



**VALUE ADDING AND SUPPLY CHAIN DEVELOPMENT FOR FISHERIES AND
AQUACULTURE PRODUCTS IN FIJI, SAMOA AND TONGA**

Scoping study for *Caulerpa* (Sea Grapes)



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**Value adding and supply chain development for fisheries and aquaculture products in Fiji,
Samoa and Tonga: Scoping study for *Caulerpa* (Sea grapes)**

Institute of Marine Resources
School of Marine Studies
Faculty of Science, Technology and Environment
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INTRODUCTION

Sea grapes (*Caulerpa* species. Chlorophyta) are widely consumed in the Pacific as a salad and as an addition to many dishes. The traditional harvesting and consumption of sea grapes in the Pacific may well have had their origins among the South East Asian peoples who migrated to and colonized the Pacific Islands 3-4,000 years ago (McHugh, 2003). According to Horstmann (1983), who described the cultivation and marketing of *Caulerpa racemosa* var. *occidentalis* in the Philippines, “seagrapes are cultivated in artificial ponds in the intertidal mangrove zone, where they show good tolerance of a range of variable conditions. However, in extreme conditions, the plants are unlikely to survive. In the Philippines, *C. racemosa* can be kept fresh for up to 7 days if the shoots are kept wet, and chilled. After harvesting, the shoots are washed in seawater and then placed in 100 – 200 g packages. When air freighting (e.g. to the market in Metro Manila) the shoots are packed in baskets lined with banana leaves (20-30 kg per basket), covered with more banana leaves and then placed in a plastic sack”. In Thailand *C. racemosa* is common in the Phuket market, where 10-20 kg per day is sold for use in the making of spicy sauces (<http://www.botany.uwc.ac.za/algae/studentassignments/natalieprins97/caulerpa.htm>).

Sea grapes are consumed throughout the region by Melanesian, Micronesian and Polynesian peoples. It is not, however, a preferred food item in Hawaii, where other edible seaweeds are consumed (Abbott & Williamson, 1974). The Fijian name most commonly used is *nama* (South 1993a-c), the Samoan is *limu fuafua* and the Tongan name is *tangau* or *limu fuafua*. In Fiji, Samoa and Tonga, with some local exceptions, *C. racemosa* (Forsskål) J. Agardh var. *uvifera* (Turner) J. Agardh (1873: 35), as illustrated in Meñez & Calumpong (1982), is the most commonly harvested variety.

Post-harvest treatment of sea grapes in the Pacific is primarily focused on how the plants are stored after harvesting. Plants are either retained in sacks away from the light and from any influence of freshwater or soaked in seawater. This method keeps them fresh for several days, in keeping with the harvesting, transportation and marketing system.

The perishable nature of *C. racemosa* restricts it to domestic trade and consumption in the Pacific Island countries. Shelf life of *C. racemosa* can be improved by preservation in brine, and some preliminary trials have been conducted at the University of the South Pacific's Post Harvest Facility (Lako, *pers com.* 2011). When bottled in weak (10%) brine, following treatment to reduce bacterial numbers, shoots have lasted for 3-4 months. For *C. racemosa* preserved shoots have higher fibrosity than fresh ones, and this could reduce their value to consumers. Brine has also been used successfully with cultivated *C. lentillifera* for shipment to Japan and Denmark from the Philippines (Trono, 1988). According to Chamberlain (1997) the Japanese seaweed company Horichi Co. Ltd. in Fukuoka, in collaboration with H. Tanaka, previously the FAO's Chief Technical Advisor to the FAO's South Pacific Aquaculture Development Project, has a patent pending that does not use chemical dips, but that works by restricting the chemical messenger system that causes shrinkage of the thalli, possibly by using a plant hormone such as metilen chloride to dissolve steroid receptor cells.

The purpose of this scoping study is to describe the status of *C. racemosa* in Fiji, Samoa and Tonga.

