Processing techniques for white teatfish *Holothuria fuscogilva* and black teatfish *H. whitmaei in* Fiji

Ravinesh Ram,[1] Roveena V. Chand[2] and Paul C. Southgate[3]

Introduction

The sea cucumber fishery is an important source of income for coastal communities in the Pacific (Conand 1989). Holothurians or sea cucumbers are consumed as a delicacy and for their perceived medicinal properties, and are particularly sought after in Southeast Asian markets (Bordbar et al. 2011; Esmat et al. 2013). The global trade in sea cucumbers is based on whole, gutted and dried sea cucumbers, commonly known as beche-de-mer (*iriko* in Japanese, *hai – som* in Chinese or *trepang* in Indonesian) (Bumrasarinpai 2006; Ferdouse 1999; McElroy 1990). From approximately 1,200 known species of sea cucumbers, around 58 are traded on Asian markets (Li 2004; McElroy 1990). The majority of commercially exploited species belong to the genera *Actinopyga*, *Bohadschia*, *Stichopus, Thelenota* and *Holothuria*, with Asian buyers particularly targeting species from the genus *Holothuria* (Li 2004). Sandfish (*Holothuria scabra)*, white teatfish (*H. fuscogilva)* and black teatfish (*H.* nobilis in the Indian Ocean or *H. whitmaei* in Asia Pacific) are among the highest value species (Holland 1994) in Asian markets where well-dried 'A' grade product commands prices of around USD 70–190 per kg according to size and quality (McElroy 1990).

Beche-de-mer processing entails an uncomplicated sequence of actions resulting in a product that is non–perishable if stored in dry, dark conditions. The processing techniques currently used for beche-de-mer in Fiji were developed in the 1800s and have changed little since then. Post-harvest steps include first boiling, slitting and gutting, second boiling, smoking and finally sun drying (Holland 1990; Kinch 2002; Li 2004; McElroy 1990; Purcell 2014b; Sachithananthan et al. 1985; Seeto 1999; SPC 1994). Although these steps are uncomplicated, they require continuous attention to obtain a standardised dry product, and failure to do so can result in reduced quality and value of the final product (Purcell 2014b; Sachithananthan 1985; SPC 1994).

Processed white teatfish (*H. fuscogilva*) is ranked as the most valuable and superior product from Fiji's sea cucumber fishery, with a value of more than USD 140 per kg dry in Asian markets (Purcell et al. 2012). White teatfish replaced sandfish (*H. scabra*) as the dominant and most valuable product from the Fijian beche-de-mer industry in 1989, when Fiji's natural sandfish stocks collapsed because of overexploitation. Black teatfish (*H. whitmaei*) is currently the second most valuable product from Fiji's sea cucumber fishery in Asian markets. It is favoured for its relatively thick tegument (~12 mm).

A number of studies have reported the general processing methods used for sea cucumbers (Ram et al. 2014a) but there is limited literature reporting on specific processing methods used for individual sea cucumber species (Sachithananthan et al. 1985). Factors affecting the quality of beche-de-mer have been poorly studied. There is a particular lack of information relating to the influence of processing methods on the value of beche-de-mer in Asian markets (Battaglene and Bell 2004; Conand 1990 and 2004; Li 2004; Purcell 2014b).

Sea cucumber harvesting and trading are increasingly becoming restricted in the Pacific Islands region because of overexploitation. Even where stocks are still healthy enough to keep sea cucumber fisheries open, it is important to make sure that the value of the catch is maximised by proper processing techniques. This paper details for the first time the proper processing technique used by some processors in Fiji for white teatfish and black teatfish. If standardised, this method will help processors increase the value of their white and black teatfish products. They should then be able to give a better price for these sea cucumber species to fishermen, who will therefore need fewer sea cucumbers to make the same income. Hopefully, the end result will be less pressure on wild stocks.

