, providing samples of the promotional material that had been used and also leaf samples from her garden.

Discussions were held with the project team to establish a nursery at the WIBD site in Nu'u Research Station. The nursery would be used to maintain different varieties of pele and other leafy vegetables, and importantly to investigate a range of different propagation methods for pele, the aim being to optimize propagation rates.

In March 2013, a second visit was made to Samoa. The original focal point for this project had been assigned to other projects. Two new members of staff from WIBD were given the responsibility of this project, Fuatino Aquinas Afato and Kalais-Jade Stanley. 18 leaf samples of different varieties of taro (*Colocasia esculenta*) – namely the five varieties recommended by the Samoan government for export (Samoa, 1, 2, 3, 4 and 5) - growing in five different sites were collected to assess whether the genotype and environment interaction would affect the nutritional composition in any way. These leaf samples were dried immediately using the project protocol, and then hand-carried to Australia and handed over to AQIS for processing. Soil samples were also taken from the different sites for pH testing. The pH results have proved useful to the farmers who are members of the Taro Improvement Programme (TIP) as the soils from two sites were shown to be too acidic for taro (those farmers use herbicides and practice continuous planting); they will now be advised to put those soils to fallow.

Time was spent with the project staff, Fuatino and Kalais revising the questionnaire; interviews were carried out later with six farmers/people using the revised questionnaire.

This second round of interviews did generate a little more information. Some leafy vegetables had been used in the past more frequently. For example, one interviewee commented that cassava leaves were used more in the past in soup but people stopped using them because they didn't like the colour of the soup and also the scent. The problem with scent was raised again by another interviewee who said that some leafy vegetables were rejected because of the scent. One interviewee also commented on the unpleasant smell of drumstick though acknowledged its nutritional value. This is interesting as one reason Samoans gave for liking taro niue – their favourite taro before it was wiped out by taro leaf blight – was the smell.

A couple of interviewees commented on leafy-type vegetables that used to be collected from the wild - cinnamon and fern, lau kale (similar to basil) and akoge (no English name known).

Some interesting recipes were provided. For example patties made of noodles, pele and mince, or completely vegetarian – a soup comprised of taro leaves, pele, choko and spring onions.

Ideas were put forward as to how best to promote increased production and consumption of leafy vegetables. More emphasis on social marketing was required and greater effort to be focused on the children and youth. Children at school should not just be taught the theory of nutrition; more practical training is required. All interviewees once again acknowledged the roles that school, home, church and government can play in promoting production and consumption of leafy vegetables. Government should incorporate leafy vegetable production into policies, and generally agriculture should be more involved. Very few farmers obtained their planting material from agriculture, mostly material came from friends, some from the Samoa Farmers'

Association. The Ministry of Health has a garden from which planting material can be sourced but its urban location makes the access to the garden difficult for those in the rural areas. The Ministry of Women, Community and Social Development have small grants for vegetable gardens.

Some of the interviewees suggested the importance of working as a group with possibly a lead farmer being responsible for providing planting material and advice. Regular meetings would keep the momentum going and maintain enthusiasm. Others suggested the need for demonstration plots so people from the community could come and see the vegetables growing and learn about their nutritional value.

The economic value of these vegetables was recognized by some; one farmer was selling to a local tourist resort and commented on their high value, especially for the tourist market.

See **Appendix 7** for Kalais-Jade Stanley's Workshop Report.

c. Objective 3

To recommend a strategy for further research and raising awareness of the health benefits of nutritionally-rich leafy vegetables.

The context for our recommendations from this scoping study is well described by earlier researchers:

> *Food security in Solomon Islands communities depends largely on managing complex and diverse natural ecosystems and farming systems with some cash cropping. The farming systems are characterised by diversity and local crops, planting methods and technologies. The cash economy provides cash income for some important needs of rural communities, but the cash economy is also driving unsustainable resource exploitation and the use of farming practices associated with a commodification of food and agriculture that is contrary to traditional values and the ecological sustainability associated with those values. Serious health problems are also increasing due to the increased consumption of highly processed foods.*
>
> Jansen A & Tutua J, Food Security for Papua New Guinea, ACIAR Proc. 99, 2000, pp 112-123

Generally, interventions aiming to improve the nutrition of consumers have focussed on delivering nutritional information to the consumer; promotional campaigns have tended to emphasise the importance of consuming foods rich in specific nutrients, for example, iron, to maintain good health. With home garden interventions, the emphasis has been the same – grow these foods because of their nutritional value. Links have been established with the agriculture sector but the actual engagement of the agriculture sector is relatively weak. There has been little attention given to production outside of the home garden, and also to benefits, other than nutritional.

Addressing the need to strengthen supply of nutrient-rich foods and at the same time ensuring effective delivery of nutrients to the consumer requires consideration of what happens between production and consumption and how the various steps along this chain can affect the availability, affordability, acceptability and nutritional quality of foods for the consumer. A value chain approach would enable analysis of the nutritional value at each step of the chain to include production, storage, distribution, processing, retailing, preparation and finally consumption, but at the same time recognize the importance given to other factors by the different actors. This approach would help in identifying the research required to increase the availability, affordability and quality of nutritious foods. The importance of a product in the market place would contribute to improving the perceived status of traditional food crops. A successful value chain approach would engage the private sector, enrich partnerships and provide a framework for coordinating actions and actors. It would also assist in better understanding of all benefits and advantages along the supply chain and how best to deliver the information.

Establishing baseline information for the proposed project would be achieved by a thorough analysis of previous interventions, such as home and school gardens. Research could investigate the factors/ingredients essential for these initiatives to work, for example, the role of more participatory, community-supported and self-sustaining approaches in improving their adoption. The engagement of women is important if development programs are to have a chance of success, and they usually have an important role as custodians of local germplasm[2].If urban dwellers can be educated in the nutritional (and economic) benefits of local vegetables, this should boost markets. The same analysis would help decisions to be made on which metrics enable a quantitative assessment of the impact of the interventions. Adopting novel metrics such as the nutritional functional diversity metric could help to guide agricultural interventions towards adequate nutrient diversity. Assessing the benefits of using this approach could be incorporated into a project which embraced a whole range and combination of interventions. Other regions of the world have implemented relatively large interventions, for example the introduction of orange sweet potato in rural Mozambique, which have enabled the incorporation of control groups to monitor and evaluate the success of interventions.

Promotional campaigns are rarely evaluated; research needs to consider the effectiveness of these campaigns with regard to knowledge, attitudes and practice. Adopting a social marketing approach would provide greater insight into attitudes and beliefs, as well as behaviour that has been affected. This can help to link the social marketing activity to the behavioural change, and provide feedback as to the next steps in an intervention effort.

Specific areas/issues that could generate research topics in a subsequent project include:

- Impact assessments of previous interventions to understand the lessons learnt
- Guaranteed supply: easy access and availability
- Agronomic information to support high yields and nutritional content
- Availability of good quality, diverse planting material
- Importance of self-reliant production systems, so that home garden producers, for example, can produce their own seeds/cuttings
- Nutritional information which must take into account ways in which the food is prepared (fresh, cooked and processed values), and convenient forms for cooking to meet modern demands. Rita Roshni has been working on the effects of different food preparation/cooking methods on carotenoids, etc in her Masters studies at USP Suva
- Testing the use of melaleuca leaves for flavouring in cooking (Northern Australia) as there is a concern that they may release toxins into food

- Information relating to the development impact of poor nutrition[1]; this should be a very strong message
- Information about anti-nutritional factors, for example, does the consumption of black tea (common breakfast drink in Fiji) reduce the absorption of iron?
- Promotional methods – more emphasis on social marketing is required
- Market and product development
- Trials of leafy vegetables/plants which are suitable for high pH, coralline (atoll) "soils", e.g. *Polyscias* (Ete), *Pisonia grandis* (lettuce tree), possibly Moringa oleifera (Drumstick tree), *Sesbania*, *Erythrina* (Dadap). Collaboration with Takena Redfern, Kiribati and possibly Tania Paul's PNG vegetable program (eg trials on uplifted coral on Buka, Bougainville)
- Further propagation trials, collaborating with WIBD Samoa. The Aibika/pele propagation trial in Samoa found that longer (75cm) cuttings which were cut vertically (at 35 degrees) and which included the growing tip grew best and had the best survival. See Kalais-Jade Stanley's report at **Appendix 8**
- Investigate introducing more leafy green vegetables in school gardens and support the school to promote their consumption with recipes to take home. The gardens could feature the most nutritious vegetables, and sustainable soil management and integrated pest management methods
- Assessing impact of school demonstration food gardens, involving Ian Waena (doing Masters at USP Samoa).

The African Leafy Vegetable (ALV) program[2] shows that it is possible to change behaviour regarding eating habits and illustrates the effectiveness of a coordinated and concentrated effort on promoting traditional food crops. The ALV programme and the Go Local program in FSM[3] shows what is possible with commitment and effort, and funding. Funding to support any initiatives which focus on strengthening consumption of nutrient-rich food crops, and especially traditional food crops, such as leafy vegetables has always been limited. Funding for research tends to be allocated to the staple crops, in particular, rice, wheat and maize.

Elaboration of the final two points above: Policy needs to be shifted to emphasise the importance of teaching sound nutrition, based on local nutritious foods, including leafy vegetables, from an early age (i.e. from around eight years). This education needs to include

1.Vitamin and mineral deficiencies experienced during pregnancy and 1st 2 years of life will have severe and often irreversible consequences to a child's development

2. van Rensburg JWS, de Ronde JA, Venter SL, Netshiluvhi TR, van den Heever E, Vorster HJ (2004) Role of indigenous leafy vegetables in combating hunger and malnutrition South African Journal of Botany 70: 52-59.

3. Englberger L, Kuhnlein HV, Lorens A, Pedrus P, Albert K, Currie J, Pretrick M, Jim R, Kaufer L (2010) Pohnpei, FSM case study in a global health project documents its local food resources and successfully promotes local food for health. Pacific Health Dialogue16(1): 29-36.

4. Ratcliffe MM (2011) The effects of school garden experiences on middle school-aged students' knowledge, attitudes, and behaviours associated with vegetable consumption. Health promotion and practice 12(1): 36-43.

5. Langellotto GA, Gupta A (2012) Gardening increases vegetable consumption in school-aged children: a meta-analytical synthesis. Horticultural Technology 22: 430-445.

active involvement in demonstration school food gardens, which accords with the UN's "Health-Promoting Schools" concept. It is well known that school gardening can improve students' consumption of vegetables[4,5]. In addition to teaching about the forest foods which are being lost/forgotten, this would provide an opportunity to trial and promote key species/cultivars such as Aibika, Drumstick tree, Ceylon spinach, Ete, orange sweetpotato, purple sweetpotato, higher-protein sweetpotato varieties, winged bean and cowpea. In addition, integrated pest management and sustainable soil fertility management (including composted sweetpotato mounds and the use of legumes like *Sesbania, Gliricidia, Erythrina*, lablab) could be demonstrated. This would enable students to implement these concepts/strategies when they return home. Importantly, teachers need to employ education strategies that will directly influence student behaviour (for elaboration, see Alicea Garcia's paper at **Appendix 2**). The ultimate aim is to strengthen the nutrition (and thus health) of plants, livestock and humans, improve the sustainability of subsistence agriculture, and increase food security by *i.a.* reducing reliance on growing and importing unsuitable foods/commodities which contribute to sick, impoverished populations.

7. Impacts

This was a brief scoping study, so we would not expect to see strong, if any, impacts due to it at this stage. However, the project has pointed the way to what should be effective strategies to provide increased cultivation and consumption of leafy vegetables which, if implemented extensively in the South Pacific and northern Australia, would be likely to improve nutrition, and hence health, in these regions.

7.1 Scientific impacts

The project demonstrated the effectiveness of microwave-drying of leaf samples for preserving carotenoids, compared with oven- or sun-drying.

The findings of the Aibika/bele propagation trial, *viz* longer (75cm) cuttings which were cut vertically (at 35 degrees) and which included the growing tip grew best and had the best survival, have been communicated to farmers and have the potential to increase pele yields. See **Appendix 8**.

Data on Aibika/bele growing in open (insect-infested) and shaded (insect-free) positions in the Solomon Islands have been provided to the ACIAR IPM program, which is studying this phenomenon. This information should be useful for John Bosco Sulifou.

During this project, encouragement and support was provided to two important programs being conducted on Thursday Island, Torres Strait: the *Lift for Life* nutrition/fitness trial conducted by Queensland Health Community Nutritionist, Natalie Orero, and the Thursday Island Fruit Tree Planting Program conducted by George Ernst, backed by TAFE and the Torres Shire Council. These projects have the potential to be models for successful health and agricultural interventions well beyond the Torres Strait Islands.

Several leafy vegetables, notably aibika, sweetleaf, ete, Ceylon spinach and drumstick tree, were identified as being superior accumulators of a range of minerals and carotenoids, as detailed earlier in this report. Ete was also found to grow better than other crops on alkaline coral “soils” and thus would be very suitable for atolls.

7.2 Capacity impacts

Collaborators have increased their ability to conduct surveys of knowledge and opinions on local crops; have increased their knowledge of the importance of mineral nutrients and carotenoids in local food crops, sample collection and preparation, and the influence of variety/genotype and environmental factors on mineral nutrients, protein and carotenoids in leafy vegetables.

Mineral nutrient data on breadfruit samples (fruit and leaves) supplied by Ms Takena Redfern from Kiribati have assisted her studies on sustainable development on atolls.

Two Masters students have been supported by ACIAR, linked to this project:

Ms Rita Roshni, University of the South Pacific, Suva, Fiji: *Analysing promising underutilised leafy food crops of Fiji for carotenoids, minerals and protein contents*

Mr Ian Waena, University of the South Pacific, Alafua, Samoa: *A comparative analysis of attitudes of urban and rural Solomon Islands schoolchildren to consumption of nutritionally-rich* *local leafy crop vegetables (LLCV): Implications for agricultural science curriculum development in Solomon Islands*

7.3 Community impacts

Our message of the nutritive value of local leafy food crops resonated within the communities involved. If they grow and eat local nutritious crops (including sweetpotato, cassava and taro for energy, and leafy vegetables for minerals, protein, etc) and buy less rice, bread and sugar, they will derive health and economic benefits.

As an aside, it was gratifying to see (in June 2013) organic farmer/researcher/businessman Shane Tutua growing and selling tubers/germplasm (to consumers/farmers in several provinces in Solomon Islands) of the Beauregard orange sweetpotato variety, introduced to the country during an earlier ACIAR program. Shane has found that there is strong demand for Beauregard due to its high yield, large uniform tubers, flavour, texture and high pro-vitamin A content. Using field trials he has determined an ideal cultivation method for this variety. Awareness of the importance of growing and eating micronutrient (including pro-vitamin A) rich local crops increased in the Solomons following the visits of Lois Englberger in 2007/2008, who taught the elements of her ***Go Local*** campaign at popular workshops.

7.4 Communication and dissemination activities

The leafy vegetable factsheets (n=6000) produced in this program were distributed in the partner countries, as well as Tonga and Fiji and also online, via the websites of ACIAR and partner organisations, including the Island Food Community of Pohnpei, founded by Lois Englberger. Further dissemination and explanation of the findings of this study were provided in workshops in Samoa and Solomon Islands and via the media in Solomon Islands, Samoa, Torres Strait Islands and Tonga. The Solomons Ministry of Agriculture has featured several of them in editions of their newsletter. Papers related to this project will be presented at an Indigenous Vegetables Symposium at the International Horticultural Congress in Brisbane (August 2014).

The factsheets demonstrate to researchers, extension officers, government officials, farmers and consumers that **nutritional content, flavour, local adaptability and ease of cultivation can be combined in a range of local leafy vegetable crops in the South Pacific and Northern Australia. The inclusion of one or more of these in diets is likely to improve nutrition, and hence health.**

8.Conclusions and Recommendations

The project was successful, in terms of:

- Documenting knowledge and opinions of local people on the growing and consumption of leafy vegetables in Samoa, Tonga, Solomon Islands, Torres Strait Islands and Arnhem Land
- Collecting plant samples from these countries (plus Kiribati) and regions, taking to Adelaide under permit and analysing them for a range of minerals and carotenoids (including pro-vitamin A). This enabled us to identify outstanding species across different soil types/environments
- Producing information factsheets (attached hereto) on the most nutritious (and also appetising) leafy green vegetables suitable for these areas and distributing them (total of 6000 laminated factsheets, printed in Fiji). A special effort was made to ensure that all the communities which assisted us in providing information and plant samples received feedback, in terms of a final visit in 2013 (Mary Taylor in Samoa and Fiji, and GHL in Solomons and Torres Strait) with the factsheets as well as specific information on outstanding/unusual plants in their areas
- Promoting local leafy vegetables via the media in Solomon Islands, Samoa, Tonga and Torres Strait Islands
- Support provided for outstanding programs in Samoa (organic farming, conducted by Women in Business Development) and in Torres Strait (the *Lift for Life* nutrition/fitness study conducted by Queensland Health Community Nutritionist Natalie Orero, and the community horticulture demonstration project conducted by TAFE Lecturer George Ernst)
- Building the capacity of local collaborators in terms of agronomic/plant nutrition and human nutrition knowledge and plant sample collection methods
- Providing information on optimal propagation methods for the popular vegetable, Aibika, from a field trial conducted in Samoa
- Supervising Masters students in Fiji and Samoa
- Building a collaborative network across northern Australia and the western South Pacific
- Providing guidelines for further research/promotion of the production and consumption of healthy local food crops in these areas.

We recommend that any research/interventions be conducted within a framework which recognises the complex, diverse smallholder farming systems that exist in the Pacific. It is important that cash economies do not lead to unsustainable resource exploitation and the use of farming methods which are contrary to traditional values.

Addressing the need to strengthen supply of nutrient-rich foods and at the same time ensuring effective delivery of nutrients to the consumer requires consideration of what happens between production and consumption and how the various steps along this chain can affect the availability, affordability, acceptability and nutritional quality of foods for the consumer. A value chain approach would enable analysis of the nutritional value at each step of the chain to include production, storage, distribution, processing, retailing, preparation and consumption. This approach would help in identifying the research required to increase the availability, affordability and quality of nutritious foods. A successful value chain approach would engage the private sector, strengthen partnerships and provide a framework for coordinating actions and actors. Promotional campaigns are rarely evaluated; research needs to consider the effectiveness of these campaigns with regard to knowledge, attitudes and practice. Adopting a social marketing approach would provide greater insight into attitudes and beliefs, as well as behaviour that has been affected. This can help to link the social marketing activity to the behavioural change, and provide feedback as to the next steps in an intervention effort.

Specific recommendations for areas of future research include:

- Impact assessments of previous interventions to understand the lessons learnt
- Further propagation trials (e.g.of aibika, sweetleaf, Ceylon spinach) and agronomic studies to support high yields and nutritional content
- Provision of good quality, diverse planting material, and encouragement of self-reliant production systems, so that smallholders can produce their own seeds/cuttings
- Obtaining nutritional information which takes into account ways in which the food is prepared (fresh, cooked and processed values), and convenient forms for cooking to meet modern demands
- Obtaining information relating to the development impact of poor nutrition
- Promotional methods – more emphasis on social marketing and engaging women is required
- Market and product development
- Trials of leafy vegetables/plants which are suitable for high pH, coralline (atoll) “soils”, e.g. *Polyscias* (Ete), *Pisonia grandis* (lettuce tree), possibly Moringa oleifera (Drumstick tree), *Sesbania*, *Erythrina* (Dadap).
- Investigate introducing more leafy green vegetables in school gardens and support the school to promote their consumption with recipes to take home. The gardens could feature the most nutritious vegetables, and sustainable soil management and integrated pest management methods. Teachers need to employ education strategies that will directly influence student behaviour (for elaboration, see **Appendix 2**).

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10. Appendixes

The appendices are in two groups. Those of small size are attached hereto, while the larger ones are included in a separate folder.

Appendix 1:

GREEN LEAFY VEGETABLES AND NUTRITION

A Literature Review by Dr Mary Taylor, co-Chief Investigator of ACIAR leafy vegetable project and former Manager of SPC's Centre for Pacific Crops and Trees, Suva, Fiji.