STATUS OF CAULERPA FISHERY

In the tropical Pacific there are more than thirty species and many of them have a pan-tropical distribution, although others have a more restricted distribution. Plants grow from the reef crest to the shallow back reef and lagoon, or into water up to 30m deep. Often the stolons (runners) ramify amongst the corals, or are attached to coral rubble, sand or mud. Some species are very tolerant of high wave-energy habitats, others prefer more sheltered conditions. Generally plants prefer a fully saline environment, although some may tolerate reduced or fluctuating salinity habitats. Plants may occur isolated or in sparse clusters, or else may form extensive beds, possibly originating from the same parent plant. These beds provide a sand-binding function (South, G.R. 1993b).

FIJI

It was observed during this study that some seasonal aspects were noted, in part due to weather variability. Cyclonic conditions temporarily decimate *nama* populations but the cryptic nature of the stolons (runners) allows the rapid regeneration of new thalli or uprights.

The popularity of *nama* in Fiji continues to grow, as shown in Suva market surveys reported in Pickering and Mario (1999) and in this study. Peak quantities were harvested in July – August in 1993, and again in December – January 1994, although Pickering & Mario (1999) indicated that there is no real seasonality in the harvesting levels. The quantities may represent opportunistic harvesting of *nama* compared with the relative availability of other edible seaweeds such as *Hypnea (lumicevata)* and *Gracilaria (lumiwawa)* which are certainly more seasonal in occurrence. Some losses occurred along the supply chain from harvest to sale mainly due to handling and storage.

Harvesting

Harvesting is mainly carried out by women, often assisted by their children and sometimes by their partner or other male relatives. In Fiji, harvesting is usually carried between Monday and Wednesday, so that there is sufficient time for the seagrapes to reach the markets for sale later in the week. Good harvesting sites are protected by the women, and seem to have been harvested for many generations (South, 1993b). Harvesting is a family activity that follows a regular pattern. In some sites, only the uprights are harvested and in others, the runners are harvested as well. The harvesting is not exclusively for *nama*, but is combined with reef gleaning for other species. The main harvesting sites on Viti Levu are in the Yasawa islands, Rakiraki and Tavua.

After harvest, the seagrapes are kept for up to 3 days in flour/potato sacks, in the shade and contact with freshwater must be avoided, as this resulted in a rapid deterioration of quality. The sacks are placed in coconut baskets for transportation to market by boat and/or bus on Wednesdays and Thursdays. While some families may act as vendors, for the most part the seaweeds are sold to middlemen (women) who organize their transport to the market, the main one being Suva. Seagrapes are sold on Fridays and Saturdays, and any leftovers are consumed by the vendors and their families.

Case Study of harvesting from Gunu Village, Naviti Island, Fiji (Chamberlain and Pickering, 1998).

“Approximately 40 women from Gunu village harvest *C. racemosa*. Traditionally only women harvest, however due to the commercial nature of the resource, husbands often assist with the harvesting. During school holidays children also assist and lunch is prepared and taken out to the harvesting site. On Mondays and Tuesdays of each week (weather permitting), *C. racemosa* is harvested from the sandy areas; on Wednesdays it is harvested from the reef. The reef is gleaned for 3 to 4 hours during low tide when the seaweed is most accessible. There is no particular season for harvesting *C. racemosa*. Variations in supply are attributed to other factors such as bad weather or inappropriate tide times that deter collection. Rain is the most important criterion for “bad weather” because fresh water decreases the salinity in the lagoon causing the *C. racemosa* to go soft and die soon after harvesting. The Lau women educated the people of Gunu on how to harvest *C. racemosa* sustainably. The *C. racemosa* stems (uprights) growing on the sand are picked individually. The *C. racemosa* growing on the coral is picked by the handful. The base of the stem is broken by pinching it with the fingers or by pulling at it and the stems are usually placed in a 50 kg sugar bag.

Marketing

In Fiji *nama* is sold in municipal markets in the main urban centers of Suva, Lautoka, Nadi Sigatoka, Labasa and Savusavu in heaps, at a price ranging from FJ2.00 - \$4.00 per heap. Each heap has a weight ranging from 250 – 500g. The seagrapes are displayed on woven coconut leaves, plastic plates or a variety of other materials, with a small plastic bag of fermented coconut and one or two chillies (Figure 1). The Suva vendors make considerable effort to keep the shoots fresh by putting out small amounts at a time for sale. In previous surveys (South, 1993a) it was noted that poor-quality *nama* (bleached or shriveled) was more prevalent in western Viti Levu than in Suva, where the buyers seem to be more discriminating. There are no data available on road-side sales of sea grapes in Fiji.