[1] Centre for Sustainable Tropical Fisheries and Aquaculture, College of Marine and Environmental Sciences, James Cook University, Townsville, Queensland 4811, Australia.
[2] School of Marine Sciences, Faculty of Science Technology and Environment, University of the South Pacific, Suva, Fiji Islands.
[3] Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast, Maroochydore, Queensland 4552, Australia.
* Corresponding author: ravinesh.ram@my.jcu.edu.au

Processing methods for teatfish

Information for this paper was collected online and through personal observations at the processing stations of local sea cucumber processors and beche-de-mer exporters in Fiji.

Harvesting

White and black teatfishes are found as deep as 30–40 m (Reichenbach 1999) in Fiji and generally deeper than the majority of commercially collected sea cucumber species. Fishers collect the two species by free diving and by using scuba, despite the fact that it is an illegal sea cucumber fishing method in Fiji (Carleton et al. 2013; Pakoa et al. 2013). Divers hold harvested sea cucumbers in a porous cotton or polyester sack and, because of their relatively high value, both species are held separately from other species that are harvested from the same site (Ram et al. 2014c).

Once the divers return to the surface and to the vessel from which they operate, harvested sea cucumbers are kept alive in containers filled with seawater; they are maintained separately from other harvested seafood items such as crustaceans. This reduces potential damage to harvested sea cucumbers (i.e. skin scratches and cuts), which would affect the quality and value of processed sea cucumbers. Before processing, white teatfish and black teatfish are laid on a flat surface to obtain a cylindrical shape and to relax the muscles in the body wall (Fig. 1). This relaxation is important for the subsequent cooking step, because if sea cucumbers are put in hot water immediately after being harvested, the body wall can burst open and this would have a major impact on the product quality and value (Ram et al. 2014a). The relaxing process generally takes about 15 min.

First cooking

Sea cucumbers are sorted before cooking to ensure that all sea cucumbers of the same size are cooked together. A large pot of fresh water is generally heated above an open fire. The temperature of the water must be 40–50°C before sea cucumbers are immersed individually (Fig. 2A). A wooden stirrer is used to prevent damage to the sea cucumbers during the cooking process and to assist with their even cooking.

The skin of both white teatfish and black teatfish are very fragile and wrinkles quickly if immersed in very hot water. Immersing sea cucumbers slowly and one by one also reduces the water temperature and the fire must be intensified for the water to maintain the suitable cooking temperature. The sea cucumbers are cooked at 40–50°C for 15–20 min. with occasional stirring. After this cooking period, the fire is intensified and the water

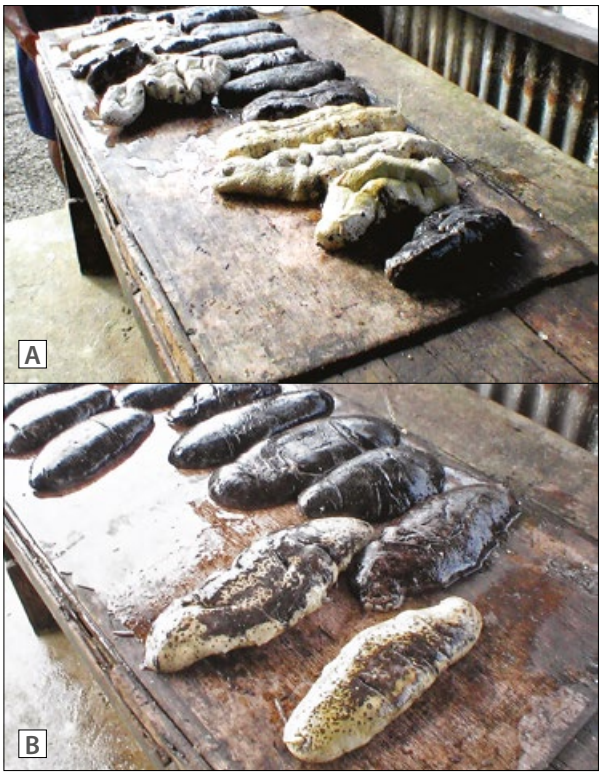

Figure 1. Freshly harvested white teatfish and black teatfish (A) laid on a flat surface to obtain a cylindrical shape and to relax the muscles in the body wall (B) before processing.