June 2013

The most recent estimate from FAO indicates that 12.5% of the global population is undernourished with regard to energy intake; however this figure does not give a clear picture of the extent of malnutrition globally. Malnutrition is the underlying cause of death for at least 3.1 million children a year, accounting for 45% of all deaths among children under the age of five, according to a recent (June 2013) report[2]. An estimated 26% of children throughout the world are stunted, 2 billion or more people suffer from one or more micronutrient deficiencies and 1.4 billion people are overweight of which 500 billion are obese. These different "types" of malnutrition can often be found in one country, household or individual (FAO, 2013).

Maternal and child undernutrition provides a guaranteed pathway for transferring poverty from one generation to the next. Poor nutrition between conception and two years of age has been shown to have a long term impact on health and on cognitive and physical development, with diseases such as hypertension, stroke and Type 2 diabetes linked to low birth weight babies (Badham and Kraemer, 2011). Developmental damage induced by undernutrition during this period cannot be reversed or regained later.

Lost productivity and direct health care costs as a result of malnutrition could lose the global economy as much as 5 per cent of global gross domestic product (GDP), equivalent to US$3.5 trillion per year or US$500 per person. Undernutrition and micronutrient deficiencies are estimated to cost 2 to 3 per cent of global GDP, equivalent to US$1.4–2.1 trillion per year. No global estimates of the economic costs of overweight and obesity exist, however these are estimated to be about US$1.4 trillion in 2010 (FAO, 2013). In 2011 the global health care expenditure for diabetes was an estimated US$ 465 billion, 11 per cent of total health care expenditure of adults (World Bank, 2012).

Despite the obvious importance of good nutrition, consumption of less than 200g of vegetables per person per day is common in many countries. Studies in various countries have indicated that less than 200g of vegetables daily significantly affects both child mortality and the weight of a child. For example, in Niger, where vegetable availability is about 121g per capita per day, there is a high preschool mortality rate (230/1,000) and a high percentage (43%) of underweight children under five years (Keatinge et al., 2011).

[2] http://www.thelancet.com/series/maternal-and-child-nutrition

Green leafy vegetables are particularly nutritious. In 2010, the British Medical Journal reported on six studies involving over 220,000 participants which showed that eating a portion and a half (106gm) of green leafy vegetables reduced Type 2 diabetes by 14% (www.sciencedaily.com/releases/2010/08/100819214607.htm). Leafy green vegetables are high in phytochemicals, protein per calorie and omega-3 fatty acids, and are an important component of diets (Nabhan, 2004). The major group of phytochemicals that may contribute to the total antioxidant capacity of plant foods include polyphenols, carotenoids, flavonoids, and the traditional antioxidant vitamins such as vitamins C and E. Of the antioxidants, flavonoids are thought to protect and enhance endogenous antioxidant defence activities (Ross and Kasum, 2002). Foods rich in provitamin A carotenoids, such as β-carotene, β-cryptoxanthin and α-carotene, protect against vitamin A deficiency and anaemia (McLaren and Frigg, 2001); these and other carotenoids, for example, lutein, zeaxanthin and lycopene, protect against diseases such as cancer, diabetes, heart disease and other non-communicable diseases (Bertram, 2002; Coyne et al., 2005).

Green leafy vegetables supply a significant amount of folic acid. Studies in the US have shown that folic acid can reduce heart-related diseases and help to prevent certain birth defects (Nabhan, 2004). Green leafy vegetables also contain high levels of fibre, iron, magnesium, potassium and calcium, and importantly have very little carbohydrate, sodium and cholesterol.

Green leafy vegetables, such as amaranth (*Amaranthus viridis*) and drumstick (*Moringa oleifera*) are widely available throughout the world and can often be found in the home gardens of communities in many countries. They are generally cheap and readily available. Despite the economic (cheap costs) and nutritional benefits associated with leafy vegetables they are somewhat neglected by the farmer, the market and the consumer, and the agriculture and research community. Consumers often perceive these foods as associated with poverty and low status, and for the research community the large number of species involved, their localized use, and their often wild, semi-wild or weedy nature act as deterrents.

Popular vegetables, such as cabbage and tomato, compared to vegetables such as amaranth and drumstick are nutritionally poor, highlighting the seeming lack of importance given to nutrition in the development of more modern-day vegetables (Davis and Riordan, 2004). In comparing cabbage with amaranth and drumstick, higher levels of protein, Vitamin A, iron, folate, zinc, calcium and vitamin E are found in amaranth and drumstick. The difference in vitamin A is very significant with the three vegetables providing 1% (cabbage), 160% (amaranth) and 146% (drumstick) of the recommended nutrient intake from 100gm of food. In the development of vegetables for the market today priority is given to marketing qualities such as shelf life, rather than nutritional value.

Present-day diets in the Pacific, especially in urban areas tend to lack diversity, and in many Pacific Island countries, vegetables, if present, are a minor component of any meal. At the time of the first European contact, a great diversity of food could be found. This diversity included the staple food crops such as taro and yam, green vegetables such as taro leaves, aibika (*Abelmoschus manihot*), and amaranth, fruit and nut crops, and supplementary crops such as legumes and sugar cane. There was also an extensive use of wild plants such as ferns and other greens, for example, blackberried nightshade (*Solanum nigrum*) (Thaman, 1982). Admittedly the extent of this diversity varied across the region, with the greater diversity being found in Melanesia, and comparatively less in Polynesia. For example, the traditional diet of Samoans was very low in fruit and vegetables (Kramer, 1903). Whistler (2000) notes that the only green vegetable consumed in the past was taro leaves cooked with coconut cream to make *palusami,* a Samoan delicacy; there were no other known green vegetables.

Pacific meals today tend to consist of processed, high-energy, low-nutrient foods, often imported, which combined with reduced exercise, has resulted in alarming rates of non-communicable diseases (NCDs). NCDs are the leading cause of death in twelve Pacific Island Countries for which data are available, frequently accounting for 70% of all deaths. Treatment of such diseases takes up 27% of Samoa's total health budget, 18% of Tonga's health costs, and 11% of those in Fiji. Micronutrient deficiencies are also common. In 15 of 16 countries surveyed, more than one fifth of children and pregnant women were anaemic - a condition typically associated with iron deficiency. Vitamin A deficiency is also a significant public health risk in Kiribati, the Marshall Islands, the Federated States of Micronesia, Papua New Guinea, and in the Solomon Islands (Englberger et al., 2010).

A study by Lako et al. (2006) reported on the phytochemical intake of the Fijian population. Dietary intakes of major phytochemicals were estimated from the consumption of 90 plant foods reported in five major surveys conducted in Fiji from 1952 to 2001. The study found that the Fijian population generally had low intakes of total phenols (275 mg/day), and total flavonoids (17.5 mg/day), but a high intake of total carotenoids (20 mg/day), in comparisons with that of other populations reported in literature. The study recommended that efforts should be made to revive the traditional Fijian food systems which have a good level of fruits and vegetables, and in particular, the consumption of sweet potato leaves and drumstick leaves, both of which tested rich in phytochemicals, should be promoted.

There are a number of factors that have contributed to the decline of traditional diets in the Pacific. The emphasis on cash cropping from plantation agriculture to commercial vegetable schemes has certainly been a factor, from establishing a cash economy to introducing new crops which are perceived as "better" than the traditional food crops. The cash generated through these commercial enterprises can then be used to purchase these more desirable foods, helping to develop a taste for such foods in preference to traditional ones. Similarly, the payment of imported rations for work on the early plantations also helped in changing taste preferences from traditional foods to imported foods. Other factors include urbanization and migration, changing aspirations and value systems, changing social relationships and so on. The decline in traditional knowledge associated with local food production has also been a strong influence especially amongst the youth and urban populations. Jansen and Tutua (2000) provide an example: around 1950, 87 food plants were commonly harvested from the forests of Babatane, Choiseul, Solomon Islands, but in 2000' less than 10 were in common use. In some countries, the emphasis on livestock production, for example in New Caledonia, has supported this erosion of knowledge (Thaman, 1982). Cost is increasingly a strong influence with imported foods often the most economical option for feeding a family.

The importance of nutrition to health is well-recognized in the region. National, regional and international agencies are all involved in implementing programmes aimed at improving nutrition. The vision of "Healthy Islands" was articulated in the Yanuca Island Declaration of 1995. In 2007, the meeting of Pacific Health Ministers stressed the need for urgent action on the burden of NCDs. This call resulted in the Pacific Framework for the Prevention and Control of Non-Communicable Diseases (2007) and contributed to the subsequent Western Pacific Regional Plan of Action for Noncommunicable Diseases (2008). Health Ministers also called for a regional Food Summit with representatives from health, agriculture, trade and finance recognizing that the nutrition and health challenge facing the region is a complex one and will not be effectively addressed by one sector. In 2010 the Pacific Food Summit was held in Vanuatu. At the multisectoral Summit, the Framework for Action on Food Security in the Pacific[3]

[3] *Towards a Food Secure Pacific: Framework for Action on Food Security in the Pacific http://foodsecurepacific.org/wp-content/uploads/2013/01/FINAL-TOWARDS-A-FOOD-SECURE-PACIFIC_June1.pdf*

was endorsed. The Framework recognizes that food security is impacted by a complex range of factors and outlines six themes related to improving food security. Its purpose is "*to help guide future actions, policy directions and funding decisions on: leadership and cooperation; regulatory frameworks; enforcement and compliance and public-private sector collaboration; enhanced and sustainable production, processing and trading of safe and nutritious local food; protecting infants and vulnerable groups; and a food security information system."* All six themes provide a foundation for the development of any agriculture-based research that aims to improve nutrition.

As previously stated, the modern Pacific diet lacks diversity and generally vegetables tend to be absent from the plate. However the region is abundant with highly nutritious leafy vegetables. The excellent SPC Handbook No. 31, *The Leaves We Eat* (Bailey, 1992) provided information, including data on minerals and vitamins, for many of the most nutritious leafy greens in the Pacific. This publication provided the basis for SPC's *Green leaves Leaflet No. 8* (SPC, 2012).The nutritional value of green leafy vegetables found in the Pacific was reported on at the Third OceaniaFoods Conference held in New Caledonia in 1991. The presentation described the analysis of 10 green leaf samples, which included bele (*Abelmoschus manihot*), taro (*Colocasia esculenta*), tree fern (*Anthyrium esculenta*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), pumpkin (*Cucurbita pepo*), breadfruit (*Artocarpus altilis*), drumstick, (*Moringa oleifera*), amaranth (*Amaranthus viridis*), chinese cabbage (*Brassica chinensis*) and English cabbage (B. *oleracea* var. *bullata*). The analysis showed how superior the traditional leafy vegetables are in providing "good" nutrition compared to English and Chinese cabbage, especially for protein, vitamin A, iron and calcium (Aalbersberg, 1991). Similarly an analysis of a range of food crops in the Federated States of Micronesia (Englberger et al., 2005) highlighted the high levels of provitamin A carotenoid (11,200 and 5530 μg beta-carotene/100 g, respectively), calcium (150 and 220 mg/100 g), and iron (both 0.8 mg/100 g) found in chaya (*Cnidoscolus chayamansa*) and pele (*Abelmoschus manihot*). Leafy vegetable nutritional data were also included in the comprehensive *The Pacific Islands food composition tables* (Dignan et al, 2004).

Another study, in which 70 Fijian foods were analysed, indicated that green leafy vegetables had the highest antioxidant capacity of all foods tested. The same study showed that variety (genotype) can influence the level of phytochemicals in vegetables. The results showed a six-fold difference in total antioxidant capacity and a 250-fold difference in β-carotene between different varieties of *Ipomoea batatas* (sweet potato) roots. The leaves were much richer in phytochemicals and antioxidants compared to the roots (Lako et al., 2007). As previously discussed, preparation, processing and cooking methods are also important and can affect the antioxidant capacity of vegetables; in some cases, the antioxidant capacity can be reduced by as much as 15% (Prior and Cao, 2000), whereas other researchers report that some phytochemicals may be more bioavailable when the food is cooked (Rock et al., 1998).

The diversity of green leafy vegetables can vary depending on the country, but generally Melanesian countries have a rich diversity. Solomon Islands faces serious problems of vitamin A deficiency (VAD) as shown by the high rates of xerophthalmia (Schaumberg et al., 1995), and proxy indicators for VAD, such as high rates of neonatal and infant deaths from diarrhoea, pneumonia and malaria (Black et al., 2003). As with other Pacific Island countries, diets have changed, with micronutrient-poor imported foods replacing traditional foods (Jackson et al., 2006). The excellent Learn.Grow publication (French, 2010) provides an insight into the significant and unique green leafy vegetable diversity that exists and provides useful information on nutritional value, growth habit, and best practices for growing and cooking. The variation in the nutrition levels depending on the vegetable illustrates the importance of knowledge and information.

Considering the benefits of green leafy vegetables and the important contribution they could make to improving nutrition and health, they somehow fail to get the attention they deserve; the less nutritious vegetables are promoted and consumed. The literature reports on several reasons for the lack of attention given to and low popularity of underutilized species (Heywood, 2013) and most of these apply to green leafy vegetables:

- Lack of information on the benefits from the nutritional value through to strengthening the resilience of food production systems.
- Lack of information and reliable methods for assessing their contribution to farm households and the rural economy
- Low productivity compared to staples and more commercial crops, often due to little or no research into production systems
- Irregularity of supply, and therefore availability
- Lack of quality standards and product standardization
- Poor shelf life and lack of technology in processing and storage
- Association with poverty giving them a status that detracts from their nutritional value, requiring significant efforts to be channelled into promoting these foods to overcome that stigma.

A study "Knowledge, Attitudes, Beliefs and Practices related to the consumption of Fruits and Vegetables in Samoa" carried out in 2004 in Samoa by FAO[4] throws further light onto the situation in Samoa, identifying the different factors that work together influencing decisions made on what to eat. The study used focus group discussions and in-depth interviews to investigate what Samoan people know, what they believe, what their attitudes are, and what they do with respect to food. The factors which influence decisions about food were divided into internal factors, those that are dependent on the people concerned and external factors, which largely are outside of the individual's control. Food availability, accessibility, cultural obligations and family income were external factors of primary importance. For example, with cost, the argument was that fruits and vegetables were expensive compared to other foods. Tradition was also a strong influence with vegetables not being considered as a Samoan food or alternatively being the food for children (to make them strong) or the sick.

The internal factors included taste, highlighting the preference for meat, salt and sugar. Some of the interviewees commented on the ease with which noodles can be cooked compared to vegetables which require harvesting and preparation. Others mentioned lack of knowledge, which included how to use/cook vegetables, and also knowledge regarding what it is about certain foods which make them healthier than others and how this relates to ill health and diseases. The results of this study highlighted the complexity of food practices in Samoa, and the importance of internal factors. Any attempts to change diets and eating behaviour in Samoa would have to consider these factors.

Nutritional information and education explaining why certain foods are healthier than others, and how these "healthy components" assist in managing certain diseases was lacking, as was knowledge on the preparation and use of vegetables. The study recommended a focus on children, increasing their exposure to fruits and vegetables when young and having school

[4] *Research Report: Knowledge, Attitudes, Beliefs and Practices related to the consumption of fruits and vegetables in Samoa. FAO, Samoa, November, 2004.* http://www.fao.org/docrep/015/an432e/an432e00.pdf

canteens and shops sell fruit snacks [see literature review by Alicea Garcia, University of Adelaide 2012, which is appended, along with the current literature review by Mary Taylor, to the ACIAR Leafy vegetable final report, August 2013]. Overall the study highlighted that any campaign which aims to change eating behaviour in Samoa must be multi-focussed. Different strategies and methodologies are essential to ensure the message is absorbed.

A consultation was recently held in Suva, Fiji (March 2013) funded by ACIAR to expand on the information acquired by the surveys during this current project, "Feasibility study on increasing the consumption of nutritionally-rich leafy vegetables by indigenous communities in Samoa, Solomon Islands and Northern Australia" and to identify the knowledge gaps. In many countries, for example, Fiji, significant effort has gone into improving dietary diversity at the grass-root level through, for example, promoting home gardens, and to some extent at the policy level. Limited impact assessment has been carried out but organizations and agencies involved in these initiatives and interventions were clear on what was required to make leafy vegetables a popular and "in demand" food. The issues that needed attention were:

1. Cost is one of the main considerations when buying food, especially for feeding a family
2. Guaranteed supply: easy access and availability
3. Convenient form for cooking to help meet modern demands
4. Agronomic information to support good yields and good nutritional content.
5. Availability of good quality planting material and diversity
6. Importance of self-reliant production systems, so that home garden producers, for example, can produce their own seeds/cuttings
7. Nutritional information which must take into account ways in which the food is prepared (fresh, cooked and processed values)
8. Information relating to the development impact of poor nutrition[5]; this should be a very strong message
9. Information about anti-nutritional factors, for example, does the consumption of black tea (common breakfast drink in Fiji) reduce the absorption of iron?
10. Promotional methods – more emphasis on social marketing is required
11. Impact assessments of past interventions to get an understanding of lessons learnt.
12. Market and product development

Impact assessments of interventions are much needed. For example, do agricultural interventions, such as the promotion of home gardens, or the production, consumption and marketing of locally grown nutrient dense foods, have an impact on nutrition? The Island Food Community of Pohnpei (IFCP), a NGO based in Pohnpei in the Federated States of Micronesia, implemented a two-year intervention in the Mand Community, Madolenihmw. The study found that there was a great diversity of foods locally available (381 food items documented), but these were underused. At the same time, overweight, obesity, diabetes, and vitamin A deficiency were identified as serious problems. To address these problems local food production and consumption were promoted using a variety of approaches including education, training, agriculture and social marketing following a "Go Local" message. Specific activities included community meetings, school activities, and agriculture workshops, cooking classes, charcoal oven development, weight loss and planting competitions, poster campaigns and other relevant mass media. An evaluation of the approach was conducted and the results indicated

[5] *Vitamin and mineral deficiencies experienced during pregnancy and 1st 2 years of life will have severe and often irreversible consequences to a child's development*

increased provitamin A carotenoid intake (110%), increased frequency of consumption of local banana (53%), giant swamp taro (475%) and local vegetables (130%); and increased dietary diversity from local food (Englberger et al., 2010). A re-assessment of this work several years later would give valuable insight into the sustainability of such initiatives.

The Fiji consultation also raised discussions on what food groups/crops, and which nutrients should be given priority? It was suggested that more impact could be achieved through promoting the more nutritious varieties of the accepted and popular root and tuber crops, for example, orange-fleshed sweet potato, which could also be easily converted into convenience food. In addition there was the little known topic of how the nutritional value can be affected at various stages of the value chain. Despite the high nutritional value of many of these green leafy vegetables, care must still be exercised in the production, harvesting, preparation and cooking processes to ensure that the levels of nutrients are not depleted. There is also the question of genotype and genotype and environment interaction. Different varieties of the same crop can have significantly different levels of nutrients and these levels can be affected by the environment.

It is generally assumed that inducing a behaviour change with regard to eating patterns requires a nutritional campaign, that is, some concerted and coordinated effort to raise awareness of nutritional values of foods and the importance of nutrition to health. Assuming this to be so, what is the most effective way of communicating nutrition-based information and promoting dietary diversity? Is nutritional information sufficient to encourage consumers to change eating patterns, or should other benefits be determined and effectively delivered? Is the “Go Local” model transferable to other communities and can it be up-scaled beyond the community level.

Finally, the producer also needs convincing that production of green leafy vegetables is worth the effort. So an important area for consideration and action is the benefits gained by the producers in generating a good supply of nutritionally-rich foods, basically what arrangements are needed to deliver health benefits to consumers and economic benefits to local horticultural producers and other value chain actors?

The African Leafy Vegetable (ALV) programmeshows that it is possible to change behaviour regarding eating habits and illustrates the effectiveness of a coordinated and concentrated effort on promoting traditional food crops. African leafy vegetables have declined in popularity over the years. Despite the diversity found in sub-Saharan Africa (about 900 species), they have been “replaced” by crops such as carrots and cabbage partly because they were more lucrative for the grower to sell which was mainly due to their “modern” status. The ALV programme was implemented by Bioversity International in several African countries, working with producers within existing production and consumption systems. The focus of the work was to strengthen information on the diversity that existed, and importantly to demonstrate the potential for improvement and competitiveness compared to the introduced commercial vegetables. The programme identified the key challenges, namely an initial negative perception of ALVs as “food of the poor”; lack of awareness in rural areas; problems in transport and distance from key markets; access to information and monitoring and coordination of all partners and agencies involved. In 2007, the impact of the ALV programme was assessed, highlighting that around 63% of households had increased their income and 45% had increased their consumption of ALV since the programme started. [6] A publication by Bioversity International focusing on farmers and their families, farm workers and supermarket workers, further reinforces the

[6] *African Leafy Vegetables in Kenya: local biodiversity in production, market and consumption (http://www.fao.org/fileadmin/user_upload/wa_workshop/Factsheet/FSNL_Fact_sheet_AfricanLeafyVegetables-12oct2011.pdf).*

success of this programme, showing how promoting ALV has not only improved the livelihood of the farmers but also their health through better nutrition[7].

