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Research Article

Harvesting and processing of tropical sea cucumbers in Fiji

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Abstract

Harvesting and processing of holothurians (sea cucumbers) in Fiji dates back to thousands of years. This study on harvesting and processing of holothurians was conducted in Fiji Islands. Data was collected through formal and informal interviews with fishers, marine product agents and through catch analysis by the fishers. The main targeted species in Fiji for harvest are *Holothuria fuscogilva* (White teatfish) and *H. nobilis* (Black teatfish). The rate at which harvesting sea cucumbers in Fiji is 5.97 pieces per hour for individual collectors. From the interviews, it was determined that men were the major harvesters of sea cucumbers other than women and children. All accessible commercial sea cucumber species (18 species) were collected. Collection methods were by gleaning; free diving, scuba diving and the use of fishing gear such as "*dri-bomb"* to retrieve holothurians from the deep sea. Sea cucumbers were processed by salting and unsalting methods and involve first boiling, slitting and gutting, salting (agents only), second cook (agents only), smoke drying, third cook (agents only) and sun drying. This research raised issues of immediate awareness programs for fishers on proper harvesting, storage and better management of sea cucumbers in Fiji Islands.

Keywords: *Holothuria fuscogilva*, *H. nobilis*, bêche-de-mer, fisheries, management.

Introduction

Bêche-de-mer fishery is one of the important sources of earnings for local communities dwelling in coastal areas in the pacific [12]. Holothurians or sea cucumber are consumed as a delicacy and for their medicinal properties. The intercontinental trade of its dry form is recognized as bêche-de-mer (*iriko* in Japanese, *hai – som* in Chinese or *trepang* in Indonesian) [3, 11]. From a total of 1200 species known today, approximately 24 – 35 species are commercially exploited in the markets [4, 8, 11, 12].

Of these exploited species, the Asian buyers target species from the genera *Holothuria* [8] while others are in the genera *Actinopyga*, *Bohadschia*, *Stichopus* and *Thelenota*. *Holothuria* species such as *H. scabra* (Sandfish), *H. (Microthele) fuscogilva* (White teatfish) and *H. (Microthele) nobilis* (Black teatfish) are among the highest value species [5] demanding superior prices in Asian markets. Well-dried product of 'A' grade would receive a value as high as US$70 – 190 per kilogram depending on size and quality [11].

Bêche-de-mer processing entails an uncomplicated sequence of actions to accomplish a product that is non – perishable if stored in dry, dark conditions. Post-harvest steps incorporate first boiling, slitting and gutting, second boiling, smoking and finally sun drying [4, 5, 7, 8, 11, 14, 16]. Although these steps are uncomplicated, it requires continuous attention to the processing method in use to obtain a standard dry product that is equivalent throughout. If the steps are not followed appropriately the result of the ultimate grade will be affected thus lowering the value of the final product [16].

This paper will discuss the methods of harvesting and processing used by the fishers and the main agents in the Fiji Islands. Data on harvesting and processing in the Fiji Islands is limited and as a result the results from the present study cannot be compared to many other published reports covering Fiji or the South Pacific.

Material and Methods

Site of study

The study was conducted in the Fiji Islands (Figure 1) between August 2006 to July 2007. The sites of study were eastern and western Viti Levu, northern and southern Vanua Levu and two islands from outer Lau group (Vanua Balavu and Lakeba Island). These two islands have two main buyers who are engaged in buying the products from other islands in the Lau group. Therefore the data from the two islands represents the data for the Lau Group. Catch analysis and interview of the fishers was done at the time when the fishers visited the main buyers on the two islands to sell their products either in raw or dry form. However, the fishers based on the main islands of Fiji were visited directly in their villages and data on harvesting and processing was collected.