Figure 2. Initial cooking of white teatfish and black teatfish (A) and products after the first cooking (B).

temperature is increased to 80–90°C. Sea cucumbers are then cooked until they begin to swell, attaining a cylindrical shape and becoming harder and less rubbery. The whole 'first cooking' process takes approximately 30 min. to complete.

Cutting and gutting

After completing the first cooking, sea cucumbers are removed from the cooking pot and arranged on a clean dry surface to cool for around 30 min. (Fig. 2B). Using a sharp knife, a neat cut is made on the dorsal surface of the cooked sea cucumbers, ending around 25 mm from the mouth and the anus at either end (Fig. 3). Once the cut is complete, the viscera are removed and the resulting cavity is cleaned. In Fiji, a faulty cutting step in sea cucumbers processing is a major contributing factor to quality and revenue losses (Ram et al. 2014b). For example, for both white and black teatfish, Fijian fishers often cut from the anterior to posterior end thus opening the entire gut cavity.

Figure 3. Slitting and cutting white teatfish and black teatfish on the dorsal surface. Note: the space left from the mouth to the slit on one side and from the anus to the slit on the other side.

Salting

The salting step is used to speed up the drying process and to preserve sea cucumbers from spoiling. In Fiji, a bag of salt costs around FJD 30.00, which is expensive for local fishers. As a result, sea cucumber fishers rarely use salt for the high value species they collect. After cleaning and gutting, salt (Grade 11, coarse solar salt) is pushed into the gut cavity (Fig. 4A) and into the two ends near the mouth and anus until there is no exposed surface that could be prone to spoilage. Teatfish are then turned upside down with the ventral surface facing upwards (Fig. 4B) and covered in salt. The sea cucumbers are spaced so that salt can be packed tightly between them before they are covered entirely with salt. Salting is done in containers that have tiny holes to allow moisture to drain from the sea cucumbers during the dehydration process. The salting container is held in an inclined position to facilitate drainage and is covered with a polyester cover to prevent external moisture entering the container. Teatfish are kept in salt for 48–60 h.

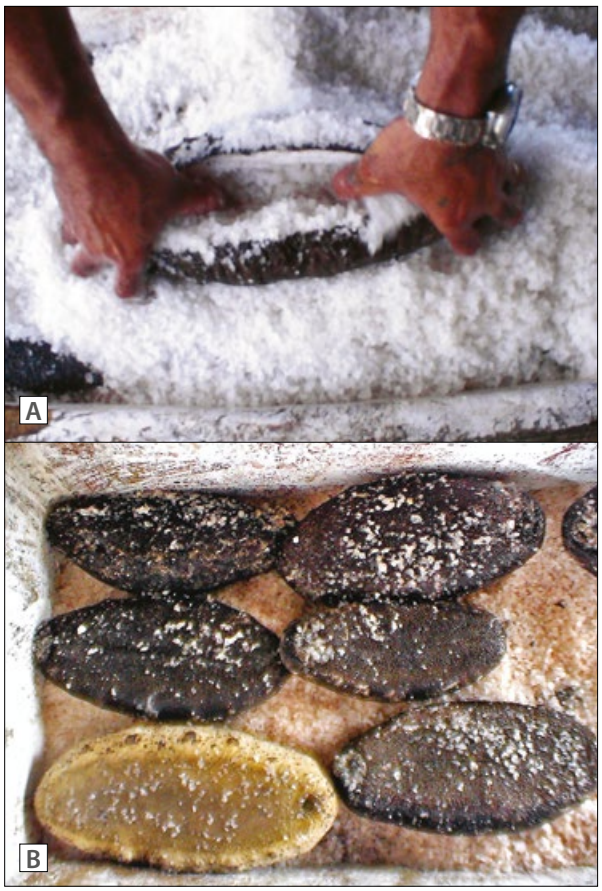

Figure 4. The salting procedure used for teatfish showing salt being pushed into the gut cavity (A) and individuals covered with salt (B).