The ALV programme and the Go Local programme in FSM shows what is possible with commitment and effort, and funding. Funding to support any initiatives which focus on strengthening consumption of nutrient-rich food crops, and especially traditional food crops, such as leafy vegetables has always been limited. Funding for research tends to be allocated to the staple crops, in particular, rice, wheat and maize. However, recently (June 2013) the G8 held a "Nutrition for Growth" summit acknowledging that "Global prosperity is being undermined by the silent crisis of undernutrition, which prevents people and countries reaching their full potential**".** Commitments of US4.15bn were secured to tackle malnutrition, and governments and businesses joined science organizations to sign a global nutrition for growth compact. "The compact will seek to: ensure at least 500 million pregnant women and children benefit from effective nutrition interventions; prevent at least 20 million children under the age of five from stunted growth; and save at least 1.7m lives by reducing stunting, increasing breastfeeding, and treating severe acute malnutrition"[8].

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[8] *http://www.guardian.co.uk/global-development/2013/jun/08/london-hunger-summit-child-malnutrition*

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Appendix 2:

Appendix 2

Literature Review (complementary to the literature review by Mary Taylor)

Introduction to the sustainable agriculture of leafy vegetables: smallholders in the Pacific

by Alicea Garcia, University of Adelaide

January 2013

Introduction

The sustainable growing of food crops and low nutritional intake are two major obstacles faced by rural communities in developing countries (Wenhold, 2007). Encouraging smallholders in these areas to more sustainably grow and eat nutritious food is important for food security, improving health and alleviating poverty (Lumpkin, Weinberger, 2006). Leafy vegetables in particular can be a rich source of micronutrients and consuming a wide variety can improve the negative effects of micronutrient malnutrition (Bailey 1992). It is argued that organic methods of growing are particularly beneficial to smallholders because chemical pesticides can have unexpected ramifications such as health risks and contamination of local water supplies (Bagley et al., 2006). Nutrition education in schools has been deemed an important asset in addressing these issues at early childhood (Lineberger, 2000). This literature review aims to investigate and analyse academic literature based on these problems. In particular smallholders, organic growing, leafy vegetable ecology and nutrition education in schools will be addressed.

Smallholders

Research shows that smallholders in low-income countries are likely to gain an income increase through intervention into their food habits and nutritional intake. This means that encouraging smallholders in developing countries to more sustainably grow and eat nutritious foods will not only improve general health, but can also contribute to poverty alleviation (Lumpkin and Weinberger, 2006). Studies have also shown that in areas such as the Pacific, efforts to increase the consumption of nutritious foods are most effective when paired with nutrition education interventions or workshops. These programs generally focus on changing attitudes towards leafy foods, increasing knowledge and improving practices in the areas of good nutrition, health and dietary intake. These combined improvements can mean that increased food supply and income can translate more readily into improved dietary quality (Wenhold, 2007). Besides meeting dietary requirements, there are other key issues that smallholders face. For example, smallholders in remote areas need better education on prices, markets and how to look for cooperatives to sell their produce at higher prices. Ensuring food security is another ongoing issue that can be affected by adverse climatic conditions such as drought or prolonged rainy periods as well as the threat of pests and diseases. Using chemical pesticides to ward off pests can have adverse ramifications, particularly in developing countries. It can be argued that too much pressure has been put on the 'modernisation' of growing techniques through the use of chemicals to ward off pests and increase yields (Dinham, 2003). This often leads the discussion into the benefits of a more organic approach to sustainable agriculture in these areas.

Organic Growing

Many studies have shown that organic methods for growing vegetables in developing countries are often the best option; among these studies are those by Bagley et al (2006) and Crucefix (1998). One of the main reasons for this is the negative effect inorganic pesticides can have. These problems have been widely documented and include:

- Many smallholders have little or no training in pesticide use and rely on pesticide companies for information.
- Complex instructions on pesticide packaging can be difficult to understand and apply.
- Lack of training means that smallholders often mix chemicals in the hope that they will be more effective.
- Many cannot afford the appropriate protective clothing or even the chemicals themselves.
- Runoff can result in contamination of local water supplies
- Pesticides include some of the most hazardous chemicals for human health (Dinham, 2003).

Despite these risks there are many who believe that the benefits of chemical pesticides outweigh the costs. For example it is argued that the potential of chemical pesticides to increase yields means that there is a greater assurance of food security and in turn, nutritional intake (Cooper et al., 2007). There is also less labour involved in using chemicals to ward off pests, leaving time and energy for other tasks as well as leaving green manures for other uses e.g. animal fodder and fuel for fires (Cooper et al., 2007). However, pesticide use is not inevitable and there are many effective ways of dealing with pests and increasing yields that do not require inorganic methods. Some of the methods that are used to increase soil fertility without resorting to chemical fertilisers include (1) crop rotation so as not to deplete the soil of the main nutrients the crop requires; (2) the use of cover crops to prevent erosion and smother weeds; (3) adding aged animal manures and plant wastes as fertilisers; (4) planting crops known as 'green manures' that can be ploughed back into the soil as an enriching method; (5) the use of 'waste' materials as mulch on soil surfaces to reduce water loss and weed growth (Worthington, 2001). All of these methods require an additional labour input, but also mean that chemical fertilisers may not be necessary and the health and nutritional hazards that can come from harmful chemicals can be avoided. These methods have also proved effective in affecting soil dynamics and plant metabolism. This means that organic methods of growing often result in vegetables of a higher nutritional value (Worthington, 2001).

Ecology of Leafy Vegetables and Nutrition

Leafy vegetables can be a rich source of micronutrients and have been identified as a key instrument in improving the negative effects of micronutrient malnutrition in developing countries. The potential benefits of increasing the consumption of nutritious leafy vegetables of vulnerable communities are large and thus study into the ecology of certain plants has become an important priority in many areas around the world. This includes the way that these vegetables interact with our bodies as well as the way people interact with the plants. In areas like the Pacific, many indigenous species of leafy vegetables are seen as the most nutritious and can also enhance the bioavailability of micronutrients in other staple foods when eaten together. Indigenous crops can also grow under a wide range of environmental conditions and are generally accepted as being less labour-intensive (Aphane et al, 2003). Identifying the more culturally acceptable crops of a high nutritional value can be important in improving the general health of a community. The following are leafy vegetables of a high nutritional value that could be beneficial to communities in the Pacific:

- **Taro *Colocasia esculenta*:** A rich source in Vitamin A when cooked. The best leaves to eat are the first four produced. These are often cooked with coconut cream (Bailey, 1992).
- **Papaya Shoots *Carica papaya*:** The sap of this plant is high in papain, an enzyme that helps break down protein. Does not withstand frost well (Bailey, 1992)
- **Nightshade *Solanum nigrum*:** Contains the alkaloid atropine, atropine sulphate can be used as a treatment for organophosphorus insecticide poisoning. Leaves are best eaten young but unripe berries are poisonous (Bailey, 1992).

- **Winged bean *Psophocarpus tetragonolobus*:** Usually grown for its edible immature pods that can be eaten like French Beans. Has the ability to fix atmospheric nitrogen with its large nodules formed on the roots. This means the plant can grow in relatively low fertility soils (Bailey, 1992).
- **Cassava *Manihot esculenta*:** Will grow on the poorest soils but will not provide a good root yield on them. Grows best on light, sandy loam soils of high fertility but can easily be grown on soils of a moderate to low fertility. High in Vitamin A, iron and zinc and can be easily grown in home gardens. A plot of around 10 square metres can produce 1-2 kg of young leaves per week, enough pro-vitamin A for a family of six weekly. Should be eaten cooked (Bailey, 1992).
- **Tropical Spinach *Amaranthus viridis*:** Generally not affected by nematode attack, fungal infections or pests such as caterpillars. This makes it a good plant for any garden crop rotation (Bailey, 1992).
- **Sweet Potato *Ipomoea batatas*:** Can be wrapped around wounds to promote healing. Cannot tolerate poorly drained soils. Young leaves and growing tips can be eaten and older leaves along with stalks can be fed to pigs (Bailey, 1992). Can be harvested several times a year. High concentrations of polyphenolics. Leaves can provide protection from diseases linked to oxidation such as cancer, hepatotoxicity, human immunodeficiency virus, ageing and cardiovascular problems. Published information on healthy doses is rarely available (Islam, 2006).
- **Aibika *Hibiscus Manihot*:** This small tree is found almost everywhere in the tropics and can be used to wrap food and make mats and ropes (Bailey, 1992).
- **Drumstick Tree *Moringa oleifera*:** Provides amino acids, vitamins and nutrients. Pods and leaves are eaten fresh or cooked. Flowers are eaten cooked and are high in Calcium and Potassium. Reported to have antibiotic properties (Bailey, 1992).

It is important to note that due to the presence of many variables, there is an overlap in nutrients amongst these vegetables. The levels of nutrients, in particular minerals in each vegetable can also vary between different soil types. This means that the best way to ensure a healthy intake of nutrients and minerals is to consume a wide variety of these plants and to view them as a group rather than individually when considering dietary intake (Bailey, 1992).

In order to make these nutrients more accessible to poor communities it is essential to understand the way in which communities interact with and view nutrient rich leafy vegetables. Increasing contact with modernisation and western culture in developing countries is resulting in the decline of knowledge concerning the benefits of consuming nutritious leafy vegetables and in particular, wild edible plants. Besides the introduction of imported processed foods, western eating habits and an association between traditional foods and 'low status' or 'poor rural lifestyle' are also contributing (Termote, Damme, Djailo, 2010). As mentioned earlier the educational tools and methods of intervention can help to make traditional leafy vegetables and wild foods more widely accepted in certain areas. Research has shown that farmers who are informed about the characteristics of nutrition in these foods and their market value are better able to cultivate them and set their own prices, in turn increasing their families' and their own income and nutrition intake. It has been found that areas in which there is little access to ethnobotanical data, qualitative methods can be especially successful (Termote et al., 2010).

Nutrition Education in Schools

Datas on food education in developing countries' schools are rarely available but what is offered does indicate that the nutritional and health status of many students reflects that of pre-schoolers. Under-nutrition and micronutrient deficiencies can result in many negative outcomes, including reduced growth of children e.g. stunting, becoming underweight and becoming more susceptible to infectious diseases. Low nutrition can also impede and reduce a child's capacity to learn and absorb information. School feeding, treatment for worms and micronutrient supplementation tend to have overshadowed nutrition education in many previous interventions of this nature. This means that there is a serious need for projects that focus on providing children with skills concerning food and nutrition that can be translated into their lives outside of school (Sherman et al., 2007). Schools provide the most effective way to reach a large number of the population while they are still young and impressionable. Some interventions can also have a positive effect on teachers, parents and community members. Intervention strategies have been particularly effective when teachers and families have been involved. The involvement of community members such as local businesses and smallholders can also have a positive effect on educating children on the benefits of healthy foods. Emphasis has been put on ensuring that adequate time and intensity of the intervention is provided along with feedback and follow-ups that allow children to reflect on what they have learned and to continue their practices (Aranceta et al., 2003).

The main issue with many past projects has been that while retaining knowledge and information on food nutrition, many children will not transfer what they have learned to their everyday behaviours. Previous literature reviews have identified nutrition education that is directly linked to food behaviour in and outside of school to be the most successful. This means that teachers must find a way to educate that will directly influence behaviour (Sherman et al., 2007). Projects and interventions must also take into account the specific nature of the community in which the education will take place. Using broad education techniques can result in children feeling as though the information does not relate to themselves and in turn will prevent them from increasing their intake of vegetables that are specific to their dietary needs. Teachers must also be careful not to make requests that are unrealistic of the students, for example the intake of vegetables that are not available, or the frequent washing of hands when there is little water availability. These requests can make children feel distanced from what they are learning. Relevant research should be conducted of the area in question and projects should also take into account what children already know and can do (Aranceta et al., 2003) Activities involving scenarios that are relevant to the students' lifestyle and incorporating recurring characters can help to allow children to see the importance of the issue. School meals can also act as a valuable tool with which to increase children's intake of healthier foods (Sherman et al., 2007).

Some other activities that have been proved effective in educating children on nutrition include class discussions, worksheets, keeping food records, shopping exercises and taste-testing. More hands-on activities mean that children can apply what they have learned to their home-life as well as their school-life (Aranceta et al., 2003). Homework can be another important factor in translating nutrition education into home-life scenarios. Homework tasks in which students are asked to find out about food, ask their parents about food and report back in class are especially effective. Activities such as these also mean that parents have the opportunity to become actively involved (Sherman et al. 2007). Training programs for teachers are especially important so that they can work towards implementing nutrition education into their everyday classes. Perhaps the biggest barriers seen by schools have been the lack of teacher involvement, other school priorities and other environmental/societal factors (Gaglianone et al., 2006).

More recently recognised as one of the most valuable tools for nutrition education are school gardening projects. Gardening projects involving fruit and vegetables allow students to experience first-hand the nutritious foods that they are being encouraged to eat. Education on agriculture is an important asset for future food security and can also provide students with the means to grow and sell their own produce in the future (Lineberger et al., 2000). Low intakes of fruit and vegetables is often associated with low accessibility and so teaching children to grow certain foods can be extremely valuable in raising their intake of nutritious foods. This suggests that appropriate nutrition education would be a valuable component of school curriculums in the Pacific (Aranceta et al., 2003). Studies have shown that children's preferences for certain vegetables were widely broadened after they are educated on how to grow and eat many different nutritious vegetables. With this kind of hands-on education there is also the added benefit of children being physically active while participating. School fruit and vegetable gardens can not only be used for nutrition education but can also be implemented into art, science and humanities classes (Hermann et al., 2006). Research has shown that most food and exercise habits that are carried on throughout life are developed before the age of 15. This makes nutrition education in early schooling a crucial need. Schools with gardening programs have reported an increase in vegetable intake after the commencement of gardening projects. Children are also inclined to opt for more nutritious varieties after being involved in a project that involves theory being teamed with a hands-on gardening project (Lineberger 2000)

Conclusion

Food security and increased nutritional intake are important for the well-being of rural communities in the Pacific. High micronutrient levels in leafy vegetables make them a feasible focus of sustainable agriculture in these regions. Species such as Taro, Sweet Potato, Abika and Drumstick Tree offer a wide range of micronutrients and can be a positive component of a healthy diet (Bailey, 1992). Organic methods can also act as a safe and effective way of maintaining food crops and allow smallholders to avoid some adversities such as water contamination and health risks from exposure to chemicals (Bagley et al., 2006) . Smallholders and children alike can benefit from education in these fields and it is important that initiatives are designed for the specific communities in which they take place (Aranceta et al., 2003). Help and education in these topics can mean increased income, food security and improved health for people living in rural areas of the Pacific.

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Appendix 3:

Questionnaire for ACIAR PC/2010/063 SRA

1. What leafy vegetables/edible leaves do you know of locally?
    a) Which of these do you grow in your garden or close to your house?
    b) Which of these do you collect from the wild?
    c) Which ones do you eat most often?
    d) Which are used mostly for cultural events?
    e) Which ones do you use for medicinal purposes?
    f) Which ones do you usually sell?
    g) How often do you harvest them?
    h) Are there any that the old people ate which aren't eaten now? Why not?
    i) Are there any that people collect only at certain times of the year (e.g. dry season/wet season)? [Mainly applicable to Northern Australia]
    j) Do you eat any plants from the sea?

2. Which leafy vegetables are growing in your garden now?
    a) Why do you grow these? (e.g. tradition, taste, high market value, nutrition)
    b) What planting/growing methods do you use?
    c) Where did you get the planting material?
    d) Are these leafy vegetable planting materials readily available?
    e) Which leafy vegetables have you tried to grow before, but were not successful? Why not?
    f) Which leafy vegetables do you not like to eat? Why not?
    g) Do you use fertiliser (this includes compost and foliar fertilisers)?
    h) If yes, what type of fertiliser do you use and where do you get it?
    i) What kinds of pests and diseases do you see on the leafy vegetables? List them
    j) Do you use chemicals/pesticides to control the pests?
    k) If so, what kind of chemicals do you use and where do you get it?
    l) How much time do you think you spend looking after your leafy vegetables?

3. Do you think the leafy vegetables that you eat are good for you?

a) Why do you think leafy vegetables are good for you?

b) Are there any that children really like or really don't like to eat?

c) Do you eat leafy vegetables each day? If not, how often?

d) How do you prepare these leafy vegetables for a meal?

e) Which do you usually/sometimes eat raw?

4. How is awareness about nutrition promoted in your community?

a) Is nutrition/diet taught at the local school?

b) Does the school have a food garden?

c) If so, what crops are grown there?

d) Do the children eat any of what they grow in the school garden?

e) Do you feel that it is important to promote the idea of growing leafy vegetables in schools, churches and homes?

f) Is there any vegetable/fruit that you would like more information on?

5. Are there any barriers to growing leafy vegetables?

(a) What do you see that could prevent people from growing their own leafy vegetables? [eg taboos, and in towns: lack of garden space]

(b) What do you think could be done to change this?

Appendix 4

Feasibility study on increasing the consumption of nutritionally rich leafy vegetables by indigenous in Samoa, Solomon Islands and Northern Australia

Top End - Northern Territory Component

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Background

The geographical focus of this report is the Top End of the Northern Territory, extending from the Tiwi Islands north of Darwin, south to Nitmiluk, west of Darwin to Cox Peninsula and east into Arnhem Land.

The Top End has a dry monsoonal climate with a very distinct dry season beginning around May, and lasting to the end of November. The wet season begins around December and lasts until early April, bringing daily heavy showers, periodic monsoonal bursts and flooding, and extreme humidity. The period from September through to November is characterised by high temperatures, up to 38°C in some places, with very high humidity and very little rainfall.

In this extreme climate, naturally occurring leafy green plants are uncommon. The extended dry season with no rain and relatively high temperatures means that most plants have tough leaves adapted to the long dry season and intense wet season. The indigenous vegetation generally has tough unpalatable leaves, and so people traditionally obtained nutrients and vitamins from traditional food sources other than leafy greens. Introduced vegetables can be grown in the dry season under irrigation, but the wet season poses problems with fungal and bacterial disease, and high pest pressure due to the ideal conditions of heat and humidity. The bulk of vegetables and fruit stocked in stores and supermarkets throughout the Northern Territory are supplied from southern growers.

Methods

Due to constraints of time, issues around intellectual property and the use of traditional knowledge, and problems in using information gathered from direct sources in remote communities, the Northern Territory / Top End component of this project used key informants, interviewees and third party sources to gather information and data, rather than in depth engagement and research within communities. This avoided uncertainty and delays in gaining approval to enter communities to conduct interviews and focus groups. Gaining confidence and trust of individuals within each community also takes time. Given the short time frame of the project, it was more efficient to use the above alternative data collection methods.

There were legal requirements to obtain permits from the NT Parks and Wildlife Commission for collecting native species for sampling or testing, which also gave rise to complications around intellectual property rights over the results of any sample testing. Indigenous communities in the Top End are vigilant about maintaining and protecting their intellectual property rights on traditional knowledge around plants and plant use. Any research involving traditional knowledge, including this project looking into the consumption of edible green leaves, requires additional intellectual property clauses in the ethics forms relating to bush tucker and Northern Territory communities.

Key informants included nutritionists with the Menzies School of Health Research which has a strong focus on indigenous health issues, indigenous community members willing to share their views and information, a doctor working in remote communities, and teachers conducting training in remote communities on setting up and looking after school and community gardens. The interviews with the key informants were conducted using the questionnaire developed by the project team.

The information shared by key informants has been collated and summarised, then coded and sorted into relevant topics.

Results: Summary of interview responses

Preferences

Generally, people in indigenous communities in the Top End don't buy or grow leafy greens. People generally prefer fruit, and either gather these from the bush or buy from the store. Most people buy their vegetables from the local store, which usually stock English potatoes, and the white variety of sweet potato, as the orange variety is less preferred. Sometimes people buy the white sweet potato to roast.