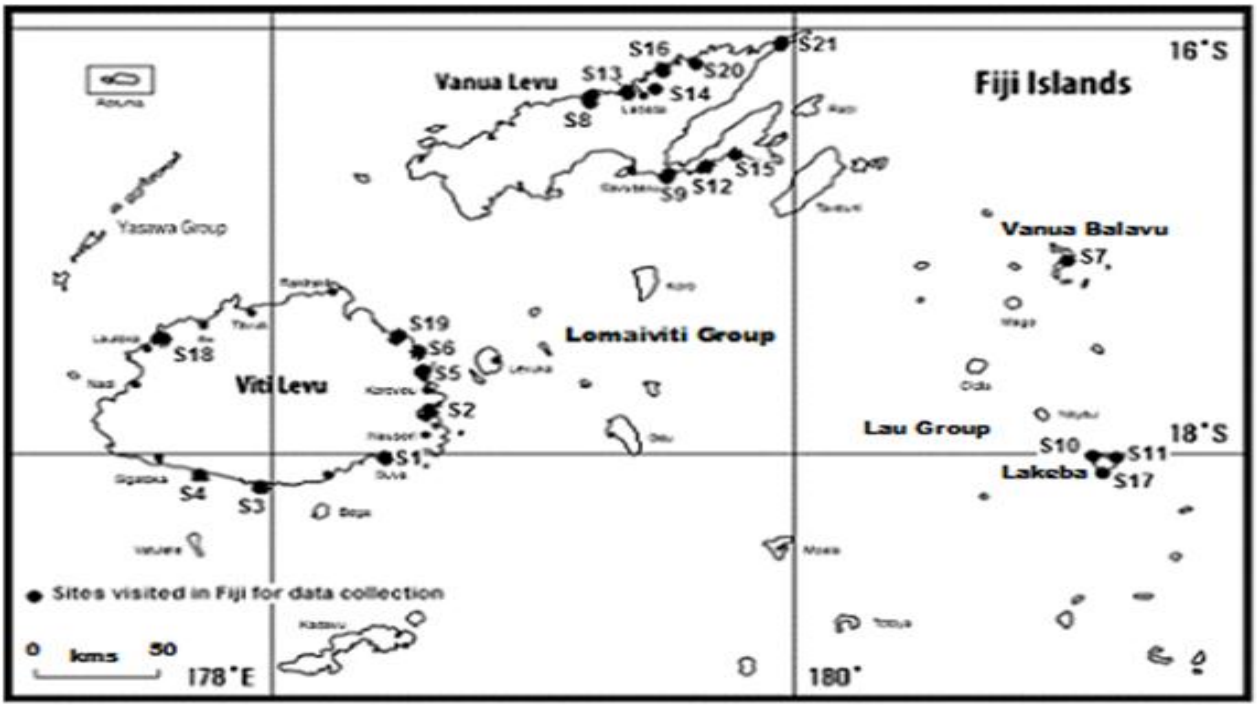

Figure 1: Sites visited in Fiji for collection of data (source: USP Media center, Fiji Islands).

Data collection

Data pertaining to sea cucumber fishery in Fiji was gathered through library and internet research while information on key issues such as processing was acquired through formal and informal interviews and questionnaires given to fishers at various sites (n = 21) around Fiji, the fisheries officers at the Ministry of Fisheries and Forests of Fiji and the main exporters of bêche-de-mer in Fiji. The data that were gathered from the fishers were mostly on the location of harvest, number of harvesters in a group, number of hours fished, time or season of the harvest, the species harvested, total number of species harvested, total live weight harvested and the processing technique used to process the sea cucumbers.

Structured questionnaire forms were prepared and given to the target population. The key population targeted for interviews and catch analysis were the artisanal (bêche-de-mer) fishers (n = 86), middleperson (n = 8) and the main exporters of bêche-de-mer (n = 5) but for this study one exporter was involved. An identification card and sea cucumber charts were also shown to the fishers and buyers during data collection to easily identify the sea cucumber species.

Harvesting and processing sea cucumber

The harvest done on each day by the fishers was recorded and graded by species and size. Length of sea cucumber was measured using a ruler to the accuracy of 0.1centimetre. Sea cucumbers were left out of the water for approximately five minutes before any measurements were taken. Weight of individual sea cucumber was measured by an analytical balance to the accuracy of 0.1g. Harvesting and processing for each of the sites visited was recorded. Processing techniques generally (harvesting, boiling, gutting, smoke drying and sun drying) used by the fishers were noted by critically evaluating all steps involved in processing sea cucumbers. Similarly this was also done for the exporters of bêche-de-mer.