Figure 1: *Nama* on sale at Suva Market, with fermented coconut and chilli (Photo: J. Seeto)

Consumption

Nama is consumed as a salad and in Fiji, the most popular way to eat it is to wash in freshwater and drain it immediately before serving, place it in a small bowl, pour several spoonfuls of dilute fresh coconut cream (*miti*) containing finely-chopped onion, sprinkle some *kora* (which is essentially a coconut “cheese”) and add chopped fresh chilli. This is then served to accompany fish and a root crop like boiled taro or cassava (South & Pickering, 2006). Another popular way of preparing *nama* in Fiji includes marinating with lemon juice and then adding coconut cream (*lolo*) with some finely chopped chilli and canned fish, usually herring or pilchard (South, 1993a). Fijians view this preparation as a delicacy, and it is traditionally consumed on Sundays with the special meal served after church services.

Even though approximately half of the population in Fiji is comprised of Indo-Fijians (South, 1993b), the consumption of seaweeds is largely an indigenous Fijian activity. In Nadi, Tavua and Ba however, sea grapes are regularly purchased by Indo-Fijians. They are also purchased by other races in Fiji, including Chinese, Europeans and other Pacific Islanders.

Fiji fisheries database

Since sea grapes are included with other products, it is currently not possible to segregate these data in order to produce an overview of the harvest and market value on a national basis.

[Note: See (Morris and Bala, 2011) for more details on the supply chain of seagrapes in Fiji]

SAMOA

Seagrape uprights alone and uprights with runners are harvested in Upolu and Savaii. The *ofu limu* sold at the markets of Upolu and along the roadside were wrapped in breadfruit leaves. *Limu* is eaten raw as an accompaniment to the main meal, as a decorative feature in dishes and for the Sunday feast or *to'onai*. The consumers of *limu fuafua* are locals. Most of the product surveyed appeared healthy but there were some that looked wilted or light brown.

Harvesting (Savai'i Island)

Lano Village

One of the main harvesting sites for seagrapes (*limu fuafua*) is at the village of Lano along the northwest of Savaii island. Harvesters from the neighbouring villages of Asaga and Siufaga harvest *limu* almost on a daily basis.

Men usually carry out the harvesting, with occasional help from their wives, children or relatives. Canoes are used to get to the site which is about 300 m from the shore. Coverage of *Caulerpa* on the reef top was generally patchy with extensive coverage in some places. The harvest site was bisected by a reef opening with coverage on either side of the reef. The habitat was of a high energy reef with waves crashing at about 8-10 m from the sea grape meadow.

Vailoa, Palauli

The harvesters at Vailoa Palauli stated that the *limu* growing on the reef top is different from that harvested at Lano. According to them the runners and uprights are harvested and each has a different taste. The harvesters also mentioned that in April of each year the *limu* starts to die out, although some remain until October when it is in full bloom again and harvests are plentiful.

At any one harvest, an average of 16 *ofu limu* (baskets or containers of sea grapes) is harvested but special orders will usually require a bigger harvest of up to 20 *ofu*. In a good week or when there are special orders, one harvester said he could sell up to 70 *ofu* a week. The average weight of *ofu limu* harvested each day is estimated to be a little over 22 kg. Harvesters whose livelihood depends on *limu* sales is estimated to harvest up to 110 kg a week based on the average weight of *ofu limu* harvested per day (1.38 kg). Not all of the harvest is sold as some are given away or donated to neighbours (3-4 *ofu limu* a week) and some eaten by the family (1-2 *ofu limu* a week).

Salimu, Faga Village

A harvester from Siufaga harvests *limu* from the reef crest at *Salimu*, a neighbouring sub-village of Faga usually with the help of a family member. He uses his canoe to get to the harvest site. He usually harvests about 22 *ofu limu* at a time and puts them into an empty 20 kg rice sack to hold for transport back to shore. He harvests *limu* three times a week and takes about 30 minutes to fill the 20 kg sack. This site could not be accessed as the harvester was occupied with other family commitments during the survey.