Nutrition

From a nutritional viewpoint, a large issue in the Top End is the proportion of protein to energy in traditional diets. The protein obtained from stores in remote communities is often of low quality in the form of bread and flour. The majority of bushtucker has been analysed for its nutritional content, and published in the book by Brand-Miller, *Tables of Composition of Australian Aboriginal Bushfoods* (full reference given at end of report). The book gives nutritional tables and includes figures for content of dietary fibre, thiamine, riboflavin, vitamin C, sodium, potassium, magnesium, calcium, zinc, copper, lead, cadmium and phosphorus, as well as water, energy, protein, fat, carbohydrate and ash.

Introduced vegetables and leafy greens

There are some communities in East Arnhemland that grow beans, and there are market gardens in Oenpelli and Milikapiti on Melville Island in the Tiwi Islands. Key informants report that people in communities do eat the usual introduced vegetables like bok choy, lettuce and chili when it is available and when the price is affordable.

Aibika or pele (*Abelmoschus manihot*) is grown on Croker Island and the people there eat it. The local story is that it was introduced many decades ago by missionaries, and is thought to have been introduced from Kiribati, though no one is completely sure. Aibika or pele is cultivated on a very small scale in backyard gardens around Darwin, but it is not a commonly grown vegetable and not widely known. It is not clear where the plants in Darwin backyard gardens have come from, and it seems that most of these plants have been propagated by people sharing cuttings.

Popular traditional foods

Traditional diets are high in fruits, nuts and seeds, for example the Kakadu plum, *Terminalia ferdinandiana* which is very high in vitamin C. Some other indigenous fruits that are popular are also very high in vitamin C, such as the native blackcurrant *Antidesma ghesaembilla or A. parvifolia.*

Meiogyne cylindrocarpa is a bright red to orange fruit, eaten in east Arnhem Land when fruiting, usually starting in the early wet season between November and going through to January. A sample of this fruit was sent for testing and it was found to be highish in potassium (28,000 parts per million) and it contained 38ppm of a di-ester of the carotenoid, lutein. *Sterculia quadrifida* and *S. holtzeii* are very popular and taste like peanuts, and have good protein content. One grows in the monsoonal vine thickets, and the other in the more open woodlands.

The only root vegetables in traditional diets are yams, but there are many species and varieties that people collect and eat. When collecting yams, people usually plant a small tuber back in the ground to ensure more yams for the future.

The four most common yams are:

1. Boewitj - *Brachystelma glabriflorum* – see it all around Darwin in the wet season, can eat it straight up
2. *Dioscorea transversa*
3. *Vigna vexillata* and *V. acuminata*
4. Big bush potato - *Ipomoea costata* – its grows wild and people go mad for it but it's hard to get, and the little bush potato too

Traditional leaves

People also eat pandanus midrib (*Pandanus spiralis*), and the seeds contained in the bright orange fruits. Other leaves of plants which people report eating include ferns, which are high in folic acid, and the cabbage of the Carpentaria palm (*Carpentaria* acuminata). The cabbage of the very tall palm, *Gronophyllum ramsayii*, is much better than the Carpentaria palm, but it is much taller and more difficult to get. People often chop these palms down after cyclones and collect them to eat. Sometimes people collect small to medium size ones and eat them. The commonly occurring sand palm, *Livistona humilis*, is often collected to eat the cabbage or growing tip.

People report collecting and eating aquatic plants, for example, the stems of *Nymphaea* species (water lilies) and the roots. The stems are peeled and eaten like celery, and the outside parts taste better. The roots need to be cooked before they can be eaten. The seeds and roots of the red lotus, *Nelumbo nucifera* are eaten when the seeds are in season.

Generally, leaves are used in the diet as a flavouring when cooking, for example, melaleuca leaves. A lot of nutrients (such as Fe, Zn, vitamin C and carotene) are obtained from other sources in the diet, for example vitamin C from fruits and from the livers of animals like turtles. Green, yellow and orange fat on a turtle also provide a source of carotenoids in the diet. The turtles feed on vegetation with high carotenoid content which is then concentrated in their body fat. Other sources of lutein and carotenes in traditional diets include shellfish and flower pollen.

Declining Use

In the past, people with access to the ocean ate seaweed, though this has declined considerably now. People used to eat *Amorphophallus paeniifolius,* a type of yam. It is high in silica and so needs lots of preparation otherwise it's too cheeky. Old people used to cook it, but it is too much work now.

Cycad nuts (from *Cycas arnhemica*) are sometimes prepared into a bread after careful processing, though this is a lot of work and usually only done on the homelands and is old time food usually only prepared for special occasions. There is ceremony around it which takes time, so this people prefer to not worry about this one.

Availability

Availability and consumption of store bought vegetables is influenced by price, how it is stored and refrigeration, and consumption and collection of traditional foods is affected by access; access to homelands, access to boats for example. Reduced or lost access to homelands is a problem in terms of preserving and passing on cultural and traditional knowledge to the next generation. People are generally not able to collect bushtucker or hunt on other people's land, and so if they are living in towns or urban environments, this means that there is no access or very limited access to traditional foods. In town and urban environments, people still actively seek out traditional foods by requesting visitors to bring in season food with them, or when someone brings a highly prized food into town, people will travel a long way to share in the food.

Future activities

- Trialling recipes with people to see if this increases some of the leafy greens and gives ideas on how to use and prepare them, especially vegetables like Aibika/Pele.
- Look at introducing more leafy green vegetables in school gardens and support the school to promote their consumption with recipes to take home. These would have to be in plain English or perhaps could consider some translations.
- Introducing some biofortified cultivars into the school gardens.
- Trialling something like the SPC booklet "The Green Leaves We Eat' which compares store bought food and traditional food, adapted to the Top End and TSI.
- Adapting SPC leaflets comparing white and yellow sweet potato nutritional values, these are really good leaflets.
- Testing the use of melaleuca leaves for flavouring in cooking as there is a concern that the leaves may release some toxins into the food. Testing different recipes and cooking methods to check toxin levels.
- Trialling the effect of different soil types on the taste and texture and perhaps if it makes a difference to nutritional content of *Dioscorea transversa*, and trialling the differences between wild and some grown in bags.

Top End Popular and Common Bushtucker

Scientific name	Common name	Part eaten
Abelmoschus moschatus	Wild carrot	Raw tuber (mostly Bathurst Island)
Acmenosperma claviflorum		Dark red to black fruit
Amorphophallus glabra	Cheeky yam	Large tuber eaten after soaking and cooking. Old lots of silica, cooked in ashes and coals sunrise to
Amorphophallus paeniifolius	Bush pumpkin	Wife of A. glabra. Lots of preparation and long co
Ampelocissus acetosa	Creeper	Fruit
Ampelocissus frutescens	Upright	Fruit
Anacardium occidentale	Cashew	Fruit and roasted nut
Antidesma *parvifolia*		Fruit - when dark purple
Antidesma ghaesembilla		Fruit - when dark purple
Avicennia marina	Grey mangrove	Fruit eaten after roasting
Boerhavia dominii		Perennial tuber
Brachychiton diversifolius	Northern Kurrajong	Tap root of young plant, seeds roasted-irritant ye
Brachychiton megaphyllus		
Brachystelma glabriflorum	Small bush potato	Disc shaped yams, white raw or roasted and very
Buchanania arborescens		Red fruit, found in jungles, similar to B.obovata w
Buchanania obovata		Raw fruit, roots of young plant- mashed
Canarium australianum		Seeds
Canthium schultzii		
Capparis umbonata		Raw fruit eaten when yellow /red
Carallia brachiata		Fruit when red
Carpentaria acuminata	Carpentaria palm	Soft flesh of growing tip/cabbage, a soft jelly whe
Cassythia filiformis	Dodder laurel	Fruit when clear and translucent
Cayratia trifolia		Perennial tuber roasted and eaten with skin peel
Cochlospermum fraseri		Long tap root of young plants
Cycas armstrongii		Female seeds, need to be crushed, washed and c
Cynanchum pedunculatum		Raw fruit, young only
Cyperus bulbosus		Underground bulbils, roasted
Dioscorea bulbifera	Round yam	Must be cooked all night
Dioscorea transversa	Long yam	
Erythrina vespertilio	Coral tree	Tap root roasted in hot coals
Erythrophleum chlorostachyes	Ironwood	Exuded sap eaten raw bush toffee
Erythroxylum ellipticum	Kerosene wood	Fruit eaten when red and ripe

Exocarpus latifolius	Santalaceae	Ripe raw fruit
Ficus coronulata	River fig	Fruit when brown
Ficus opposita	Sandpaper fig	Fruit
Ficus opposita		Fruit when brown
Ficus virens	Banyan tree	White fruit
Flueggia virosa	White currant	Fruit
Grewia orientalis		Purple fruit
Grewia retusifolia		Fruit
Gronophyllum ramsayii		Palm cabbage
Heteropogon triticeas	Poaceae family	Long stems sucked for juicy sap
Ipomoea costata	Big bush potato	
Livistona humilis	Sand palm	Growing tip, cabbage
Livistona inermis	Palm	Growing (apical) tip, leaf bases
Marsdenia viridiflora	Asclepiadacaea	Fruit - eaten as collected
Mnesithea rottboellioides	Poaceae family	Culms of stem sucked for sugar and water, rhizon
Morinda citrifolia		Raw fruit
Nauclea orientalis	Leichardt tree	Fruit when yellow and soft
Nymphaea violacea	Water lily	Fleshy stem of flowers are peeled and eaten, Seeds raw or ground into flour, tubers and roots
Pandanus aquaticus		Soft inner fibre of the fruit
Pandanus spiralis		Seeds from the red fruit,and remaining peduncle
Passiflora foetida	Stinking passionvine	Fruit when orange, skin and seeds
Persoonia falcata	Milky plum	Green yellow fruit
Planchonia careya	Cocky apple	Fruit, tastes like quince
Portulaca pilosa		Tuberous root roasted and peeled
Pouteria sericea		Purple fruit
Sterculia quadrifida		Black seeds eaten raw - spit out seed coat
Sterculia holtzeii		Black seeds eaten raw - spit out seed coat
Syzigium armstrongii		Fruit
Syzigium eucalyptoides subsp bleeseri		Pink fruit
Syzigium forte ssp potamophilum		Ripe white fruit
Syzigium suborbiculare	Bush apple	Red fruit
Tacca leonpetaloides		Fruit when yellow and small white seeds are cook
Tamarindus indica	Tamarind	Fruit
Terminalia ferdinandiana	Billy goat plum,	Yellow fruit, very high Vitamin C, collected off the

	Kakadu Plum	
Terminalia grandiflora		Seeds when the fruit is dry
Vigna acuminata	yam	Roasted, peeled tuber
Vigna vexillata	yam	Roasted, peeled tuber
Vitex glabrata		Fruit

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Appendix 5

Report on trip to the Solomon Islands 24/6/12 – 4/7/12

ACIAR Leafy vegetables project PC/2010/063

Graham Lyons and Pita Tikai

Investigators: Pita Tikai (AVRDC), Rosemary Kafa (S. I. Ministry of Health), Graham Lyons (University of Adelaide)

1.Malaitan communities at Burns Creek, Honiara (peri-urban): Falo Local Farmer Association (Leader: Peter Usi): 15 villagers at meeting.

Main soil type: calcareous brown sandy loam, pH (H_2O) 8.0

12 plant samples collected, including 3 medicinals

The major edible leafy plants known of and eaten regularly here are *Sliperi kabis/Aibika/Bele/Abelmoschus manihot)* (henceforth referred to as Aibika), sweet potato leaves (only the young leaves, which have a superior flavour, are eaten), Colocasia taro, pumpkin (young leaves), *Boneo/sweetleaf* (*Sauropus androgynus*), *sandpaper kabis* (*Ficus spp*), *Ofenga* (*Pseuderanthemum whartonianum*) and *Ete/Bebenu* (*Polyscias* spp). If other leaves are unavailable, cassava leaves may be eaten (not the youngest leaf cluster, which are bitter and contain more HCN-related compounds, but the next 3 youngest leaves are eaten, and not the older leaves). Of all leaves eaten, Aibika is the most popular; it is a traditional leafy staple with an excellent flavour and is commonly eaten several times a week. The above plants/crops are either cultivated or growing naturally near the community, rather than “wild harvested” from the bush, which is far away.

Recently introduced leafy vegetables which are popular here include lettuce, cabbage, bok-choi and Singapore taro. These are also the leafy vegetables (along with Aibika) which are marketed, and are preferred by younger people, while older people prefer “the traditional ones”. The introduced vegetables are seasonal, whereas the local ones are usually available year-round. To obtain sustainable, high yields of the introduced vegetables, NPK fertiliser and insecticides are required. Insecticides are not used on local crops as insects are usually not a problem on these crops, except for Aibika. An aqueous chilli extract is also sometimes used as an insecticide.

Traditional planting methods, described simply as “planting straight into the ground”, are considered to be best here. Soil management includes the use of corn trash and banana trunks as compost/mulch, although these are not used in sweet potato mounds, which are entirely soil.

Although the communities are located near to the coast, seaweed is not eaten in this area, but two types of seaweed are eaten in North Malaita, where the settlers come from: a variety with small green berries (which is eaten fresh) and a “reddish, flat-leaved” type (which is cooked).

The villagers interviewed were aware of the health properties of certain medicinal leafy plants but did not know whether the leafy vegetables they consumed for food had any health benefits. They were enthusiastic about having samples of both food and medicinal plants analysed, so it was decided to broaden the scope of the survey/study to important leafy medicinal plants. In this community, these include *blackberried nightshade (Solanum nigrum)* for pneumonia (boil the leaves and drink the fluid), although none were growing at this time, *pawpaw/papaya* (youngest leaves used for malaria and as a painkiller), *guava* (youngest leaves used for diarrhoea), *Mile a Minute (Persicaria perfoliata),* introduced by the Americans in WW2 to help camouflage equipment (used to promote skin healing), *Konare* (cough suppressant and insect repellent) and *Malasya/malaria* plant (*Rorippa* spp) (an imported, very bitter, antimalarial bush). Information on these plants has been passed on from older people.

A variety of cooking methods are used, including boiling and baking. The favourite method is a traditional one in which food is cooked inside a section of bamboo.

Children as well as adults like to eat leafy vegetables. There is reported to be some nutrition education provided at the local school, but no school-based food garden. It was considered that it was important to increase knowledge of these crops, and school would be the most suitable place for this.

2.*Kastom Gaden Association* (KGA) HQ, Burns Creek, Honiara (peri-urban demonstration food gardens/germplasm bulking centre. KGA has a comprehensive program throughout the Solomons, AusAID funded. Field Officers Verlyn and Thechla and financial officer Susan present)

Main soil type: dark-brown clay loam. Composted cultivated area: pH 6.8; unimproved area (same soil type) pH 8.0

21 samples collected, including 2 medicinals, Vetiver grass and drumstick tree (*Moringa oleifera*), the only example found on this trip.

The KGA officers supplied us with a list of current available germplasm (planting material can be purchased for a small fee). It is dominated by sweet potato varieties; of 131 plant lines available, 17 are leafy vegetables/herbs, including basil, mint, Thai coriander, cabbage, Chai cabbage, King tree, Tumariki herb, Boneo, yellow Amaranth, green mignonette lettuce, sandpaper kabis, lemon grass, Moringa and okra.

It was considered that green leafy vegetables and various wild leaves are popular throughout the Solomons, but there was little knowledge of health benefits (except for specific medicinals).

3.Interview with Ms Sherin Feris, AVRDC trainee at AVRDC office, Chinatown, Honiara

Ms Feris's family lives just to the south of Honiara (peri-urban). They eat leafy vegetables daily, mostly Aibika and ferns (which are either grown or "wild-collected"), and also kangkong taro leaf and introduced lettuce and cabbage. This family/small community does not eat SP leaves or cassava leaves. They grow Aibika, ferns, Chinese cabbage and lettuce organically (no inorganic fertilisers or pesticides)…she considers this to be a healthy approach. They do not eat seaweed.

Ms Feris considers the leafy vegetables to be healthy and an important part of her diet. Ferns and taro leaves have been eaten by this community for a long time. Children generally prefer Aibika. The community has a tractor and sells, *inter alia,* Aibika, fern and cabbage at the Kukum fishing village market on the main road just east of Honiara. She and other family members work in the gardens daily. She could not think of any leafy vegetables that they had tried to grow but which had failed.

The main preparation method is boiling, sometimes with coconut cream. She does not consider that there are any obvious barriers to growing leafy vegetables in their area, and they are easy and cheap to grow.

Nutrition is taught at the local school, which also has a food garden, including Aibika, taro, cassava, SP, corn, pumpkin and watermelon. Ms Feris considers it important to promote leafy vegetables in schools, churches and homes, and she hopes that leafy and other vegetables can form a major part of her career, hence her interest in working with AVRDC.

Pita Tikai (AVRDC), Rosemary Kafa (Ministry of Health) and GHL flew to Marau Sound at the eastern end of Guadalcanal and met Willie Loufeli, the Marau APHEDA representative, who was our guide.

4.Mani Kalaku market, Marau

Leafy vegetables for sale included Aibika, fern, kangkong, watercress, taro leaf and pumpkin tips. The main items were betelnut, “mud shells” (large cockles), cassava, coconuts, banana and pawpaw. Prices were much lower than in Honiara, eg watercress SI$5/bunch v $15; betelnut 20c each v $1.

5.Porokokore village, above Makina Catholic Mission, Marau Sound. Leaders: Isaac and Godfrey (20 people).

Soil: At village: brown clay-loam, pH 5.5; on hill closer to Makina: red-brown clay (cassava planted), pH 5.0

Food gardens growing mostly on the site of an old coconut plantation and cattle farm; main crops are SP 9only two varieties present) and cassava. The local foods promotional poster produced under the ACIAR orange SP program was on display in Isaac’s house, alongside an HIV awareness poster.

7 samples collected, including 1 medicinal.

Butcher’s paper worked well, using one question (derived from the questionnaire) per page, in Pidgin. There was much enthusiasm for our project, particularly from Godfrey. Main findings:

Q1: *Which leafy vegetables do you know of locally?*

Boneo, taro leaf, kangkong taro leaf, Ete, tree fern (*kai poso*), fern (*kasume*), purslane (*Ui’a*), sandpaper kabis (*Amusi*), kangkung, Aibika (*Reko/Paha’aro*), watercress (*Pariki*), *Ku’aku’a*, chilli leaf, king tree (*Su’a*), sweet potato leaf, *Raraha*, cassava leaf, SP leaf, pumpkin tips.

Q1(a): *Which do you grow?*

Watercress, taro, kangkung taro, ete, kangkung, ku’aku’a, chilli, SP, raraha, cassava, kasume fern, pumpkin.

Q2(a): *Why do you grow these?*

Easy to grow; good taste; in demand (can sell); ornamental (“decoration on the road”). No apparent knowledge of the nutritional attributes of these plants.

Q1(b): *Which do you collect from the wild?*

Purslane, tree fern, sandpaper kabis, king tree.

Q1(c): *Which ones do you eat most often?*

At least one of the following is usually eaten at least once (and often twice) per day:

Boneo, taro leaf, ete, sandpaper kabis, kasume fern, pumpkin tips, tree fern.

Q1(j): *Do you eat any plants from the sea?*

Yes, several: we wash them and eat with dried coconut.

Q2 (f): *Which leafy vegetables do you not like to eat much?*

SP leaf, cassava leaf, kangkong taro, ku'aku'a, chilli leaf, Su'a, raraha.

Reason: they don't taste as good as those listed at Q1(c) above. Other barriers to eating particular leafy vegetables/leaves: difficult to grow; specific concerns, eg an older woman mentioned that "Too much Boneo can cause yellow fever", and Pita had heard that it "can cause cancer". I later investigated this and found several cases in Taiwan where it may (when an extract was eaten to excess as a weight reducer) have caused destruction of bronchioles in the lungs. No evidence of increase in cancer risk from its consumption was found, and yellow fever is caused by a parasite.

Q2(i): *What kinds of pests and diseases do you see on the leafy vegetables?*

Pests are not a problem, except on Aibika: sometimes they won't bother planting it if there was a previous severe insect infestation (this can be considered as a barrier to Aibika production).

Q1(d): *Which leafy vegetables are used mostly for cultural events?*

Tree fern, sandpaper kabis (eaten with pig), raraha (eaten with clam shells), watercress.