Statistical analysis

The data collected was entered into a spread sheet by sites visited and number of species harvested by the fishers. The data was transformed by log n + 1 and a *Bray – Curtis* similarity was performed before multi-dimensional scaling was used to detect the patterns in the results attained in Fiji (Primer 5 software). The plot is represented in Figure 6. Mean harvests from each site visited were calculated and data is shown in Table 2 with its standard deviation

Results and Discussion

Main target species

The main species targeted by the buyers and fishers due to its superior value in Fiji are:

- *Holothuria fuscogilva* (White teatfish white and brown variety) (Figure 2.0)
- *Holothuria nobilis* (Black teatfish) (Figure 2.0)

At least 18 species are harvested in Fiji for commercial purposes (Table 1). There are two varieties of White teatfish harvested and exported [1, 5]. These are white (rare in Fiji) and brown variety (Figure 2). The white variety is preferred exceedingly over brown variety in Asian markets due to its meat texture and taste.

Harvesting sea cucumbers

The other genera that are targeted for harvesting are from *Holothuria, Actinopyga, Stichopus, Thelenota* and *Bohadschia* species. From a total population interviewed, 61.6% men, 11.6% women and 26.7% children were involved in gleaning. Harvesting of sea cucumbers generally occurs at low tide and the collection methods are by hand, free diving and by use of SCUBA (Table 2). Women and children generally collect from the reef area while men go for free diving outside the reef to a depth of 10 meters in water passages and reef slopes to gather larger sizes of holothurians (Table 2). The collectors gathered all the available species of all size range from the reefs. Fiji however, has a size limit of three inches (7.62 centimetres) on harvests and exports on all sea cucumbers either in natural or processed form [2].

The catch rate was high by each collector with a mean collection rate of 5.97 pieces per person per hour. On average each collector was able to collect in between 30 – 300 species per day (Table 1) where low value species dominated the catch.

Figure 2. White teatfish (brown variety and white variety (on the right)) and Black teatfish. (Photo: Ram, 2008)

The harvest is usually stored in 20 litre drums (Figure 3) that are cut in half (Table 2). All the species harvested is mixed together with other seafood such as fish, crabs and lobster. Keeping sea cucumbers with other seafood often damages the skin of the sea cucumber often having harmful consequences on the quality and value of the end product after processing.

Figure 3. Sea cucumber harvested and storage. (Photo, Ram, 2008)

Table 1. Average number of species harvested per day by fishers (n = 86) in Fiji Islands*

English name	Fijian name	Value in Fiji	Average number of pieces harvested per day	Standard error	Common size harvested (cm)	No. of respondents
White teatfish	*Sucuwalu*	High	15	0.7	5 – 25	75
Black teatfish	*Loaloa, lolo*	High	21	0.8	7 – 30	74
Sandfish **[banned]**	*Dairo, tero*	High	30	1.3	7 – 16	67
Prickly redfish	*Sucudrau*	Medium	17	0.8	5 – 42	73
Stonefish	*Dri – vatu, Ki*	Medium	41	1.2	9 - 14	72
Surf Redfish	*Tarasea*	Medium	44	1.3	16 – 22	75
Blackfish	*Driloli*	Medium	46	1.3	14 – 21	73
Elephant Trunkfish	*Dairo-ni-cakau*	Low	46	1.1	30 – 46	69
Greenfish	*Dri-votovoto; Tarase*	Medium – High	139	2.8	10 – 40	77
Curryfish	*Laulevu*	Low – Medium	143	3.4	5 – 20	75
Amberfish	*Dri - volavola*	Low	34	1.5	30 – 50	71
Brown sandfish	*Vula*	Low	72	1.2	10 – 20	78
Deep water redfish	*Dri-tabua*	Low – Medium	33	1.1	8 – 40	72
Lollyfish	*Loliloli*	Low	118	2.2	8 – 35	83
Sea cucumber	*Mundra, midro*	Low	110	2.6	9 – 19	84
Snake fish	*Loliloli*	Low	71	1.6	25 – 60	67
Geci (Curryfish D grade)	*Laulevu*	Low	214	2.7	5 – 8	60
Pinkfish	*Dri – damu*	Low	65	2.6	12 – 45	60
Tigerfish	*Vula – ika*	Low – Medium	63	1.5	8 – 22	78

* Data gathered from observation, catch analysis and interviews with the collectors.