Handling & Storage

After harvesting, the *limu fuafua* were kept inside sacks, coconut baskets, buckets or pots overnight for 6–8 hours prior to preparation for sale the following day. Water is drained from the storage vessel and the *limu* is rinsed in saltwater and allowed to drain. Once drained, the *limu* is scooped as heaps into breadfruit leaves before wrapping them in young coconut leaves and tied at the top to hold them upright. The harvested *limu* is generally stored overnight prior to sale the following day. Unsold *limu* is taken back home and rinsed in saltwater and kept in a storage vessel to drain. The following day new breadfruit leaves are used to wrap the *limu* for resale at the market.

According to the harvesters, the *limu* will stay fresh up to three days at the most after harvest. Conflicting reports from the harvesters with regards to the weight of the *limu* after 3 days, with most reporting no change, but one asserting there was a change. It is uncommon for the *limu* to be used after 3 days. If there are leftovers, which according to the harvesters are usually about 3 *ofu limu*, these are either consumed by the harvester's family or given to neighbours.

Marketing

Packaging of *limu* in Savaii was usually with breadfruit leaves and a then a layer of young coconut leaves known as "*lau o'o*"; other harvesters use *laugapā* leaves and tied with the stripped bark of beach hibiscus plant. These are the standard practice used for marketing the *limu* at the Savaii market or along the road-side (Figure 2).

The *limu* in Savaii is sold at a standard price of SAT\$ 5.00 per *ofu* (bundle) at the market and along the roadside. The survey noted a considerable weight difference of *ofu limu* among the Savaii vendors. According to the Fisheries Division staff, the Savaii *ofu limu* were heavier than those sold in Upolu. The weight range of *ofu limu* sold in Savaii was 1.1–1.6 kg, with an average of 1.38 kg. This is the weight of the *limu* without the leaf wrapping.

The transport of *limu* to the markets is usually by bus, and/or by boat if the orders are from Upolu. The cost associated with transport to Salelologa market by bus (return bus fare) ranges from SAT\$ 4–5.00. Some orders do come from caterers and hotels, but more often these buyers will buy directly from the harvesters in Savaii. A Lano harvester supplies orders for Upolu caterers and hoteliers usually up to 20 *ofu limu* at one time. These are taken by bus to Salelologa wharf by the harvester or a relative, and then by boat to Mulifanua Wharf in Upolu, and then by bus to Fugalei market and finally by taxi to its final destination. The costs associated with this is approximately SAT\$ 48.00. The price of *limu* according to the harvester from Lano remains the same at \$5.00 per *ofu limu* for Upolu orders.

Most of the *ofu limu* sold range from fresh to a few days old. Some harvesters admitted that they will keep the *ofu limu* and rinse with saltwater and change the breadfruit leaves each day. Despite the daily rinsing and new wrappings, some of the *ofu limu* looked old. According to the sellers they remove the bleached or light coloured *limu* as they do not look good and appeared 'wilted' which will put buyers off. There seems to be no clear pattern of seasonality of *limu fuafua* as production data suggests a year-round availability. However, prices seemed to increase at the end of the year coinciding with the festive season and New Year's celebrations (Figure 3; Tables 1 & 2).

Consumption

The *limu* is always eaten raw, and is never cooked by locals. It is used as an accompaniment or side dish to the main meal. It is also used for decorative purposes usually in the presentation of dishes. Some buyers are aware of the two different types of *limu fuafua* that are available. There is the variety harvested from Lano where only the uprights are plucked, and the variety from Vailoa, Palauli where the whole plant (the runners and uprights) is harvested. *Limu* is also commonly used as a decorative feature in hotel and restaurant dishes but the main consumers are the locals. It is also used as a main dish for the Sunday feast or *to'onai*.