Q1(f): *Which do you usually sell?*

Watercress, taro leaf, Aibika, fern, kangkong, pumpkin tips. These are harvested at any time.

Leafy plants used for medicinal purposes: guava leaf (scabies, diarrhoea), pawpaw leaf (malaria, toothache, earache), siri (sore throat, cough), Marauvo (for malaria: boil 8 young leaves), raroro (headache, boils), Mile a Minute (cough, sores). The leafy food plants, on the other hand, were not associated with any particular health/nutritional benefits.

Cooking methods: Baking (of which the most popular method is the traditional bamboo-stem method), boiling.

6.Legalawa village, inland from crab-hole estuary, Marau (27 people).

Soil: new garden land: orange clay, pH 5.9; kava plantation beside stream: light-brown loamy sand, pH 6.0

11 leaf samples collected, including 3 medicinals.

Q1: *Which leafy greens do you know of locally?*

i)Food: kai boto, pahosa, kalo, hende, tutumbu, palupalu, horu, chui (taro leaf), boto (tree fern), sagere, kuika, pumpkin tips, puchi (Aibika), pure, nuli, suha, , watercress, lingi, halo, Tokelau, kakake (Giant swamp taro), bohore (tree fern).

ii)Medicinal: taumana (*kastom icecream*), rure (for diarrhoea and bakwa), toro/noni ("to improve blood"), mamuso (for yellow fever), savuli kaipuchi (to heal cuts/sores), blackberried nightshade (aqueous leaf drink for dengue fever).

They mostly eat Aibika, taro leaf, tree fern, tutumbu, pahosa, lingi, kuika and halo. Most are not eaten raw, but usually boiled. They eat greens at least every second day. They don't eat (or don't like to eat) SP leaf, cassava leaf, Tokelau, kakake, kaipalupalu.

They grow Aibika, pumpkin, taro, hende, watercress, pure, lingi; collect the following from the bush: boto, pahosa, halo, tutumbu, hour, sagere, kuika, suha, and sell Aibika and boto (tree fern). None of these Marau communities use chemicals/pesticides on their crops.

There were no apparent general barriers to growing and eating leafy greens, just two specific concerns: there was a rumour that the tree fern could cause "dry blood" if too much was eaten, and Colocasia taro leaves (from the variety which grows on swampy ground), despite tasting good and increasing lactation, could "increase the size of the spleen".

This notwithstanding, and as was the case with Porokokore village, there was much enthusiasm for leafy vegetables, whether for food or medicinal purposes. Indeed, the people were even keener to have the medicinals analysed than the food plants. It was mentioned that nutrition is taught at the local school, but the school has no food garden and no-one was aware of any benefits from eating leafy greens. However, it was considered that education on this would be highly desirable.

7.Nunure village, home of Willie Loufeli (APHEDA), around 3km further inland, following a stream (gave talks in the evening to 27 people).

Soil: lower ph (4.7) than the other sites; light-brown clay soil, growing SP, cassava and pineapple on a sloping garden. Needs more organic matter.

7 samples collected, including one medicinal (pawpaw leaf v malaria). A shrub with red leaves growing in the stream bed (probably *Alternanthera* spp, Amaranth family) was later analysed with a high selenium concentration (around 8ppm DW)…will investigate this further.

Plenty of leafy greens are known and eaten, similar to the other communities. SP, cassava and taro are grown, but (as elsewhere) several local wild-collected leaves are preferred (mostly because of taste); no obvious barriers; nutrition is taught at local primary schools (a teacher was present). There was a long discussion on agriculture, health and nutrition. It was mentioned that there had been a decline in SP tuber yield from 1970 all the way to the present. This is probably due to a combination of soil nutrient depletion and accumulation of SP viruses. Advised to avoid burning trash wherever possible, to try to increase soil organic matter.

8.Tawa'ahi island (Alite village), where we stayed while at Marau Sound.

Soil: coralline sand with some humus; pH 8.0

Collected 6 plant samples (2 cassava, one of which was very chlorotic and shown by ICP analysis to be Fe deficient), and 4 Ete, which is reputed to increase lactation…in fact, this seems to be a common theme…every community we visited mentioned several leafy plants which were eaten for this purpose. Subsequently, I checked one of these and found that it had been investigated using a mouse model and did indeed upregulate genes controlling the production of oxytocin and prolactin.

9.Makina Catholic Mission

Soil: dark-brown sandy loam, pH 6.8

Collected 3 plant samples, including 2 medicinals.

10. Marau airfield

Sandy soil, pH 8.0. One family was making compost to improve the soil.

4 plant samples, including 2 medicinals. Pawpaw and Aibika chlorotic: shown to have Fe and N deficiencies.

11. Vatukulau village, Aruliho, West Guadalcanal (Olga, Maria and Atu)

Soil: topsoil (black clay loam, high OM, pH 5.7); subsoil in yam garden (grey micaceous, pH 6.5); deeper subsoil (1.5m…reddish, pH 5.0)

These people have a sound knowledge of leafy vegetables and grow and eat Boneo (sweetleaf), Ete (ghende), Pure (Ofenga, looks similar to Ete and both are used to increase lactation and Ofenga was also used against leprosy), sandpaper kabis (Kemau), leaves of taro, chilli, SP, cassava, yardlong bean, and Aibika.

Mike Furlong (Univ of Queensland) had mentioned the phenomenon of Aibika plants growing in sunny positions being susceptible to insect infestation, while the same plants growing in shaded areas usually had few or no insects on them, so Pita and I were looking for situations where this was occurring (on the same soil type), so we could sample the plants and see if there were differences in minerals that were not due to different soils. This village provided just such a scenario: Aibika growing in the sun and decimated by small, brown/red *Nisotra* insects (the "Aibika flea beetle"), with the same plants growing 10 metres away in the shade…with pristine leaves and no insects. The shaded leaves were found to be higher in Mg (92% higher), Zn (+38%) and S (+38%) than the full-sun leaves and similar in all other minerals tested. Of course, this phenomenon may be unrelated to minerals, but rather be due either to lack of sun causing accumulation of a specific phytochemical with insect-repellent properties, or, more likely, high sun exposure increasing photosynthesis, resulting in more CHO (including sugar), which attracts the insects.

12.Kukum fishing village market (1/7/2012) and Honiara market (2/7/2012)

Leafy vegetables represented: Aibika, lettuce, cabbage ("ball-head"), ferns, kangkong, okra, cassava leaf.

SUMMARY

In this small, opportunistic survey it was found that leafy vegetables form an important part of the diet of many Solomon Islanders, whether they live in remote or peri-urban settings. In the rural areas, wild collected leaves form a major part of this leafy dietary component. In addition, the leaves of particular species are used to stimulate lactation and for medicinal purposes, e.g. against malaria, diarrhoea, TB, influenza, fever, inflammation, and to stimulate wound healing.

In contrast to the widespread appreciation and knowledge of these medicinal leaves for specific health purposes, there was little or no understanding of the link between "regular" food and health. Leafy crops are grown/eaten mainly because they are easy to grow and taste good. In general, leaves such as Aibika, Boneo, Ete, Ofenga and sandpaper kabis are preferred (because of superior taste) to leaves of SP and cassava. Programs which provide appropriate nutrition education, in particular inclusion in school curricula (and which include a practical element, e.g. sustainable, nutritious school food gardens managed by the students) are likely to lead to positive health outcomes for Solomon Islanders.

The mineral analyses of the 85 leaf samples collected on this trip revealed large genotypic variability in mineral nutrient accumulation (shown by sampling and analysing different species growing on the same soil) as well as showing the influence of soil type (by analysing the same species across several sites). There were species that appeared to be very good at accumulating particular nutrients/micronutrients, e.g.:

Fe: Moringa (Drumstick tree), Ete, yardlong bean, Boneo (note that some leaf samples were not included in plant Fe assessment due to soil/dust contamination. In my experience, such contamination, as long as not severe, affects only Al, Fe and titanium levels)

Zn: Ete, Boneo, watercress

S: Moringa, watercress, cabbage

Mg: Ofenga

Ca: Ofenga

P: Ofenga

K: Pumpkin tips, soursop, chilli

Ni: Bohore fern

Se: red-leaved Alternanthera

N/protein: Boneo, local kabis (at KGA), Moringa, cassava.

And "good all rounders" included Boneo, Ofenga, Ete, Aibika and Moringa.

Appendix 6

Report on Kingdom of Tonga visit October 2012 by Roger Goebel, Consultant rggoebel@bigpond.com

Just one small section of the Ag Show displays 2012

Summary

For the week October 12th to 20th I visited Tongatapu and Vava'u islands in Tonga primarily to report on the fruit tree situation for an ACIAR/ SPC activity.

I have visited Tonga more than 10 times in the past 4 years and knew many people that were interested in nutritious foods. Over this time I had regular visits to various produce markets to assess what was available in relation to fresh produce. I had noted an obvious increase in the availability of leafy green vegetables particularly Chinese cabbage types. With some weekend and evening time available, I was encouraged to undertake some interviews and leaf sampling.

Although I spoke to over 20 people I recorded 5 interviews in some detail. 22 leaf samples were collected and bought back through Quarantine in Cairns.

I was fortunate to be invited to 3 family dinners where a variety of locally prepared dishes were served.

On Friday 19th I attended the Annual Agricultural Show on Tongatapu which gave me the best opportunity to view the produce from all the various villages on the Island.

Key points

Interviews

1. Lucy Fa'anunu of Vava'u Island
2. Christy Butterfield and 2 other ladies of Vava'u Island
3. Luseane Taufa of Nukualofa
4. Pila and Lita Kami of Nukualofa

5. Mr. Chin of Tokomololo

In addition to these interviews I spoke to various others in relation to specific points.

Ben, owner operator of the Ali Baba Guesthouse grew up in the Middle East then lived in Sydney for many years before arriving in Tonga. He commented that in the last 3 years there has been an increasing supply of green leafy vegetables in the markets. This was due to the increase in people growing Asian and Chinese vegetables for sale, their own consumption and to supply Asian/Indian style restaurants. Before that he could not get the ingredients to cook some of the dishes that he had when he was growing up. Now with the plentiful supply of suitable leafy green vegetables he can cook with more variety in his meals.

Mrs. Halavatau who prepared Thursday evening meal is a nutritionist by profession having studied under Mrs. Susan Parkinson of Fiji. The meals that she prepared were varied with a Tongan, Fijian, Northern Indian and European aspects. She was very supportive of our project aims and commented on the increasing interest by some in their diet and the array of ingredients available.

They grew some fruit, vegetables and herbs around the house.

Family dinners

Sunday is a day of Church and Sunday lunch is a very significant family event. I was invited to Sunday lunch with the Kami family. It consisted of around12 separate dishes including salad and cooked green vegetables particularly dishes cooked in Taro leaves.

One evening meal with Ben consisted of chicken cooked in large amounts of shredded pele leaf served with steamed potatoes.

Another meal on Thursday night was also prepared along traditional lines with roasted pig, fish, chicken, cooked with various leafy vegetables and root crops.

Even the left over cabbage and Chinese cabbage greens, surplus to the sample needs, were steamed and flavored for an evening meal in the Lab.

Samples

1 Kang Kong *Ipomea aquatica* ex market, Nukualofa

Grows well and is known by most that I spoke to but not eaten as widely as Pele.

Cost TP$3/good handful/bunch

2 Chives *Allium schoenoprasum* ex market, Nukualofa

4 or 5 different spring onion/chives type vegetables available in fair supply.

3 Ceylon spinach *Basella alba* ex home garden, Nukualofa

Grows well but not eaten as widely as kang kong.

4 Silverbeet *Beta vulgaris* ex home garden, Nukualofa

Grows well especially in cooler months when it is regularly seen in the markets.

5 English cabbage *Brassica oleracea* ex market, Nukualofa

Very common in the markets and roadsides. Grown commercially. Cost TP $1 for a head peeled back to white leaves.

6 Bok Choy - white stem type *Brassica rapa var chinensis* ex roadside stall, Nukualofa

Not as common as English Cabbage but still very plentiful. Grown commercially. Known and used by most that I spoke to.

7 Seagrape seaweed *Caulerpa lentillifera* ex fish market, Nukualofa

Commonly available if you are early enough as it is popular in dishes like raw fish in coconut cream. Cost TP $9 for 2 handfuls wrapped in leaves. This seaweed is harvested from the outer fringe of the reef. This seaweed dried quickly into a very palatable product that could be used as a salt ingredient in various dishes.

8 Mozuku type Seaweed *Cadosiphon*? Ex Food Research Unit MAFFF

A brown stringy seaweed not regularly used but with export potential.

9 Mozuku seaweed *Cladosiphon okamuranus* ex Food Research Unit MAFFF

Not as commonly used as another brown stringy seaweed but with good export potential.

10 Parsley – Broad leaf *Petroselinum crispum* ex home garden, Nukualofa

Available in the markets for around TP$2 /bunch

11 Choko tips *Sechium edule* ex Chinese market garden, Tokomololo

Although choko fruit are regularly seen in the markets the vine tips are not. Even the grower did not know they were a palatable vegetable till he tried some.

12 Sweet Basil *Ocimum basilicum* ex home garden, Nukualofa

Available in the market but sometimes grown around the home.

13 Lettuce – ball head *Lactuca sativa* ex roadside stall Nukualofa

Commonly available most of the year but quality drops as the weather warms. This was a poor example and cost TP$3 for a small head about to go to seed.

14 Coriander leaf *Coriandrum sativum* ex home garden, Nukualofa

Regularly available in the markets.

15 Taro leaf *Colocasia esculenta* ex small garden Tokomololo

Widely available and used to parcel various dishes steamed or baked where the leaf is also eaten. Not as popular as the youngest full leaf of Xanthosoma.

16 Common Parsley *Petroselinum hotense* ex home garden, Nukualofa

Parsley was available in large supply in the markets at TP$2/big handful bunch.

17 Tannia/ Taro palangi *Xanthosoma sagittifolium* ex roadside stall Nukualofa

Very common and in good demand at TP$1 to $2/ roll of 12 leaves.

18 Tania/ Taro palangi *Xanthosoma sagittifolium* ex market, Nukualofa

Very common and in good demand at TP$1 to $2/ roll of 12 leaves. Almost had to fight a lady for the last roll. She took all 6 rolls so I went to another stall.

19 Chinese Cabbage – open head *Brassica rapa* ex roadside stall, Nukualofa

There are many different looking types of Chinese cabbages for sale. They are fairly plentiful and appear to be popular. I expect some of the variation is from people keeping their own open pollinated seed.

20 Pele/Aibika *Abelmoschus manihot* ex small garden, Tokomololo

One of a range of leaf types this one had large palmate leaves with 5 fingers.

Pele is a very (possibly the most) popular vegetable in Tonga.

21 Pele/Aibika *Abelmoschus manihot* ex home garden, Tokomololo

One of a range of leaf types this one had large entire leaves with red stems.

22 Pele/Aibika *Abelmoschus manihot* ex home garden, Tokomololo

One of a range of leaf types this one had large entire leaves with green stems.

Drying samples.

As a microwave oven was not available for the time needed and a commercial drying unit was. We chose to use the drier. Samples were started at 35 degrees C and raised to 50 degrees C . Some samples too 4 days to dry to crisp. Ceylon Spinach was the most difficult to dry and needed the stem to be crushed.

Seaweeds were very dry in a surprisingly short time (24 hours).

Observations on other leafy green vegetables

Drumstick tree leaves, I did not see in any markets but have seen two small trees in backyards but the leaves did not appear to be harvested.

Squash tips, although a true pumpkin type is being grown for export and some fruit is available in the markets, tips were not seen and only a couple of people were aware of the value of squash tips as a vegetable. I am unsure if the tips of the pumpkin (called Squash locally in Tonga) are as nutritious or palatable.

Fern leaf and tips, not seen in the markets and not spoken about although on a previous visit a person was collecting a special fern growing in stonewalls. He was asked by his wife to get it for medicinal uses, something to do with pregnancy but he was short on detail.

Breadfruit leaves are in good supply but not regularly eaten. There were comments about young leaves being regularly eaten in Vanuatu.

Cassava is a very popular root crop in Tonga and is widely grown. No discussion on the leaves being used as a vegetable but were said to be fed to pigs.

Watercress is popular in other Pacific areas but I have not seen it in Tonga markets. One person I spoke to was interested in how to grow it.

Rocket is grown in some home gardens and appears popular. In Vava'u one lady said that it was her favorite green and has good potential in the restaurant trade.

Agricultural Show Tongatapu

On my last day I spent most of it at the Agricultural Show.

It was my second show visit as I attended this show in October 2011.

Previous to that it was the United Nations sponsored "World Food Day" which has now been integrated into the revamped Agricultural and Industrial Show.

All villages on Tongatapu put in various displays and the whole event is very impressive.

Lots of large groups of school children are among the thousands of people that turn up to look at the event. I was overhearing some teachers with one large group of young school children. They were at a very impressive display of vegetables and were pointing out to the children that these vegetables were what they were talking about in class as being very good foods.

The King himself attended and visited all the displays and handed out the prizes.

At some stalls there were some publications promoting good food. The Tonga Health stall had by far the best collection and my baggage weight only prevented me from getting more than the couple of kilograms of publications that I did bring home. Among them was the latest edition, 2012 of SPC Green leaves leaflet.

Leaflet No. 8 in the very popular series on healthy foods of the Pacific.

The 2012 revised edition is 12 pages in colour treating 22 leafy greens.

Giving some background, nutritional information and 6 recipes.

In addition to the SPC leaflet series the stall also had numerous posters on health, foods, fruit and vegetables. There was also a laminated color card series with a photo of a food on one side and some brief information in English and Tongan on the reverse.

Acknowledgements

I use this opportunity to acknowledge the input of the many people in Tonga who listened to what I was interested in and supplied genuine and valuable input. I thank them for their help.

Staff of the Ministry of Agriculture & Food, Forests & Fisheries of the Kingdom of Tonga were keen to help, with Mrs. Luseane Taufa supplying interesting information, access to the drier and collecting some of the samples. Much of which was done out of normal work hours.

The drying was done at the Stabex Project Post harvest and Agro processing Building located near the main wharf in Nukualofa.

Appendix 7

WORSKHOP REPORT

by Kalais-Jade Stanley

Workshop title: Increasing access to, and the consumption of, nutritionally-rich leafy vegetables in Samoa

Date: 13/06/13

Time frame: 10.00am – 3.00pm

Venue: Small Business Enterprise Centre (SBEC)

Workshop coordinator:

- Kalais-Jade Stanley, WIBDI

Workshop facilitator:

- Mary Taylor, ACIAR, SPC

Workshop presenters:

- Christine Quested, MOH
- Kay Paterika, MOH
- Pule Toleafoa, WIBDI
- Tilomai Sikuka, WIBDI
- Kalais-Jade Stanley, WIBDI

Objectives of workshop:

- To investigate the nutritional value of locally available leafy vegetables
- To discuss the most effective means of propagation for these leafy vegetables
- To identify effective composting practices to assist with the growth of leafy vegetables
- To develop strategies for further research and raising awareness of their health benefits within homes, communities and the country of Samoa

Report

For the first time, the Australian Centre for International Agriculture Research (ACIAR) partnered with Women in Business Development Inc. (WIBDI), to coordinate a workshop promoting nutrition in Samoa. The workshop entitled 'Increasing access to, and consumption of, nutritionally-rich leafy vegetables in Samoa' set out to do just that; address issues of nutrition and health through the encouragement of growing and consuming more nutrient rich vegetable varieties.

The turnout exceeded expectation, with 38 participants in total; 22 females and 16 males. Of these, nine participants had travelled from the island of Savaii and the remainder had come from 18 different villages throughout Upolu. The average age of attendees was estimated to be between 40 and 60 years.

All components of the workshop were presented in Samoan for easier understanding and each participant was given a course folder consisting of a note book, pen, 12 fact sheets, pamphlets on composting and pele leaf, a transportation allowance, and a schedule outline for the day. They were also presented with cuttings – drumstick, spinach vine and pele, and a variety of seeds – pumpkin, lettuce, cabbage and basil.

A presentation by Kay Paterika and Christine Quested from the Ministry of Health, described factual information on the nutritional content of some of these leafy greens, namely; pele leaf, taro leaf, chilli leaf, sweet leaf, kangkong, pumpkin and choko tips, spinach vine, amarantha and drumstick.

It was explained how the darker the green the better it is for you, and how consumption of different leafy greens provides the body with the essential vitamins, minerals and fiber necessary for good health.