Table 2. Collection of holothurians in Fiji Islands.

Characteristics*	**West Viti Levu** (on canoe day time)	**East Viti Levu** (on foot and on canoe day and night)	**North Vanua Levu** (by canoe day time)	**South Vanua Levu** (on foot day time)	**Outer islands** (on foot day time)	**Diving by Scuba**
Number of catches surveyed	4	10	2	4	4	2
Number collected /day)	2048 ± 93.43[a]	2297 ± 112.54[a]	2327 ± 165.14[a]	2181 ± 122.87[a]	6311 ± 322.80[a]	249 ± 16.43[a]
Quantity (Kg collected/day)	74.88 ± 0.35[a]	136.73 ± 0.19[a]	98.97 ± 0.41[a]	125.35 ± 0.22[a]	173.77 ± 0.22[a]	226.00 ± 0.65[a]
Number of days per week collected	1 – 2	1	1	1	2 – 4	3 – 5
Sex of collectors	Male and female	Male and female	Male and female	Male and female	Male and female	Male
Age of collectors	16 – 50+	12 – 50+	10 – 45+	9 – 40+	17 – 50+	25 – 35+
Maximum time of collection (hrs)	3 – 5	3 – 5	3 – 5	3 – 5	5 – 6	6
Equipment required	20L gallon drum, 10L buckets and floaters	Canoe (motor engine, torch, lantern) 20L gallon drum, 10L buckets	Canoe (motor engine) 20L gallon drum, 10L buckets	20L gallon drum, 10L buckets	20L gallon drum, 10L buckets	Sack, diving gear, canoe (motor engine) spear, *dri-bomb*
Method of collection	Hand	Hand	Hand	Hand	Hand and *dri-bomb*	Hand and *dri-bomb*
Cost per trip	Motor fuel < $FJD 50.00	Motor fuel, lantern fuel < $FJD 50.00, nil expenses for collectors on foot	Motor fuel < $FJD 80.00	Nil	Nil	Motor fuel, torch battery < $FJD 150.00
Location of harvest	FR/RC/RS	FR/RC/RS	FR/RC/RS	FR/RC/RS	FR/RC/RS/ DW	RS/DW
Depth (m)	0.2 – 1.0	0.5 – 1.5	0.5- 1.5	0.2 – 1.0	0 – 0.5	1.5 – 45
Tidal phase	Low tides	Low tides	Low tides	Low tides	Low tides	Low tides
Species harvested	C	C	A & C	C	A & C	A
Season of harvest	Year round	Year round	Year round	Year round	Year round	Year round
Limitations of harvests	Cyclones, torrential rain and floods that reduce visibility	Cyclones, torrential rain and floods that reduce visibility	Cyclones, torrential rain and floods that reduce visibility	Cyclones, torrential rain and floods that reduce visibility	Cyclones, torrential rain and floods that reduce visibility	Cyclones, torrential rain and floods that reduce visibility

FR = fringing reef: RC = reef crest: RS =reef slope: DW = deep water passages

[a] Total catch plus one standard deviation.

A = {**White teatfish**, Black teatfish****, Prickly redfish, Tigerfish, Surf redfish, Blackfish, Stonefish, Brown sandfish}

B = {**White teatfish**, Black teatfish****, Tigerfish, Brown sandfish, Surf redfish}

C = {**White teatfish**, Black teatfish****, Prickly redfish, Tigerfish, Surf redfish, Blackfish, Stonefish, Brown sandfish, Lollyfish, Sandfish, Curryfish, Greenfish}

* Data gathered from observation, catch analysis and interviews with collectors.