Figure 2: A typical roadside stall selling *Limu* at Lano, Savaii, Samoa (Photo: M. Lober)

Samoa Fisheries database

- Production data are recorded by the Fisheries Division from vendors at the Fugalei (Upolu) and Salelologa (Savaii) markets and along the roadside, which is surveyed three times a week. The roadside surveys are carried out on Upolu Island only. The bulk of harvested production each year is sold at the Fugalei market followed by the Salelologa market and with the least sold at the roadside.
- Vendors are asked which village they are from, how much *limu* they are selling on the day and the price. The total production is estimated from a weighted average raised by a factor calculated regularly. **This average is currently under review following the results of the surveys carried out under this project.**
- *Limu* was harvested from a total of 47 villages on Upolu and Savaii islands from 2005 to 2010. On Upolu Island, 32 villages produced *limu* while the latter recorded 15 villages that harvested *limu*.
- Annual harvests for 2005 to 2010 [Tables 1 & 2] showed production was generally high during this period with the highest recorded in 2010 (9,753.25 kg). Smaller harvests in 2006 (6,071.13 kg) and 2009 (8,266.73 kg) were exceptions to the trend. The cause for the marked decrease in *limu* in 2006 is not known.
- Value of *limu* generally increased from SAT\$100,090.29 to \$134,241.46 in 2005 to 2010 (Table 2). The lowest value of *limu* in 2006 (SAT\$ 91,336.78) equated to smaller

harvests but this short-fall in supply led to an increased average price per kg (SAT\$15.04/ kg). This was a sharp increase from SAT\$ 10.46 / kg in 2005. A drop in price and production in 2006 and 2009 (SAT\$ 122,907.16; 8,266.73 kg) were the exceptions to the trend. Average prices dropped to SAT\$ 13.76 / kg in 2010.

- The five villages with the highest annual harvests recorded overall in descending order are Leauva’a, Satapuala, Mulifanua, Satuimalufilufi and Lalovi (Table 2). All villages are located on north to north-west Upolu where the widest expanse of lagoon up to 3 km occurs in Samoa at its widest point.
- Leauva’a consistently produced the highest harvests overall from 2005 to 2010 ranging from 2,776.65 to 5,065.68 kg per annum. The highest production for Leauva’a in 2005 (5065.58 kg) had an estimated value of SAT\$ 57,331.68 [Table 1]. The general trend however showed a decrease in harvests over the years with the lowest in 2008 (2,611.23 kg) followed by moderate increases into 2010 (3,004.55 kg). The value of Leauva’a *limu* showed a similar trend, decreasing from the high of 2005 (SAT\$ 57,331.68) to its lowest in 2008 (SAT\$ 41,850.25) and rising slowly in 2010 (SAT\$ 44,132.55).
- Satapuala the second highest producer harvested about half of what Leauva’a produced each year. The exception was 2007 with its highest recorded harvests in that period of 2,822.13 kg. Mulifanua has increased annual production over the five years with highest production in 2010 (2,452.19 kg). Satuimalufilufi and Lalovi has had erratic production since 2005 with highest production for the former in 2005 (1,242.28 kg) and the latter in 2008 (1,003.14 kg).
- Production from Savaii island was less in comparison to Upolu although the biggest producers are Asaga, Faga, Salelologa, Lano and Vailoa, Palauli during 2005 to 2010 [Table 2]. The first four villages are located on the north to north-west of Savaii Island while Vailoa-Palauli is towards the east. Unlike the villages in Upolu, those villages in Savaii do not produce consistently.
- Monthly production of *limu fuafua* showed no general trend or season. Availability of *limu* suggested by the data is year-round with outliers of exceptional monthly production during the year. These are believed to be associated with annual events such as annual church meetings, White Sunday, Mother’s and Father’s Days, Christmas and New years.