These include; Vitamin C which helps repair and protect cells, and may also help reduce risk of cancer, heart disease and diabetes, Vitamin A which is important for growth and development, for the maintenance of the immune system and for good vision, Calcium which is essential for strong bones and teeth, Iron which is needed for healthy blood, energy and growth, and Fiber, which helps with digestion and reducing blood sugar, fat levels, and weight.

It was also mentioned that a person should consume at least 3 to 4 servings of green leaves per week, and that when choosing these, it is important to realize that the most nutritious are those that are dark green, crisp, and without signs of yellowing or wilting.

WIBDI senior project officer Pule Toleafoa, also led a discussion on suitable propagation methods for each of the crops mentioned above. Learning about the multiplication of drumstick and spinach vine in particular, seemed to be of great interest to participants. Although propagation of both of these leafy greens is in fact very easy and straight forward, it seemed that they are not commonly planted crops - primarily due to lack of awareness.

Pule also worked with the participants to address some of the major issues that they had found with farming these particular leafy vegetables. Most people agreed that the greatest obstacle faced was the management of pests and disease. This was particularly evident for those attendees who were farming organically. Another reoccurring problem was the viability of the seeds, whereby a lot of people said that even in scenarios where numerous seeds were planted, only a handful would grow.

Tilomai Sikuka; WIBDI senior field officer, presented on the topic of compost making, and its importance in relation to the growth of these leafy vegetables. She described how compost allows for the addition of nutrients to the soil and how it is a key component in organic farming. She also described the contents of successful compost, stating that successful compost should contain microbes, appropriate Carbon rich (green) and Nitrogen rich (brown) plant material, air and moisture. A method for compost making that is commonly practiced by our organic farmers was also provided, whereby dead logs, green and brown plant material, soil, manure and water are used, as well as seaweed and ash when available to the farmer.

Multiple group activities were also conducted relating to each of the presentation concepts. In small groups participants brainstormed to compile lists of all the leafy vegetables that they knew of, and discuss what they thought the nutritional content of each might be. This information was then presented to the larger group and further discussed as a whole. Vegetables that were most commonly mentioned by participants as being high in nutrition were pele leaf, taro leaf, cabbage and pumpkin tips. Participants were surprised to learn that the estimated nutritional value of one pele leaf is the equivalent of approximately 17 lettuce leaves.

For another activity, groups listed the most common problems that they have with growing these types of leafy vegetables and together discussed how these problems could be remedied. The most common problem described by all, was the effect of pests and disease, however other issues such lack of planting material and lack of knowledge about these other varieties, was also mentioned.

There was also a discussion around the propagation methods previously used by farmers and the success rate of these in comparison to those who had tried the recommended practices by WIBDI.

Ana Epati was one of many WIBDI farmers, who said that her vegetables are growing a lot better now that she has altered some of her methods of propagation.

The final activity was concerned with how farmers in their areas could work together to increase awareness and the overall intake of leafy greens in their communities. A common suggestion from famers was the prospect of village nurseries, whereby people of a village or within a region work together to achieve this. Another idea was increasing nutritional education in schools, at both the primary and secondary level, with the practical component of school gardens also mentioned.

The potential business opportunities available to growers were also discussed. Research shows that there are not enough green leaves sold in our local markets, supermarkets or available in schools, and because vegetables and fruit can be grown from home and with minimal costs, it could be a very profitable venture, if done properly.

Upon conclusion of this workshop, we provided an evaluation form whereby each participant gave an anonymous account of their understanding and potential benefit from the workshop. The questions asked were as follows;

1. What lessons have you learnt from this workshop?
2. What would you like to learn more about?
3. What section, if any, did you not understand?
4. What was your favourite element of the workshop?
5. On a scale of 1-5 (5 being the best), how useful was this workshop to you?

The most common responses were as follows;

1. The importance of eating leafy greens and planting methods of one’s that we’ve never eaten before
2. Composting and pests and disease
3. None
4. Composting and nutritional content of different leafy greens
5. Average of 4.5

All feedback from the workshop was very positive. A lot of farmers said that although it was good to hear about the nutritional content of these leafy vegetables that they would like to learn more about how to nurture them through healthy soil, composting and pest and disease management. They also said that they would like more information on affordable ways of cooking these leafy vegetables, and the provision of more seeds and seedlings of greater varieties.

Over all, I feel that this workshop was a success. It was an excellent opportunity to share knowledge and also hear from the participants; exactly what they would like further information on.

List of Farmers for ACIAR Workshop - 13th June 2013

1. Rosalina Pritchard	Satitoa	F	Upolu
2. Fagaote Lealaiauloto	Vavau	M	Upolu
3. Sapela Simi	Saleilua	F	Upolu
4. Leuta Sakaria	Solosolo	F	Upolu
5. Fiauu Tavita	Matautu Lefaga	F	Upolu
6. Tala Talitiga	Aleisa	M	Upolu
7. Malofou Lomiga	Toamua	F	Upolu
8. Solema Isamaeli	Tiavi	F	Upolu
9. Kilali Alailima	Siusega	M	Upolu
10. Apineru Wright	Leulumoega	M	Upolu
11. Filisika Wright	Leulumoega	F	Upolu
12. Mavaega Seigafo	Afega	M	Upolu
13. Lau Pepese	Lotofaga	M	Upolu
14. Faaliga Pepese	Lotofaga	F	Upolu
15. Nofa Afualo	Faleasiu	F	Upolu
16. Ana Epati	Faleasiu	F	Upolu
17. Peka Meafou	Faleasiu	F	Upolu
18. Ethna Sauvao	Faleasiu	F	Upolu
19. Toafa Koleni	Faleasiu	F	Upolu
20. Tutulu Meafou	Faleasiu	F	Upolu
21. Leonia Eteuati	Faleasiu	F	Upolu
22. Lafai Lasi	Lano	M	Savaii
23. Leaoa Sasalu	Patamea	M	Savaii
24. Fituafau Siolo	Tafuatai	M	Savaii
25. Eveliga Kalolo	Sataua	F	Savaii
26. Maugalii Atonio	Faleula	M	Upolu
27. Mapu Atonio	Faleula	F	Upolu

28. Tilomai Anesone	Faleula	F	Upolu
29. Popo Malaulau	Saoluafata	M	Upolu
30. Tanielu Masoe	Samelaeulu	M	Savaii
31. Poasa Tagaloa	Taga	M	Savaii
32. Aupito Tuigasala	Matatufu	M	Upolu
33. Alofa Tanu	Satitoa	F	Upolu
34. Faiumu Faimafili	Taga	M	Savaii
35. Kelemete Sefo	Sagone	M	Savaii
36. Selesa Sefo	Sagone	F	Savaii
37. Taugafie Ah Liki	Motootua	F	Upolu
38. Talisuaga Lemeko	Motootua	F	Upolu

Appendix 8

Pele/Aibika propagation trial in Samoa: a brief report

by Kalais-Jade Stanley

Women in Business Development Organic Project Officer

Methodology

Treatment 1: 25cm stem cuttings, top portion of plant

Treatment 2: 50cm stem cuttings, top portion of plant

Treatment 3: 75cm stem cuttings, top portion of plant

Treatment 4: 50cm stem cuttings, middle portion of plant

Treatment 5: 25cm stem cuttings, middle portion of plant

There were 20 samples per treatment per trial plot; 10 of which were cut at a 35◦ angle (vertically) and the other 10 at a 65◦ angle (horizontally).

Trial plots were measured to 30m^2 and were surrounded by a single buffer row of transplanted pele plants.

The allocated spacing between plants and rows was 50cm.

Trial plot 1	Trial plot 2	Trial plot 3	Trial plot 4
Treatment 1 25cm stem cuttings top portion 20 pele samples	**Treatment 2** 50cm stem cuttings top portion 20 pele samples	**Treatment 3** 75cm stem cuttings top portion) 20 pele samples	**Treatment 4** 50cm stem cuttings middle portion 20 pele samples
Treatment 2 50cm stem cuttings top portion 20 samples	**Treatment 3** 75cm stem cuttings top portion 20 samples	**Treatment 4** 50cm stem cuttings middle portion 20 samples	**Treatment 5** 25cm stem cuttings middle portion 20 samples
Treatment 3 75cm stem cuttings top portion 20 samples	**Treatment 4** 50cm stem cuttings middle portion 20 samples	**Treatment 5** 25cm stem cuttings middle portion 20 samples	**Treatment 1** 25cm stem cuttings top portion 20 samples
Treatment 4 50cm stem cuttings	**Treatment 5** 25cm stem cuttings	**Treatment 1**	**Treatment 2**

middle portion 20 samples	middle portion 20 samples	25cm stem cuttings top portion 20 samples	50cm stem cuttings top portion 20 samples
Treatment 5 25cm stem cuttings middle portion 20 samples	**Treatment 1** 25cm stem cuttings top portion 20 samples	**Treatment 2** 50cm stem cuttings top portion 20 samples	**Treatment 3** 75cm stem cuttings top portion 20 samples

Results

WEEK 1 & 2

Treatment 1: No growth.

Treatment 2: No growth.

Treatment 3: Rapid growth. Particularly evident in those that had been cut at a 35◦ angle (vertically), in which an average of 8 shoots per plant was observed.

Treatment 4: No growth.

Treatment 5: No growth.

WEEK 3 & 4

Treatment 1: Still no growth patterns observed. A few shoots from some samples – not consistent across trials.

Treatment 2: Growth observed. Average of 5 new shoots observed in both horizontally and vertically cut samples.

Treatment 3: Continued growth. Further development of small leaves.

Treatment 4: No growth.

Treatment 5: No growth.

WEEK 5 & 6

Treatment 1 Growth observed, with an average of three shoots per sample. Other samples that did not sprout, showed signs of wilting and change in colour to brown.

Treatment 2: Continued growth. Further budding and development of small leaves.

Treatment 3: Continued growth. Further budding and some leaves beginning to mature.

Treatment 4: Growth observed, with an average of two shoots per sample. Other samples that did not sprout, showed signs of wilting and change in colour to brown.

Treatment 5: Growth observed, with an average of two shoots per sample. Other samples that did not sprout, showed signs of wilting and change in colour to brown.

Current

Treatment 1: 60% of samples still growing well, 40% have died. Leaves are less developed and smaller, and also seem to be those attacked the most by pests. No difference observed for those cut horizontally or vertically.

Treatment 2: 75% of samples still growing well, 25% have died. Leaves of varying sizes. Of the plants still growing well, 55% of samples were cut vertically and 45% were cut horizontally.

Treatment 3: 95% still growing well, 5% have died. Developed leaves appear to be larger than those that are developed in Treatment 2. Of the plants still growing well, 65% of samples were cut vertically and 35% were cut horizontally.

Treatment 4: 25% still growing well, 75% have died. Leaves less developed and smaller. No difference observed for those cut horizontally or vertically.

Treatment 5: 25% still growing well, 75% have died. Leaves less developed and smaller. No difference observed for those cut horizontally or vertically.

Overall Observations

There was a big difference observed in propagated growth rate across all treatments; slant of cutting (horizontally - 65◦ angle or vertically - 35◦ angle), portion cut (tip or middle section) and cutting length (25cm, 50cm and 75cm).

Cutting technique was not a common factor for all of the treatments, as there was no significant difference in cutting horizontally or vertically for samples in treatment 1, 4 and 5. However there were differences observed in Treatment 2 and 3, whereby slicing the plant material at a 35◦ angle showed to encourage faster growth (observed in treatment 3) and also better chance of plant survival (observed in treatments 2 and 3).

There was also significant evidence that keeping the tip intact with the propagating material, bettered the chance of survival, with the least effective propagation observed in treatment 4 and 5, which were extracted from the middle portion of the plant.

Stem length also showed to play a role in overall health and development of the plant, whereby 75cm cuttings appeared to have both the fastest and most abundant shoot growth, and also appeared to have the best chance of survival, with 95% of samples currently growing well. Those that were most effected by pests appeared to be those in treatment 1, which may possibly have been due to stem length of the plant, whereby leaves were closer to the ground.

Therefore, from the results obtained, it can be determined that the most effective pele propagating material is that which is of 75cm in length, including the plant tip, and cut vertically at an angle of 35◦.

Kalais-Jade Stanley

Appendix 9

Leaf samples collected on Guadalcanal - Solomon Islands, 2012

Sample no.	**Date collected**	**Local/common name**	***Scientific name***	**Site collected**
1	26/6/2012	Lettuce	*Lactuca sativa*	Falo, Burns Creek, Honiara, Guadalcanal
2		Sliperi kabis	*Abelmoschus manihot*	
3		Cassava	*Manihot esculenta*	
4		Guava	*Psidium guajava*	
5		Boneo	*Sauropus androgynus*	
6		Sweet potato	*Ipomoea batatas*	
7		Sweet potato	*Ipomoea batatas*	
8		Ofenga	*Pseuderanthemum whartonianum*	
9		Ofenga	*Pseuderanthemum whartonianum*	
10		Mile a minute	*Mikania cordata*	
11		Malasya	*Rorippa spp.*	
12		Konare	*Antibacata twinium*	
13	26/6/12	Sweet basil	*Ocimum basilicum*	Kastom Gaden Assoc, Burns Creek, Honiara
14		Sliperi kabis	*Abelmoschus manihot*	
15		Boneo	*Sauropus androgynus*	
16		King tree	*Gnetum gnemon*	
17		Okra	*Abelmoschus esculentus*	
18		Ginger	*Zingiber officinale*	
19		Sliperi kabis	*Abelmoschus manihot*	

20		Chilli	*Capsicum frutescens*	
21		Local kabis	*Lactuca spp.*	
22		Vetiver grass	*Chrysopogon zizanioides*	
23		discarded		
24		Black pepper	*Piper nigrum*	
25		Soursop	*Annona muricata*	
26		Lemon grass	*Cymbopogon citratus*	
27		Sliperikabis	*Abelmoschus manihot*	
28		Pumpkin	*Cucurbita moschata*	
29		Pigeon pea	*Cajanus cajan*	
30		Land watercress	*Rorippa nasturium*	
31		Creeping weed	*Manihot dysery*	
32		Drumstick tree	*Moringa oleifera*	
33		Sand paper kabis	*Ficus copiosa*	
34		Curry tree	*Murraya koenigii*	
35	29/6/12	Ete (Bebero)	*Polyscias spp*	Tawa'ahi Island-Marau
36		Ete	*Polyscias verticillata*	
37		Cassava (looks OK)	*Manihot esculenta*	
38		Ete	*Polyscias fruticosa*	
39		Ete	*Polyscias fruticosa*	
40		Cassava (pale: Fe deficient)	*Manihot esculenta*	
41		Smol furuti	*Wikiblad fruitum*	Legalawa village-Marau
42		Pure/Ofenga	*Whartonium spp.*	
43		Kaihalo	*Talinum triangulare*	

44		Kaipoto fern	*Dicksonia antarctica* or *Cyathea*	
45		Kaibohore fern	*Cyathea spp.*	
46		Sandpaper kabis (Kemau)	*Ficus copiosa*	
47		Kaikuika (Climbing swamp fern)	*Stenochlaena palustris*	
48		Taro	*Colocasia esculenta*	
49		Butterfly tree	*Melicope elleryana*	
50		Savuli kaipuchi	*Ficus variegata*	
51		Ginger	*Zingiber officinale*	
52		Cassava	*Manihot esculenta*	Porokokore village- Marau
53		Sweetpotato	*Ipomoea batatas*	
54		Sweetpotato	*Ipomoea batatas*	
55		Boneo	*Sauropus androgynus*	
56		Ete	*Polyscias fruticosa*	
57		Creek fern	*Stenochlaena palustris*	
58		Marauvo	*Malariana foliata*	
59		Breadfruit	*Artocarpus altilis*	Nunura village- Marau
60		Cassava	*Manihot esculenta*	
61		Sandpaper kabis (Kemau)	*Ficus copiosa*	
62		Ete	*Polyscias scutellaria*	
63		Taro	*Colocasia esculenta*	
64		Redleaf	*Alternanthera dentata*	
65		Pawpaw	*Carica papaya*	Sample missing
66		Ete	*Polyscias scutellaria*	Makina Mission-

				Marau
67		Tatale (Indian spinach)	*Basella rubra*	
68		Aruba	*Arubango spp.* or *Polyscias*	
69	30/6/2012	Sliperi kabis	*Abelmoschus manihot*	Marau airport-Marau
70		Pawpaw (pale: Fe defic)	*Carica papaya*	
71		Sliperi kabis	*Abelmoschus manihot*	
72		Loreta	*Loredana riunnin*	
73	1/7/2012	Egg plant	*Solanum melongena*	Aruligo, West Guadalcanal
74		Pumpkin	*Cucurbita moschata*	
75		Chilli	*Capsicum frutescens*	
76		Chilli	*Capsicum frutescens*	
77		Sandpaper kabis (Kemau)	*Ficus copiosa*	
78		Yard long bean	*Vigna unguiculata*	
79		Sliperi kabis (sun)	*Abelmoschus manihot*	
80		Sliperi kabis (shade)	*Abelmoschus manihot*	
81		English cabbage	*Brassica oleracea capitata*	Honiara market

Appendix 10

Selected mineral nutrients in leaf samples collected on Guadalcanal, Solomon Islands in June/July 2012

Units are mg/kg for micronutrients and Na, and % for macronutrients.

Sample no.	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Na mg/kg	Ca %	Mg %	K %	P %	S %	N %
1	46	17	11	20	1090	1.9	0.33	6.4	0.3	0.27	4.4
2	31	25	9	32	188	1.8	0.47	3.3	0.44	0.34	4.3
3	46	21	7	40	12	0.56	0.23	2.1	0.47	0.33	5.7
4	31	30	16	17	290	1.2	0.21	2.0	0.22	0.28	
5	180	65	9	61	6	2.6	0.65	2.8	0.76	0.80	4.6
6	27	40	18	30	13	0.4	0.25	3.4	0.54	0.30	4.0
7	44	38	16	27	770	0.75	0.22	3.9	0.50	0.33	4.8
8	48	41	16	43	1000	3.4	1.6	3.5	0.51	0.28	4.3
9	42	32	11	49	530	2.4	1.6	3.5	1.1	0.31	2.7
10	80	34	24	37	1210	2.2	0.30	3.2	0.32	0.78	
11	53	28	11	83	181	4.7	0.58	3.6	0.26	0.23	
12	23	29	25	56	5000	2.0	0.50	2.7	0.49	0.31	
13	30	20	19	52	10	2.2	0.37	4.1	0.44	0.30	4.3
14	46	21	7	35	106	1.9	0.69	3.2	0.40	0.34	5.0
15	89	33	8	64	7	1.2	0.50	3.0	0.50	0.49	5.6
16	64	28	6	31	37	0.6	0.21	2.4	0.29	0.32	4.3
17	18	27	11	31	47	3.0	0.44	2.6	0.39	0.36	4.3
18	157	14	5	27	45	0.94	0.36	3.3	0.28	0.25	
19	126	34	9	43	270	2.8	0.86	3.6	0.42	0.68	5.1
20	26	27	10	23	8	1.2	0.35	4.3	0.36	0.41	5.1
21	31	19	8	33	260	3.1	0.41	3.5	0.50	0.87	5.5
22	25	2	6	15	67	0.19	0.10	2.0	0.21	0.15	1.5