** Bold means the target species for harvest

Use of scuba gear for sea cucumber collection is banned in Fiji but the Ministry of Fisheries in Fiji issues licences to fishers and buyers who have safety diving certificates and gear that is in compliance with occupational health safety standards of Fiji. Harvesting with scuba is facilitated with the use of *dri-bomb* (Figure 4) to retrieve sea cucumbers from the deep that creates hole in the tissue or flesh of the holothurian that in the end stages of processing affects the quality of the product [8] (Figure 5).

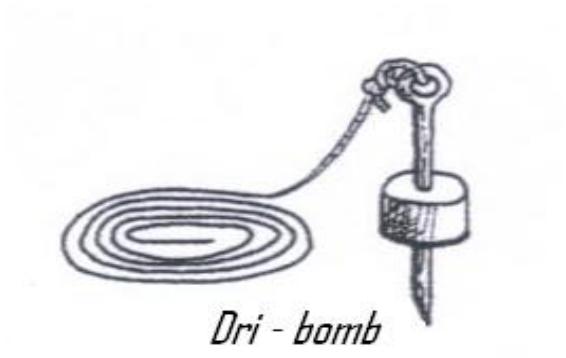

Figure 4. Diagram of "*dri – bomb*" used to harvest sea cucumbers from the deep.
It consists of a sharp hook and a mass of lead to sink the hook accompanied by a long string. This gear is gently lowered over the sea cucumber in the deep and stabbed, and then is gently pulled by the aid of the string to collect the sea cucumber.

Figure 5. White teatfish showing hole in its body wall due to harvesting the product with *dri – bomb* and the effect on quality after drying.
(Photo: Ram, 2008)

The number of holothurians harvested from the reef was high for all the sites studied in Fiji Islands (Table 2). Harvesting number for each of the sites exceeded 2000 pieces per day. Most harvesters gathered sea cucumber once a week only. Scuba divers however, collected broodstock from the deep that were larger as compared to the sizes found on the reefs and inshore areas. Broodstock are for the reproduction of holothurians for the future stock [14]. In one dive collection was in excess of 200 pieces per day within four hours of diving (Table 2). The harvest of high value species has begun to decrease due to stock depletion (Table 1). Therefore harvest of high number of low value species (Table 1) are done to supplement the dry weight for export by the main agents. Fiji however, does not have any current monitoring in place for harvesting and exporting of holothurians.

The data on harvests was analysed and plotted to attain the *Bray – Curtis* similarity plot for harvest in Fiji (Figure 6). The nearness of the sites to each other symbolizes that the harvesting of sea cucumber are similar or the fishers target the only species targeted by the buyers. Sites 1, 2, 5, 6 and 19 are from eastern Viti Levu. Sites 3 and 4 are from western Viti Levu. Sites 8, 13, 14, 16, 20 – 21 are from northern Vanua Levu. Sites 9, 12 and 15 are from southern Vanua Levu and sites 7, 10, 11 and 17 are from outer
islands. The sites close to each other also signify collection of numerous low value species as compared
to high value sea cucumbers. Collection from sites 4, 13 and 20 suggests that the quantity of harvests deviate since these sites are further from each other and is an indication that collection of one variety of sea cucumber species dominate as a result of over – exploitation or the collectors are encouraged to target one species (Table 3) (e.g. White teatfish) by the buyers.

Table 3. Percentage of species harvested per day per sector.