Second cooking

After salting, teatfish are boiled a second time and the 'second cooking' is of a longer duration than the 'first cooking'. Salted sea cucumbers are washed free of salt using running fresh water and then immersed one by one into a cooking pot containing hot water at 40–50°C.

They are left at this temperature for around 10 min. and then the water is brought to the boil for a further 10–15 min. Introducing salted teatfish to boiling water directly damages their skin and reduces the quality of the final product. The skin of teatfish is fragile after salting. After the boil, teatfish become hard and attain a cylindrical shape (Fig. 5), indicating that the second cooking is complete. The products are then prepared for sun drying.

Figure 5. White teatfish cooked twice with a perfect shape.

Figure 6. Sun drying white teatfish and black teatfish. Note: small lengths of wood are used to hold open the gut cavity to facilitate the drying process.

Sun drying

To facilitate sun drying, a small stick of wood, around 50 mm long, is used to hold open the cavity of each sea cucumber (Fig. 6), which is then left in the sun with the dorsal slit surface facing upwards. The drying process continues for 5–6 days (with warm sunny days) or may take longer with less favourable weather. During the night, the products are stored in an enclosed room with fans. During the drying process, the teatfish become shorter and the tegument thickness shrinks from around 12 mm to 6–8 mm. As the product dries,

a salt crust forms on the skin surface and this must be removed with fresh water before drying continues. If this salt crust is not removed, it attracts external humidity and compromises the drying process. After washing, the length of the pieces of wood holding open the gut cavity is reduced to around 25 mm so that the cavity can be closed properly after the final cooking. After about 5–6 days of drying, the sea cucumbers become hard with a tough texture, indicating that the product is ready for the final cooking. Once the gut openers are removed, the teatfish are returned to the pot for the third and final cooking.

Third cooking

The third cooking is done primarily to assist with straightening the sea cucumbers and maintaining a cylindrical shape, which maximises their quality. During the third and final cooking, the gut cavity closes and the product attains a neat cylindrical shape (Fig. 7B). The final cooking last for only 5–10 min at a temperature of 60–96ºC before a final sun drying with the gut cavity closed (Fig. 7B).

Figure 7. Final drying of teatfish in an oven (A) and in the sun until the final product is very hard (B).

Final drying

Drying of the final product is further enhanced using an oven at night to prevent spoilage until the product has lost a considerable amount of moisture. Sea cucumbers in their driest state have only 8–10% moisture (SPC 1994). To monitor the drying process, beche-de-mer processors apply pressure to the outer skin of the product. Sea cucumbers that are not fully dried emit a 'squeaky' noise and are left to continue drying. Properly dried sea cucumbers make no noise when pressure is applied and have a very hard outer surface. This indicates that the product is fully dried and can be packed after grading.

Packaging and grading

Before packaging, the final products are graded according to size, shape, quality and appearance (Table 1). They are then stored in polyester sacks (Fig. 8) that are sealed and stored in a cool, dry place. The dried sea cucumbers are hygroscopic and absorb moisture if exposed to high levels of atmospheric humidity.

Figure 8. Packaged sea cucumbers.

During the processing of sea cucumbers accidents do occur, particularly when processing large batches. Common problems include over-cooking or over-drying, depending on the size of the sea cucumbers. These incidents have a significant effect on the final product quality and value. High value species, including teatfish, are graded into four categories or grades before packaging (Fig. 9).

'A' grade beche-de-mer generates the highest revenue while 'D' grade product generates only a fraction of this revenue (Table 1). 'C' and 'D' grade beche-de-mer can also be produced by marine products agents, particularly

Table 1. Grading system used for processed white teatfish (WT) and black teatfish (BT) in Fiji, and their approximate values.