24	38	3	5	24	60	0.32	0.14	2.9	0.18	0.10	
26	101	19	11	20	210	1.59	0.25	2.5	0.19	0.16	
27	58	25	8	55	54	2.4	0.58	2.8	0.54	0.33	4.5
28	29	32	7	38	34	1.81	0.36	4.1	0.56	0.26	
29	45	19	12	21	21	0.68	0.27	1.2	0.29	0.22	4.5
30	33	21	9	114	96	1.83	0.36	3.9	0.75	1.10	
32	30	21	7	31	39	2.0	0.37	1.95	0.40	1.23	5.1
33	25	54	9	25	19	1.88	0.39	2.80	0.27	0.23	3.1
34	21	66	8	22	19	1.78	0.46	1.75	0.19	0.21	3.7
35	29	53	6	106	2400	2.8	0.67	2.2	0.14	0.15	2.3
36	42	36	5	88	7500	2.9	1.02	0.89	0.17	0.16	2.5
37	91	77	6	54	91	1.92	0.65	0.76	0.23	0.22	3.9
38	63	45	9	82	1410	2.4	0.35	2.3	0.20	0.18	3.0
39	65	39	6	55	7300	2.6	0.29	1.78	0.15	0.15	
40	80	92	8	80	61	2.1	0.60	1.51	0.29	0.30	3.3
41	133	35	16	76	6200	0.67	0.49	3.7	0.35	0.40	
42	61	19	13	37	4500	1.81	2.4	3.2	0.28	0.36	3.3
43	115	19	9	74	172	1.43	0.29	1.63	0.33	0.26	
44	55	27	32	68	1380	0.19	0.44	3.7	0.52	0.35	4.6
45	52	20	41	62	88	0.11	0.47	4.0	0.67	0.47	5.4
46	26	34	10	31	94	2.9	0.69	3.0	0.54	0.36	4.4
47	45	18	24	39	136	0.12	0.29	4.6	0.56	0.29	4.6
48	149	19	24	41	29	1.18	0.34	3.3	0.44	0.29	5.1
49	177	28	6	19	1110	2.5	0.55	1.75	0.17	0.18	2.7
50	116	15	18	15	124	0.35	0.39	2.2	0.18	0.16	2.7
51	48	10	8	36	63	1.54	0.46	3.2	0.23	0.28	
52	560	42	7	108	53	1.1	0.67	0.99	0.20	0.22	
53	146	35	13	28	105	0.37	0.37	2.9	0.25	0.30	

54	163	32	13	24	19	0.36	0.37	2.8	0.23	0.27	
55	2300	54	9	174	19	1.89	1.26	1.38	0.23	0.59	4.4
56	650	32	10	129	5900	1.35	0.82	1.25	0.19	0.17	2.8
57	126	10	9	21	141	0.08	0.19	2.9	0.24	0.18	2.1
58	200	22	11	16	1980	0.76	0.40	1.73	0.19	0.35	3.5
59	36	27	8	15	103	1.07	0.36	2.5	0.26	0.18	3.1
60	320	27	8	115	27	0.96	0.45	1.96	0.20	0.24	
61	49	57	5	16	540	2.2	0.35	1.76	0.13	0.18	2.1
62	184	26	19	33	4600	1.63	1.04	4.1	0.24	0.39	4.8
63	330	26	11	27	17	1.29	0.31	4.2	0.31	0.28	4.1
64	40	31	7	21	52	1.37	1.16	4.1	0.31	0.26	4.1
66	49	49	9	59	75	2.4	0.68	2.5	0.23	0.20	
67	550	55	7	86	670	2.3	0.55	1.18	0.13	0.18	1.9
68	58	19	9	39	2600	0.87	0.27	1.42	0.19	0.21	
69	71	29	9	101	5500	4.3	1.47	1.34	0.74	0.34	2.8
70	48	39	4	31	670	1.66	0.59	2.2	0.67	0.37	5.0
71	30	26	10	76	10900	4.1	1.1	1.1	0.61	0.38	3.1
72	129	63	12	105	2300	2.2	0.70	3.4	0.54	0.28	3.2
73	26	19	18	19	8	2.1	0.39	3.1	0.45	0.32	
74	31	40	11	34	33	1.7	0.43	3.3	0.53	0.25	4.9
75	11	65	14	20	117	2.6	0.38	3.1	0.17	0.30	2.5
76	32	72	26	22	102	1.99	0.46	5.0	0.49	0.38	
77	26	54	8	18	29	2.5	0.32	2.2	0.21	0.21	3.1
78	98	36	6	20	24	2.2	0.40	1.66	0.30	0.20	4.3
79	67	25	9	69	151	2.8	0.62	3.4	0.65	0.34	4.2
80	69	25	12	95	136	2.5	1.19	3.4	0.68	0.47	4.3
81	31	6	2	25	990	0.74	0.18	3.1	0.37	0.76	

Appendix 11

Carotenoid levels in a sub-sample of leaf samples collected on Guadalcanal, Solomon Islands in June 2012

			Carotenoid (mg/kg DW)	
Sample no.	**Name**	**lutein**	**b-carotene**	**a-carotene**
1	Lettuce	359	134	0
2	Aibika	645	249	14
3	Cassava	563	233	5
4	Guava	175	68	17
5	Boneo	773	289	32
6	Sweetpotato	443	189	4
7	Sweetpotato	562	254	8
8	Ofenga	401	130	39
13	Sweet basil	587	274	0
14	Aibika	1024	356	38
16	King tree	737	116	122
17	Okra	693	315	4
18	Ginger	761	212	109
20	Chilli	829	340	32
27	Aibika	987	359	23
28	Pumpkin tips	869	267	22
29	Pigeon pea	572	277	6
30	Watercress	499	118	0
32	Drumstick	773	427	0
33	Sandpaper kabis	554	57	159
34	Curry tree	525	216	30
36	Ete	156	62	18
37	Cassava	383	245	0
39	Ete	447	90	69

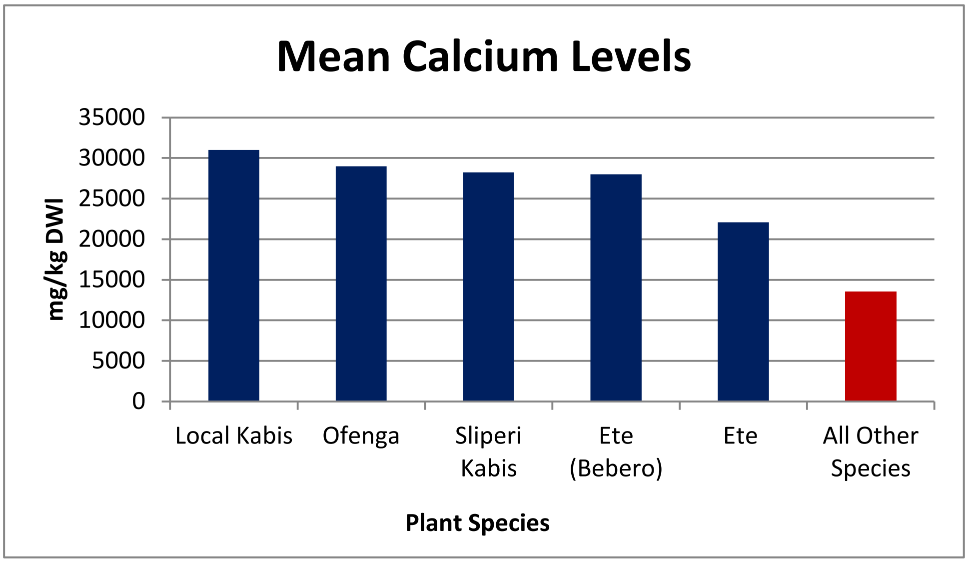
40	Cassava	237	105	1
42	Pure	713	203	95
43	Kaihalo	767	240	18
44	Kaipoto fern	246	19	11
45	Kaibohore fern	681	107	17
47	Cl. swamp fern	322	48	8
48	Taro	437	177	0
49	Butterfly tree	296	72	18
50	Savuli	225	97	8
53	Sweetpotato	534	173	3
57	Creek fern	219	37	11
59	Breadfruit	112	104	24
61	Sandpaper kabis	299	80	32
62	Ete	233	66	29
63	Taro	364	148	10
64	Alternanthera	588	212	0
67	Ceylon spinach	169	73	21
68	Aruba	238	84	5
72	Loretta	453	125	5
73	Egg plant	510	223	0
74	Pumpkin tips	905	276	11
78	Yardlong bean	810	285	7
79	Aibika (sun)	511	173	11
80	Aibika (shade)	850	288	20
81	Engl. cabbage	5	2	0

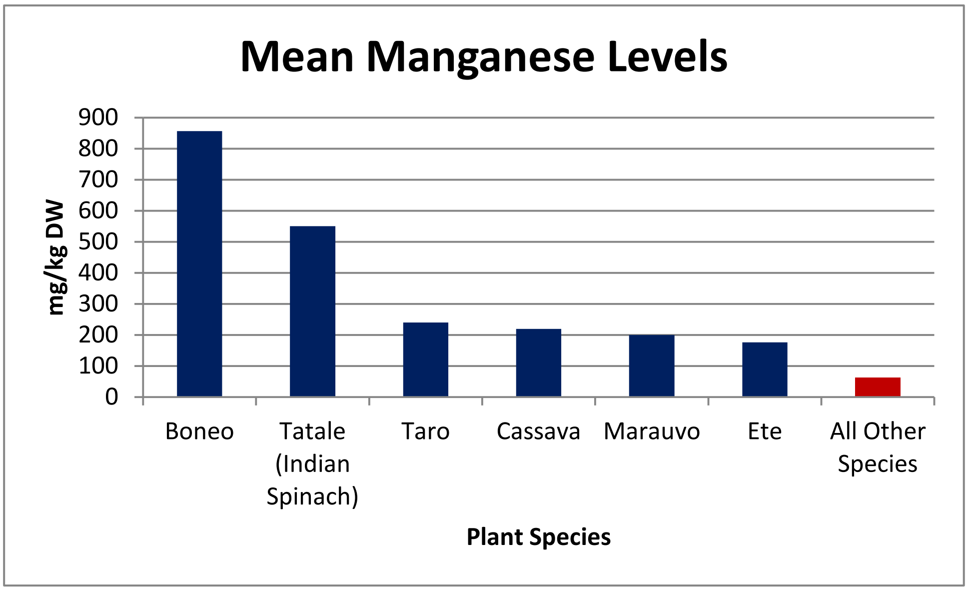
Note: The lutein form reported here is the sum of trans lutein and 3’-epi lutein (HPLC peak 446nm), which constitute the bulk of biologically active lutein

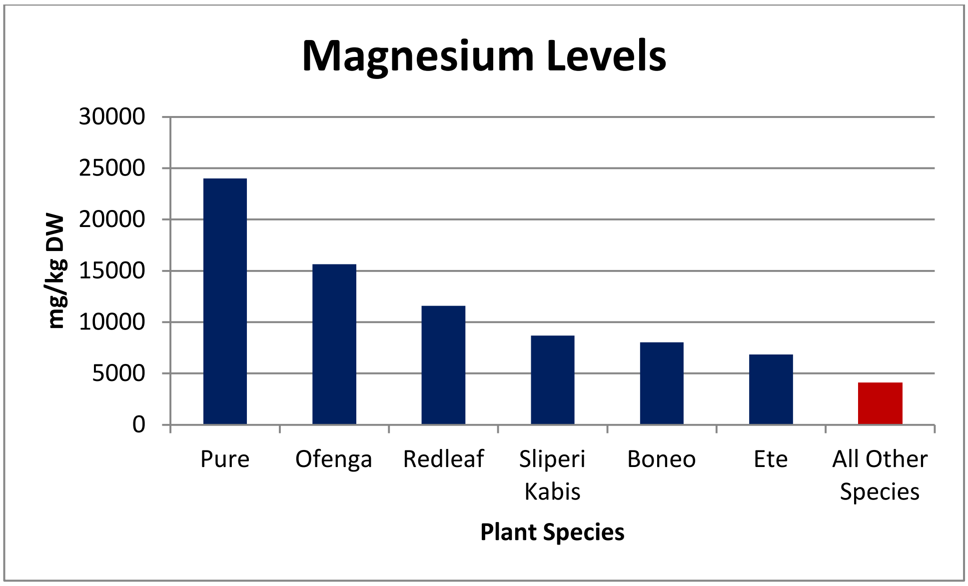
b-carotene analysed peak 451nm; a-carotene 446nm.

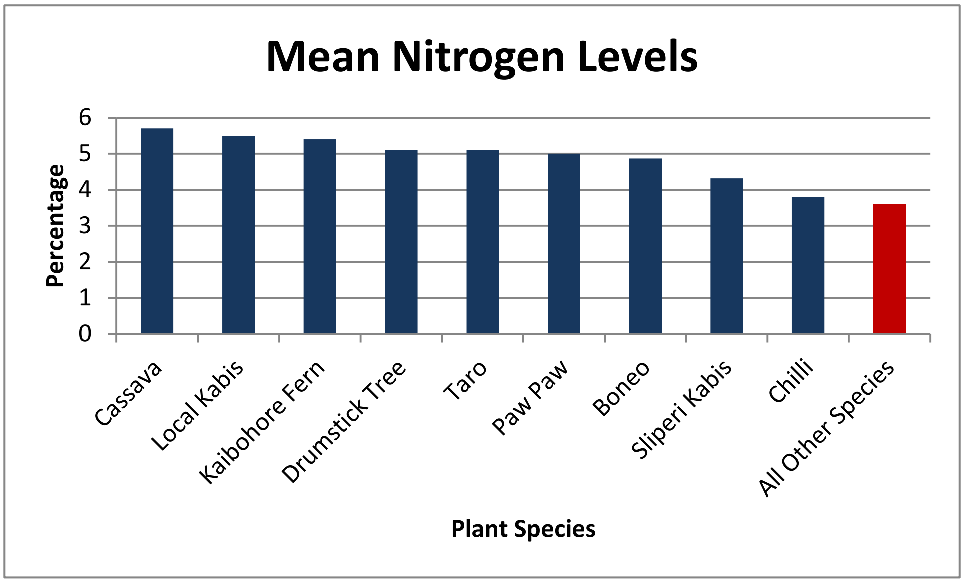
Appendix 12

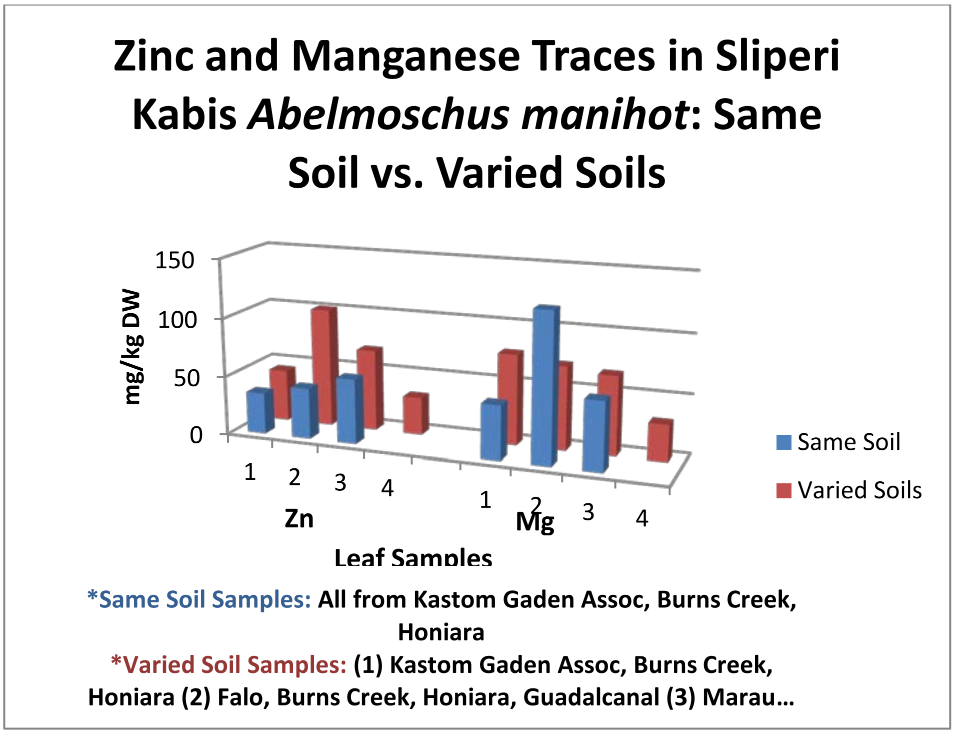
Graphs prepared by Alicea Garcia, University of Adelaide from mineral nutrient data from leaf samples collected on Guadalcanal, Solomon Islands in June 2012

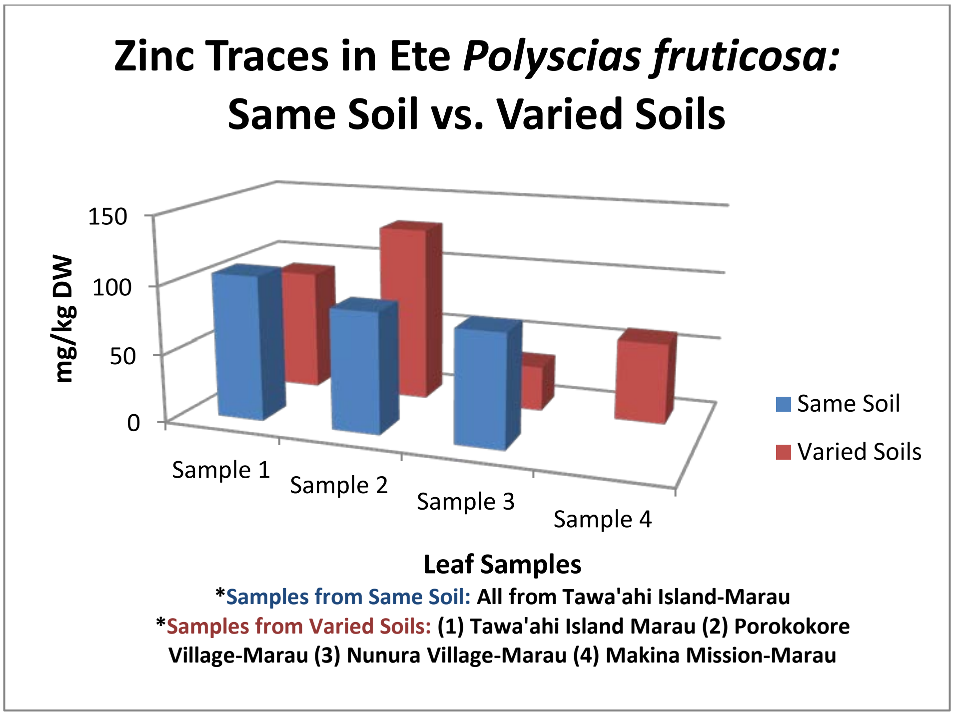





Magnesium Levels
mg/kg DW
30000
25000
20000
15000
10000
5000
0
Pure
Ofenga
Redleaf
Sliperi Kabis
Boneo
Ete
All Other Species
Plant Species


Mean Nitrogen Levels
Percentage
6
5
4
3
2
1
0
Cassava
Local Kabis
Kaibohore Fern
Drumstick Tree
Taro
Paw Paw
Boneo
Sliperi Kabis
Chilli
All Other Species
Plant Species


Zinc and Manganese Traces in Sliperi Kabis *Abelmoschus manihot*: Same Soil vs. Varied Soils
150
100
50
0
mg/kg DW
1
2
3
4
Zn
1
2
Mg
3
4
Leaf Samples
Same Soil
Varied Soils
*Same Soil Samples: All from Kastom Gaden Assoc, Burns Creek, Honiara
*Varied Soil Samples: (1) Kastom Gaden Assoc, Burns Creek, Honiara (2) Falo, Burns Creek, Honiara, Guadalcanal (3) Marau...


Zinc Traces in Ete *Polyscias fruticosa:* Same Soil vs. Varied Soils
150
100
50
0
mg/kg DW
Sample 1
Sample 2
Sample 3
Sample 4
Leaf Samples
Same Soil
Varied Soils
*Samples from Same Soil: All from Tawa'ahi Island-Marau
*Samples from Varied Soils: (1) Tawa'ahi Island Marau (2) Porokokore Village-Marau (3) Nunura Village-Marau (4) Makina Mission-Marau

Appendix 13

Nisotra prefer sunny Aibika

by Graham Lyons

It is well known that the popular tropical leafy vegetable *Abelmoschus manihot* (Aibika, sliperi kabis, bele) is susceptible to insect attack. In addition it is often observed that Aibika growing in full sunlight can be heavily infested with *Nisotra* beetles (the “Aibika flea beetle”) while plants of the same variety growing nearby on the same soil but in the shade are insect-free. Researchers have found that previously shaded, insect-free Aibika plants, when transferred to a sunlit position, remain insect-free for around two days.

What could explain this phenomenon?

It is known that ultraviolet (UV) radiation affects the chemical composition of plants, beyond increasing carbohydrate (CHO) reserves, some of which are in the form of sugars.

As part of ACIAR-funded research programs in Solomon Islands, Aibika leaf samples were collected in July 2012 at Aruligo, West Guadalcanal by Pita Tikai and Graham Lyons from sunny/shaded situations around 10 metres apart. The leaves were dried in a microwave oven (which preserves carotenoids better than a standard drying oven). Mineral nutrients were analysed using inductively coupled plasma optical emission spectrometry, nitrogen by Elementar oxidative combustion, and carotenoids by high performance liquid chromatography.