Common names	Fijian names	Percentage (%) of catch rate per species by location per day					
		West Viti Levu	East Viti Levu	North Vanua Levu	South Vanua Levu	Outer Islands	Scuba divers
White teatfish	*Sucuwalu*	5.1	1.1	0.9	3.2	1.3	4.0[b]
Black teatfish	*Loaloa*	1.2	0.8	2.8	3.7	2.5	6.0[b]
Prickly redfish	*Sucudrau*	0.9	3.5	1.3	2.7	1.8[b]	7.6[b]
Greenfish[a]	*Dri votovoto*	8.0	21.0[b]	15.3[b]	10.3[b]	16.2[b]	0.0
Amberfish	*Dri volavola*	1.8	5.5	0.4	0.9	0.1	2.0
Surf redfish	*Tarasea*	4.4[b]	6.8[b]	1.5	2.5	2.5	17.3[b]
Stonefish	*Dri vatu*	1.0[b]	5.5	1.7	1.4	3.5	15.3[b]
Deepwater redfish	*Dri tabua*	1.3	0.5	2.4	3.9	2.1	2.0
Snakefish	*Loliloli*	3.5[b]	3.4[b]	0.9	0.0	4.1[b]	0.0
Curryfish D grade	*Geci*	13.1[b]	0.0	6.4[b]	0.0	15.1[b]	0.0
Tigerfish	*Vula ika*	6.4[b]	9.3[b]	1.6	7.3[b]	7.0[b]	22.9[b]
Blackfish	*Dri loli*	3.3[b]	5.9	3.7	8.3[b]	1.6	11.2
Elephant trunkfish	*Dairo-ni-cakau*	1.6	2.9	0.1	2.5	0.1	0.8
Pinkfish	*Dri damu*	4.4	4.9	2.1	2.3	0.0	0.0
Sea cucumber	*Mundra*	3.7[b]	7.4[b]	26.1[b]	4.1[b]	11.3[b]	0.8
Curryfish[a]	*Laulevu*	20.4	7.3[b]	4.5	5.4	11.5[b]	6.0
Lollyfish	*Loliloli*	12.2[b]	6.8[b]	19.8[b]	17.9[b]	11.9[b]	0.0
Brown sandfish	*Vula*	4.6[b]	5.9[b]	8.5[b]	21.5[b]	4.8[b]	4.0[b]
Sandfish	*Dairo*	3.5	1.4	0.0	2.2	2.7[b]	0.0

[a] Catch rate has decreased due to flesh deterioration and difficulties in processing by fishers