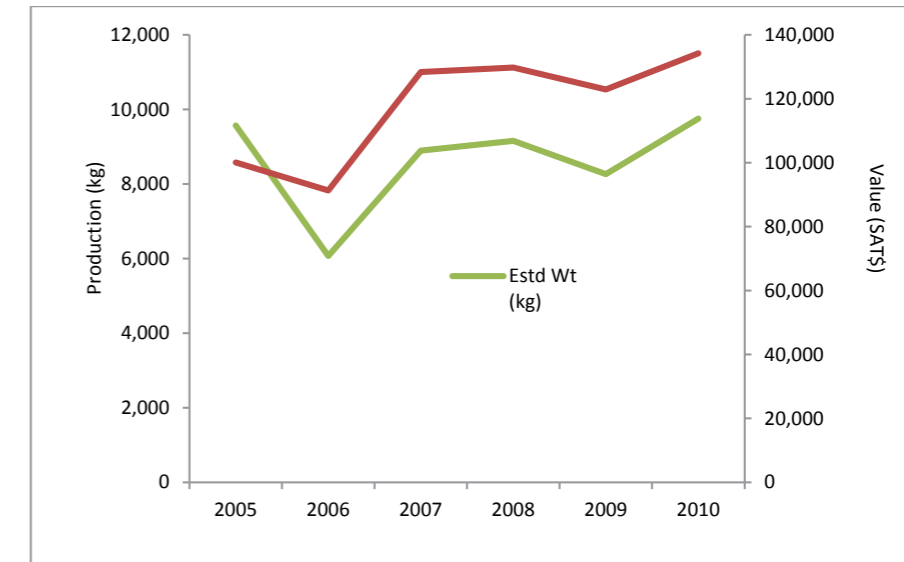


Figure 3: Value, production and average price of *limu fuafua* from 2005 to 2010

Table 1: *Limu* fuafua production (kg) from the top five villages on Savaii Island

Year	Asaga	Faga	Salelologa	Lano	Vailoa-Palauli
2005		277.05			
2006		96.05			
2007		382.30	425.57		
2008		447.30	243.75		447.30
2009	433.92	111.65		429.53	
2010	1,417.62			68.47	
Total	1,851.54	1,314.35	669.32	498	447.30

Table 2. *Limu fuofua* production (kg) and value (\$) by the top five villages in Upolu from 2005 to 2010

Year	Leauvaa		Satapuata		Mulifanua		Satuimaluilufi		Lalovi	
	Kg	\$	Kg	\$	Kg	\$	Kg	\$	Kg	\$
2005	5065.68	57,331.68	1936.89	20,741.85	264.72	2,134.04	1242.28	10,964.01	50.76	478.55
2006	3080.23	46,520.50	1424.33	21,848.51	384.70	5,918.46	907.31	13,852.95	55.09	847.59
2007	2951.76	43,999.79	2822.13	43,285.35	675.29	10,329.11	589.98	8,931.88	786.94	12,106.82
2008	2611.23	41,850.25	1379.64	21,531.75	1002.42	16,046.03	804.83	12,655.89	1003.14	16,039.14
2009	2776.65	43,656.24	913.77	14,215.35	1903.61	29,947.75	524.60	8,594.11	770.73	12,380.89
2010	3004.55	44,132.55	765.71	11,913.43	2452.19	37,698.27	639.21	9,615.20	933.15	14,264.45
Total	19490.1	\$277,491.0 ¹	9242.47	\$133,536.24	6682.93	\$102,073.66	4708.21	\$64,614.04	3599.81	\$56,117.44

TONGA

Seagrapes or *limu fuofua* (*Caulerpa* sp.) in Tongan is eaten by locals as a side dish or accompaniment to the main meal. It is harvested as a subsistence activity within communities and sold as a source of income. There are three families from the village of Patangata supplying the Nuku'alofa market on a daily basis (except Sunday). There is only one harvesting site which is the reef flat between 'Onevai and 'Onevao Island. The harvesters sell their own produce and there is no middleman involved. In Vava'u, two villages are involved in seagrape harvesting and sales; two families in Holeva Village and one family in Koloa Village. Unlike Nuku'alofa, sales are only done in the weekend, whereby the family from Koloa sell seagrapes on Fridays and Saturdays all year around, and the families from Holeva sell seagrapes on Saturdays but only for 6 months (during peak season) of the year. The harvesters sell their own produce and there are no middlemen involved. The Fisheries Department does not monitor the production of *limu fuofua*, however, they have done some grow-out trials in tanks (*Poasi Ngaluafe, pers. comm., April 2011*). Fisheries Department Staff will need to be formally engaged to carry out a more detailed survey of harvest sites around Tonga.