Table 1. Concentrations of selected minerals and carotenoids in Aibika leaves from plants grown near to each other either in full sunlight or shade at Aruligo, Solomon Islands

	Minerals (mg/kg dry wt)						Carotenoids (mg/kg dry wt)		
	K	**Zn**	**Mg**	**S**	**Cu**		**lutein**	**alpha-carotene**	**beta-carotene**
Sun	34000	69	6200	3400	9		511	11	173
Shade	34000	95	11900	4700	12		850	20	288
Change in shade (%)	0	+38	+92	+38	+33		+66	+82	+66

Most minerals (K, Mn, B, Mo, Co, Ni, Ca, Na, P) were the same in the sunny and shaded samples, illustrated by K in Table 1. There was some Al, Ti and Fe contamination as is usually the case with leaf samples (from soil and dust), making the Fe data unreliable. Nitrogen (and hence protein) was also unaffected by solar radiation in this study, unlike some previous studies which found that N level increased with increasing UV exposure. Four mineral nutrients and all three of the carotenoids analysed were higher in the shaded plants. Of course, this is just an opportunistic, exploratory study with unreplicated samples, but nevertheless the results are intriguing.

Sugars/starch were not analysed, but it would be expected that the sunny plants would have higher levels due to increased photosynthesis, and this alone could explain their attractiveness to insects. However, the differential decrease in specific minerals and the overall decrease in carotenoids suggest an explanation in addition to increased CHO, for example the insects may prefer relatively low levels of Mg, S, Zn, Cu and carotenoids, but this is unlikely: none of the shaded plant concentrations are unusually high or close to being toxic. More probable is that the UV radiation is increasing the concentration of one or more phytochemicals (perhaps flavonoids, which accumulate in epidermal cells as a protection against excessive UV radiation) which are attractive to insects, especially *Nisotra* beetles. This counter-adaptive effect suggests that *Nisotra* may be a relatively recent pest of Aibika: there has been insufficient time for the plants to develop effective resistance to this pest. Brassicas such as mustard and watercress increase levels of glucosinolates and myrosinases upon UV exposure, which strengthen the plants' defence systems against both UV radiation and herbivorous predators…but this is clearly not happening with Aibika and *Nisotra.* Samples have been sent to a biochemist in South Africa for flavonoid, etc analyses. Results just received: total phenolics were analysed (units are mg/g GE equivalent): the samples were similar using ethanol extract: 14.3 sunny, 16.0 shaded, but with the aqueous extract the sunny plants were higher: 11.3 v 4.6, the opposite finding for the minerals and carotenoids above. In keeping with the concluding line of most scientific studies, *further research is warranted.*

Appendix 14

Selected mineral nutrients in leaf samples collected in September 2012 on Thursday and Horn Islands, Torres Strait, Australia

No.	Name	Loc.	Mn mg/kg	Cu mg/kg	Zn mg/kg	Ca %	Mg %	Na %	K %	P %	S %	N %
1	Noni *Morinda citrifolia*	1	110	5	33	1.04	0.3	0.1	2.4	0.27	0.28	3.0
2	Taro *Colocasia esculenta*	1	50	9	32	1.68	0.36	0.01	3.1	0.32	0.27	4.3
3	Sweetpotato *Ipomoea batatas*	1	40	10	18	0.71	0.4	0.04	2.9	0.33	0.3	3.5
4	Lemon grass *Cymbopogon citratus*	1	19	7	24	0.4	0.18	0.02	2.4	0.28	0.1	
5	Chilli *Capsicum frutescens*	1	106	8	54	0.44	0.26	0.04	2.9	0.19	0.29	2.9
6	Chilli	1	29	14	105	1.04	0.47	0.06	3.3	0.51	0.34	
7	Hibiscus *Hibiscus rosa-sinensis*	1	128	9	74	0.99	0.34	0.33	1.29	0.34	0.22	2.0
8	Sandpaper fig *Ficus spp.*	1	36	5	58	2.0	0.25	0.23	1.33	0.09	0.16	2.0
9	Pawpaw *Carica papaya*	1	24	3	35	0.41	0.37	0.04	3.2	0.51	0.57	4.6
10	Lemon *Citrus x Meyer*	1	21	2	21	1.14	0.38	0.03	1.87	0.19	0.2	
11	Curry leaf *Murraya koenigi*	2	42	11	42	1.2	0.28	0.05	3.5	0.34	0.23	3.2
12	Aibika *Abelmoschus manihot*	3	240	6	83	3.0	0.93	0.12	2.5	0.43	0.34	3.4
13	Drumstick	4	46	6	73	1.89	0.42	0.77	1.2	0.23	0.73	4.1

	Moringa oleifera											
14	Tamarind *Tamarindus indica*	5	32	7	60	2.8	0.85	0.97	0.36	0.1	0.13	1.5
15	Sandpaper fig	6	32	4	26	1.67	0.61	0.25	2.5	0.24	0.23	2.4
16	Pumpkin *Cucurbita moschata*	7	41	10	66	1.36	0.76	0.07	3.3	0.69	0.35	
17	Pumpkin	7	91	9	42	4.1	1.71	0.11	1.89	0.32	0.3	4.9
18	Pumpkin	7	82	11	59	2.5	1.27	0.08	2.7	0.43	0.33	
19	Pumpkin	7	54	13	79	0.89	0.54	0.02	3.4	0.78	0.38	
20	Cassava *Manihot esculenta*	8	101	7	260	1.11	0.45	0.03	1.19	0.24	0.28	3.3
21	Pumpkin	8	34	22	62	0.87	0.43	0.02	3.6	1.11	0.33	7.0
22	Celery-leaf aralia *Polyscias balfouriana*	9	176	4	82	1.84	0.37	0.06	1.79	0.09	0.12	1.2
23	Celery-leaf aralia	9	200	6	65	1.43	0.4	0.07	3.2	0.18	0.16	
24	Banana (bell) *Musa spp. x Ducasse*	9	58	7	42	0.35	0.25	0.00	5.3	0.53	0.26	2.9
25	Cassava	9	66	9	111	1.0	0.32	0.02	1.49	0.28	0.26	
26	Centro *Centrosema pubescens*	9	62	14	35	0.87	0.21	0.05	2.4	0.28	0.27	
27	Pawpaw	10	34	4	23	0.55	0.45	0.16	3.2	0.44	0.38	3.7
28	Lemon grass	11	44	3	68	0.18	0.1	0.0	1.15	0.21	0.05	0.6
29	Lemon grass	11	27	4	43	0.54	0.2	0.04	2.0	0.17	0.07	
30	Sweetpotato	11	46	10	63	1.29	0.32	0.06	2.2	0.30	0.26	
31	Bush basil *Ocimum spp.*	11	34	10	198	3.9	0.37	0.03	1.35	0.35	0.18	
32	Lemon grass	12	17	2	35	0.22	0.10	0.0	2.6	0.32	0.06	0.7

33	Bok choi *Brassica spp.*	12	35	3	35	2.7	0.62	0.13	5.7	0.70	0.80	6.5
34	Cassava	14	61	7	59	0.69	0.42	0.03	0.90	0.24	0.25	3.6
35	Curly-leaf spinach *Alternanthera sissoo*	15	178	6	66	1.35	0.72	0.12	6.2	0.29	0.24	3.6
36	Galangal (ginger) *Alpinia galanga*	15	620	6	12	0.44	0.22	0.11	1.33	0.08	0.19	
37	Cocoyam (Singapore taro) *Xanthosoma spp.*	15	112	8	53	0.89	0.28	0.24	3.0	0.31	0.29	4.1
38	Cassava	15	210	8	79	0.77	0.41	0.05	1.24	0.26	0.26	4.2
39	Noni	15	181	6	36	2.0	0.26	0.68	1.22	0.10	0.37	3.0
40	Siratro *Macroptilium atropurpureum*	14	97	6	25	1.09	0.44	0.05	1.07	0.15	0.17	3.4
41	Centro	14	330	15	47	1.1	0.38	0.04	0.96	0.23	0.29	4.0
42	Sweetleaf *Sauropus androgynus*	13	199	9	2100*	2.8	0.83	0.04	1.69	0.48	0.50	3.7
43	Pawpaw	13	12	8	29	1.18	0.62	0.04	2.2	0.39	0.38	4.5
44	Mulberry *Morus alba*	13	31	6	132	1.6	0.25	0.02	2.0	0.23	0.19	3.5

*The high Zn (and also cadmium and lead levels) were due to this plant growing next to a weathered, galvanised chain-mesh fence behind the fire station.

Location key:

Thursday Island

1: Near fire station

2: Aplin, north side of island

3: Township

4: Chester St

5: Memorial Park

6: Douglas St

7: Cook Esplanade

8: Blackall & John St intersection

9: TAFE workshop

10: Hastings St

11: John St

12: IBIS supermarket, Douglas St

13: Fire station

Horn Island

14: Near jetty

15: Primary School

Appendix 15

Selected mineral nutrients in leaf samples collected on Roger Goebel's farm near Mourilyan, south of Cairns, Queensland in September 2012

No.	Name	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Ca %	Mg %	K %	P %	S %	N %
1	Parsley	210	69	8	85	1.31	0.34	5.0	0.64	0.44	2.3
2	Breadfruit	47	21	7	21	0.81	0.30	2.1	0.27	0.18	2.6
3	Brazilian spinach	176	42	10	189	0.97	0.54	7.0	0.65	0.25	4.0
4	Mint	109	25	13	104	1.02	0.35	3.7	0.42	0.32	3.8
5	Pumpkin	79	22	17	72	0.88	0.55	4.4	0.95	0.25	5.1
6	Choko	108	22	17	90	0.57	0.31	4.4	1.01	0.30	5.9
7	Balsam pear	71	19	10	82	0.61	0.39	4.4	0.74	0.27	4.4
8	Cassava	470	19	7	65	0.77	0.20	1.53	0.32	0.26	4.1
9	Malabar spinach	300	13	7	53	0.71	0.87	3.1	0.32	0.18	2.3
10	Tannia	159	13	7	51	0.79	0.24	3.6	0.37	0.22	3.4
11	Taro	130	18	7	40	1.03	0.26	4.4	0.46	0.23	3.6
12	Kangkong	490	25	10	33	0.54	0.32	4.3	0.53	0.32	4.0`` ````

Appendix 16

Selected mineral nutrients in leaf samples collected by Mary Taylor in Samoa in December 2012. See below for sample key.

No.	Name	Mn mg/kg	Cu mg/kg	Zn mg/kg	Na mg/kg	Ca %	Mg %	K %	P %	S %	N %
1	Pele 1	38	7	121	135	4.1	0.74	2.0	0.45	0.43	3.5
2	Pele 2	105	10	82	1230	1.74	0.97	2.1	0.25	0.25	4.4
3	Pele 3	40	8	91	1770	2.7	0.80	2.7	0.61	0.31	3.1
4	Pele 4	31	10	88	1230	2.3	0.85	3.4	0.37	0.39	4.6
5	Pele 4	162	9	121	4200	2.4	2.0	0.74	0.30	0.26	3.8
6	Pumpkin	30	16	108	65	0.48	0.39	3.0	1.07	0.34	6.1
7	Sweet potato 1	150	13	18	2100	1.01	0.86	2.4	0.27	0.30	4.5
8	Sweet potato 2	53	15	27	120	0.55	0.48	2.5	0.37	0.28	3.6
9	Kangkong	93	16	17	10500	0.55	0.35	2.4	0.29	0.29	4.3
10	Amaranth	32	13	104	520	2.9	1.82	3.1	0.61	0.47	5.4
11	Cassava	60	8	67	29	0.90	0.49	1.29	0.35	0.28	4.8
12	Cassava	58	6	35	66	1.5	0.31	2.5	0.26	0.27	4.9
13	Curry	18	8	20	169	2.3	0.64	1.19	0.17	0.17	3.1
14	Lauti vao	46	6	49	104	1.44	0.17	1.87	0.27	0.22	2.0
15	Lemon grass	11	4	17	37	0.33	0.29	1.25	0.14	0.08	1.1
16	Mentha	33	18	57	68	0.81	0.43	4.3	0.29	0.29	3.7
17	Pele 2	121	9	250	2500	2.1	1.02	1.54	0.37	0.37	4.2
18	Lauti ula	115	6	71	390	1.22	0.33	1.67	0.24	0.30	2.1
19	Chilli	42	15	35	230	0.75	0.78	4.8	0.34	0.54	5.1
20	Guava	67	20	17	135	0.82	0.58	0.61	0.18	0.26	1.9
21	Lemon	11	6	18	530	1.46	0.30	2.0	0.2	0.24	3.0
22	Ginger	230	10	49	32	0.38	0.54	3.7	0.34	0.27	3.3
23	Amaranth	58	10	64	700	1.55	1.88	4.5	0.64	0.44	5.3
24	Sweet	75	11	23	1800	0.55	0.46	1.59	0.36	0.32	4.6

	potato 3										
25	Indian pennywort	125	10	240	3500	1.6	0.66	3.3	0.39	0.60	2.3
26	Winged bean	47	10	34	120	1.04	0.20	1.8	0.29	0.23	4.1
27	Ceylon spinach	70	8	41	2100	2.6	1.55	2.2	0.27	0.33	4.1
28	Samoan sage	74	15	154	500	3.6	1.05	1.85	0.79	0.11	1.9
29	Ivy gourd	81	7	30	194	9.7	1.13	1.62	0.33	1.0	3.6
30	Drumstick	40	6	20	520	3.0	0.43	1.39	0.28	1.16	4.0
31	Drumstick	28	10	44	175	1.51	0.45	1.86	0.72	1.39	3.4

Samoa leaf samples key

All samples were collected by Mary Taylor on Upolu, Samoa in December 2012

Sample no.	Local name	Scientific and English names	Farmer/owner	Location
1	Laupele	*Abelmoschus manihot* Var 1	Ana Epati	Faleasiu
2	Laupele	Var 2	Apineru	Leulumoega-uta
3	Laupele	Var 3	Ana Epati	Faleasiu
4	Laupele	Var 4	Fiamu & Tevita Faletoese	Matautu, Lefaga
5	Laupele	Var 4	Apineru	Leulumoega-uta
6	Tumutumu maukeni	*Cucurbita pepo* Pumpkin	Apineru	Leulumoega-uta
7	Umala	*Ipomoea batatas* Sweetpotato Var 1	Apineru	Leulumoega-uta
8	Umala	Var 2	Lau Pepese	Lotofaga
9	Kapisi sosolo	*Ipomoea aquatica* Kang kong	Lau Pepese	Lotofaga
10		*Amaranthus* sp	Steve	Apia Park

			Hazelman	
11	Manioka	*Manihot esculenta* Cassava	Apineru	Leulumoega-uta
12	Manioka		Fiamu & Tevita Faletoese	Matautu, Lefaga
13	Kale	*Murraya koenigi* Curry leaf	Apineru	Leulumoega-uta
14	Lauti vao	*Cordyline* spp	Ana Epati	Faleasiu
15	Moegalu	*Cymbopogon citratus* Lemon grass	Apineru	Leulumoega-uta
16	Laufafa	*Mentha* spp	Sapela Simi	Saleilua
17	Laupele	*Abelmoschus manihot* Var 2	Solema Isamaeli	Tiavi
18	Lauti ula	*Cordyline* spp	Sapela Simi	Saleilua
19	Lau polo	*Capsicum frutescens* Chilli	Sapela Simi	Saleilua
20	Ku'ava	*Psidium* spp Guava	Sapela Simi	Saleilua
21	Lauti polo	*Citrus x limon* Lemon	Sapela Simi	Saleilua
22	Fiu	*Zingiber officinale* Ginger	Lau Pepese	Lotofaga
23		*Amaranthus* sp	Lau Pepese	Lotofaga
24	Umala	*Ipomoea batatas* Sweetpotato Var 3	Lau Pepese	Lotofaga
25	Togotogo	*Centella asiatica* Indian pennywort	Lau Pepese	Lotofaga
26	Pi lele	*Psophocarpus tetragonolobus* Winged bean	Christine Quested	Leififi
27	Pasele	*Basella alba* Ceylon spinach	Christine Quested	Leififi

28	Milikini	*Salvia* spp Samoan sage	Christine Quested	Leififi
29	Melo vau	*Coccinia grandis* Ivy gourd	Christine Quested	Leififi
30	Tamaligi aina	*Moringa oleifera* Drumstick	Roadside	Leififi
31	Tamaligi aina		Sogi preschool	Sogi

Appendix 17

Selected minerals from leaf samples of taro (5 cultivars suitable for export) collected from 5 trial sites on Upolu, Samoa in March 2013 by Mary Taylor

See below for sample key.

No.	Var.	Fe mg/kg	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Ca %	Mg %	K %	P %	S %	N %
32	4	83	80	17	18	53	0.89	0.35	3.8	0.66	0.36	6.1
33	2	75	74	19	17	42	0.99	0.42	2.9	0.54	0.35	5.1
34	1	58	186	24	11	17	1.35	0.37	2.7	0.52	0.28	3.4
35	5	83	101	20	20	53	0.98	0.38	3.5	0.59	0.34	5.9
36	3	67	71	21	16	36	1.02	0.36	3.0	0.51	0.29	4.9
37	5	51	60	22	14	23	1.22	0.46	1.84	0.44	0.27	4.1
38	4	73	84	20	24	48	0.86	0.52	2.8	0.60	0.32	5.2
39	3	73	113	25	18	33	0.84	0.49	2.8	0.45	0.28	4.4
40	1	56	57	21	18	24	1.5	0.48	2.7	0.49	0.27	3.5
41	2	74	74	19	27	51	0.81	0.44	3.1	0.65	0.38	5.1
42	3	63	58	23	15	28	1.25	0.36	2.2	0.35	0.26	4.7
43	1	70	67	23	20	34	1.49	0.37	2.5	0.38	0.26	4.5
44	2	52	47	22	14	27	1.13	0.30	3.3	0.47	0.29	4.0
45	2	85	58	21	21	42	0.98	0.35	4.0	0.67	0.39	5.2
46	1	52	111	26	15	22	1.41	0.43	3.3	0.41	0.27	4.1
47	3	50	90	23	14	21	1.38	0.52	1.43	0.39	0.27	4.1
48	1	57	54	23	15	20	1.93	0.31	3.3	0.42	0.25	3.4
49	2	59	56	22	21	32	0.96	0.34	3.4	0.58	0.30	4.3

Nickel was relatively high in this sample, ranging from 1ppm (sample 47) to 14ppm (sample 38). **Sodium** was low, with only two samples having higher than 1ppm (sample 38 (4ppm) and sample 47 (3ppm).

Samoa taro leaf samples key

Sample no.	Cultivar	Location	Soil type
32	4	Lalonea, Upolu	Clay loam, light brown; some signs of nutrient deficiency
33	2	Lalonea, Upolu	Clay loam, light brown, some signs of deficiency
34	1	Lalonea, Upolu	Clay loam, light brown, some signs of deficiency
35	5	Lalonea, Upolu	Clay loam, light brown, some signs of deficiency
36	3	Lalonea, Upolu	Clay loam, light brown, some signs of deficiency
37	5	Tanumalala, Upolu	Clay loam, dark brown, same deficiency as above
38	4	Tanumalala, Upolu	Clay loam, dark brown, same deficiency as above
39	3	Tanumalala, Upolu	Clay loam, dark brown, same deficiency as above
40	1	Tanumalala, Upolu	Clay loam, dark brown, same deficiency as above
41	2	Tanumalala, Upolu	Clay loam, dark brown, same deficiency as above
42	3	Lefaga, Upolu	Sandy loam, rich in humus, similar but less deficiency than previous samples
43	1	Lefaga, Upolu	Sandy loam, rich in humus, similar but less deficiency than previous samples
44	2	Lefaga, Upolu	Sandy loam, rich in humus, similar but less deficiency than previous samples
45	2	Lotofaga, Upolu	Sandy loam soil; slightly chlorotic-looking leaves
46	1	Lotofaga, Upolu	Sandy loam soil; slightly chlorotic-looking leaves
47	3	Lotofaga, Upolu	Sandy loam soil; slightly chlorotic-looking leaves
48	1	Saleilua, Upolu	Sandy loam soil; slightly chlorotic-looking leaves
49	2	Saleilua, Upolu	Sandy loam soil; slightly chlorotic-looking leaves