[b] Dominant catches for each of the sites

HARVESTING OF SEA CUCUMBER AT FISHER LEVEL

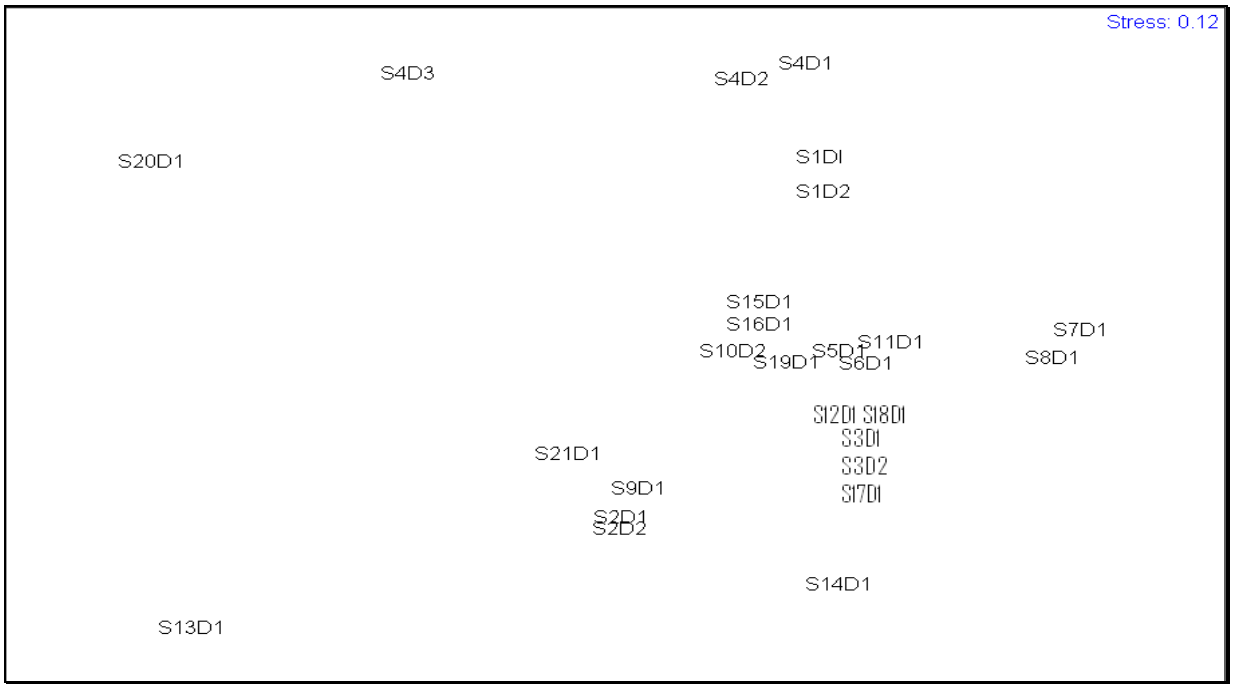

Figure 6. *Bray – Curtis* similarity plot with similar harvest rate represents the sites close together on the graph.

'S' represents site, number and 'D1' represents the day of harvest.

Sea cucumber processing

Sea cucumber processing in Fiji is done by using two different methods and these are by salting and unsalting. The method of salting is generally used by the main buyers of bêche-de-mer while unsalting method is normally used by the fishers around Fiji Islands. The salting and unsalting methods are described below.

Salting method

The freshly harvested sea cucumbers are sorted by species and boiled for 10 – 15 minutes depending on the size of the sea cucumbers. Smaller sea cucumbers are boiled together as it requires less time to cook than the larger sized species. After the first boiling the sea cucumbers are then slit and gutted as described in [14, 16]. Salt (grade 11 coarse solar salt) is packed into the gut cavities and covered entirely and left for 2 – 3 days (Figure 7). The salting containers are tilted for the removal of the salt silage from the sea cucumbers.

After salting for two to three days the products are boiled for its second time and smoke/sun dried for 16 – 18 hours. The salt crust that forms on the smoke/sun dried product is washed and boiled for third time to improve the shape of the product and finally are sun dried to achieve a moisture content of 8 – 10% [16] and stored in dry and cool place away from moisture. The final drying lasts almost 2 – 3 weeks (Figure 7) before being packed and exported to Asian consumers. Many local communities are unable to afford salt as a fundamental processing resource and end up having poorly processed and spoiled products (Figure 8).

Figure 7. Salting sea cucumbers (above) and salted dried white teatfish (below).
(Photo: Ram, 2008)

Unsalting Method

In unsalting method the freshly harvested sea cucumbers are boiled in sea water or fresh water for 10 – 15 minutes. The sea cucumbers are allowed to cool for about half an hour before slitting and gutting. The cuts are made according to the species as high value species require a neat straight cut on the dorsal surface of the animal while a small cut is made for medium and low value species near the anal region on the ventral surface of the sea cucumber. The gut contents and sand debris are removed and the sea cucumber is cleaned and left in the sun on racks for drying. At night the products are smoke dried. Asian countries prefer non-smoked product, however, due to resource availability at community level, the processors smoke the product to avoid spoilage. The products are mostly semi-dried before being sold to the marine product agents. In some cases people are greedy for the sea cucumbers monetary value and speed up the processing steps and result in poor quality products (Figure 8). This level of processing however has raised serious concerns for improvements in processing techniques in Fiji Islands.

Figure 8. Unsalted dried sea cucumbers. (Photo: Ram, 2008)

Conclusion

Sea cucumber harvesting is usually done in Fiji by the method of hand collection. There are major issues concerning the harvesting of holothurians such as proper storage during harvest and collection of sea cucumbers greater than the size limit (7.62cm) that is currently enforced in Fiji. Processing of sea cucumbers in the Fiji Islands is performed swiftly by the fishers to obtain its monetary value and the product quality is vastly affected. The outcomes from this paper have raised serious concerns for raising awareness at fisher level for improvements in harvesting and processing techniques in Fiji for improving the quality of sea cucumbers exported to Asian markets.

Acknowledgement

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