Harvesting

Nuku'alofa

The harvest site is about half an hour away from Patangata Village and costs TOP\$50 return by boat. The entire family is involved in harvesting and the frequency of harvest differs amongst the families. Family 1 harvests 8-10 onion sacks per week once a week. Family 2 harvests 14 onion sacks full twice a week. Family 3 harvests 1 large chilly bin full 5 days a week. Most of the harvesting is carried out on Mondays. The stock is expected to last until the following Monday, but if it runs out, a second harvest is done on Friday or Saturday. In cooler months, more harvesting trips are done, as the harvesters get cold quickly. Seagrapes are harvested with runners and sorted out before being transported to market.

Vava'u

In Holeva village, seagrapes are harvested (with runners) every Friday and kept in coconut leaf baskets. Harvesting is carried for 6 months only. In Kolao village, harvesting is carried out on Thursdays and Fridays every week all year around and seagrapes are also kept in coconut leaf baskets.

Handling and Storage

In Patangata, Nuku'alofa after harvesting, seagrapes are stored in large onion bags, and placed in the sea near the village for up to 2 days. One family member sorts the seagrapes (ie. pick healthy uprights from runners). Approximately 1-2 onion bags are cleaned daily and uprights are stored in onion bags and submerged in the sea. On market day, seagrapes are wrapped in leaves and transported by bus or private transport.

In Vava'u, after harvesting the seagrapes with runners are cleaned by removing debris and roots. These are then wrapped in leaves (bundles) and stored in a cool place ready to be sold on Saturday. Seagrapes are sold with the runners. Pre-prepared bundles are transported to the market via a hired carrier.

Marketing

There is some loss from the point of harvest to the point of sale (equivalent of 2-3 packs). In Nuku'alofa, weekly costs range from TOP\$20-30 for transport, purchase of onion sacks, market fee and food (while selling).

Limu is sold plain in breadfruit and coconut leaves for TOP\$5.00 per pack and packs are approximately 500-600g (larger than the Fiji packs). In Nuku'alofa, about 10 packs are sold per day during week days and 20-30 packs sold on Saturdays (Figure 4). One vendor sells every day. In Vava'u, 20 packs are sold per week. About 2-4 packs are usually unsold at the end of the week. The sea grapes at the market appeared generally healthy but some were bleached. Sales from *limu fuofua* belong to the family although exceptions include some money given to individuals transporting their produce to market. According to the market vendors, there seems to be no clear pattern of seasonality of *limu fuofua* and it is available all year-round.

One local businessman has conducted small trial shipments of 5-6 kg to New Zealand for food condiments and this was packed in full seawater a few hours before shipment. According to the businessman, there are different types of *limu fuofua* (maybe 3) and this may be site specific. It appears that the sea grapes from Ha'apai, are larger in size than those from Onevai. The key challenges for export are to preserve *limu fuofua* somewhat like that of vegetables and to find new markets (George Nakao, pers. comm., April 2011).

Consumption

As in Fiji and Samoa, *limu* is always eaten raw as a salad and used as an accompaniment or side dish to the main meal.



Figure 4: *Caulerpa* vendor, Nuku'alofa market, Tonga (Photo: G. Robin South)

Potential of *Cladosiphon* in Tonga, compared with *Caulerpa*

It seems that the brown seaweed, *Cladosiphon* sp. may have more potential in Tonga as the fishery is larger than *Caulerpa* (this cool-water preferring species does not occur in Fiji or Samoa – GR South, pers. comm., May 2011). According to Malimali (2007), *Cladosiphon* sp. or *limu tanga'u* in Tongan (Mozuku in Japanese) accounted for 6% of the national income from fishery exports. Export of *limu tanga'u* began as a supplementary supply for the Japanese sushi market in the late 90's when the production from Okinawa declined due to damages from a typhoon. When the Okinawa production re-surfaced in 2006, the feasibility of cultivating and shipping *limu tanga'u* from Tonga to Japan was lost. This seaweed is used to extract fucoidan which is used as a health supplement. There is a need for Pacific island countries like Tonga to go one step further and carry out value adding for fisheries products like seaweed and seagrapes in order to provide a niche product.

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