Grade	Product description for grading	Price per kg of dried WT*	Price per kg of dried BT *
A	Very large size, straight in shape, neat appearance, neatly cut, white and brown spot coloration, teats intact, odorless and cylindrical	USD 141–274	USD 106–139
B	Medium size (≥7.62 cm or 3'), little distortion to shape, gut cavity open, may contain debris (sand and viscera), zigzag cut, teats damaged, white and brown spot coloration	USD 60–90	USD 45–53
C	Smaller size (<7.62 cm or 3'), shape distorted, debris present (sand and viscera), gut cavity open, skin wrinkled, cuts made from mouth to anus, teats damaged, faded colours	USD 40–60	USD 30–45
D	Very small size, shape distorted, presence of debris (sand and viscera), irregular cut, holes in tissue as a result of over cooking and burst, skin wrinkled, teats damaged, faded colours	USD 15–40	USD 15–30

* Prices from Purcell et al. (2012) and Pakoa et al. (2013).

Fig 9. Different grades of beche-de-mer processed from high value species of sea cucumbers. A): Grade A; B): Grade B; C): Grade C and D): Grade D.

if processing is done on a large scale, and white teatfish and black teatfish are cooked with no prior sorting of different sizes. This often results in larger animals being cooked properly while smaller animals are over-cooked and become distorted during the drying process. Where processing is done by the sea cucumber fishers themselves in remote areas where resources such as salt are unavailable, the resulting product is generally reprocessed by marine product agents resulting in C–D grade products (Fig. 9) of low value (Table 1).

Conclusions

White teatfish and black teatfish are the two dominant high value species of sea cucumbers utilised for beche-de-mer production in Fiji. This study outlines in detail for the first time the processing procedure for these species in Fiji. This process takes up 3–4 weeks to obtain a high-grade product, and lack of attention during processing can have a significant negative impact on product quality and value (Ram et al. 2014a). Processing manuals are available to assist fishers and processors to maximise the quality and value of the beche-de-mer that they produce (Purcell 2014a). However, the information provided is often generic and does not fully cover species-specific requirements relating to the sequence, conditions (e.g. boiling temperature) and duration of processing steps that are required to produce the highest quality beche-de-mer from white teatfish and black teatfish. The results of this study fill this knowledge gap. It is hoped that the method described here will be widely adopted in Fiji to improve product quality and increase revenues generated by this important coastal livelihood activity and export industry.

Acknowledgements

The authors wish to thank the fishers and marine processing agents in Fiji for assisting in this study.

References

Battaglene S.C. and Bell J.D. 2004. The restocking of sea cucumbers in the Pacific Islands. p. 176–178. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A., (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper. No. 463. Rome: FAO.

Bordbar S., Anwar F., and Saari N. 2011. High-value components and bioactives from sea cucumbers for functional foods – A review. Marine Drugs 9:1761–1805.

Bumrasarinpai R. 2006. Overview of issues on concerned aquatic species under the convention on international trade in endangered species of wild fauna and flora (CITES). Regional technical consultation on international fisheries related issues. WP 03.

Carleton C., Hambrey J., Govan H., Medley P. and Kinch J. 2013. Effective management of sea cucumber fisheries and the beche-de-mer trade in Melanesia. SPC Fisheries Newsletter 140:24–42.

Conand C. 1989. The fishery resources of Pacific Island countries. Part 2. Holothurians. FAO Fisheries Technical Paper, No. 272.2. Rome: FAO. 1989. 143 p.

Conand C. 2004. Present status of world sea cucumber resources and utilization. An international overview. p. 13–24. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management, FAO Fisheries Technical Paper. No. 463. Rome: FAO.

Esmat A.Y., Said M.M., Soliman A.A., El-Masry K.S.H. and Badiea E.A. 2013. Bioactive compounds, antioxidant potential, and hepatoprotective activity of sea cucumber (*Holothuria atra*) against thioacetamide intoxication in rats. Nutrition (Burbank, Los Angeles County, Calif.). Elsevier B.V: United States. 258 p.

Ferdouse F. 1999. Bêche-de-mer markets and utilisation. SPC Beche-de-mer Information Bulletin 11:3–9.

Holland A. 1994. The beche-de-mer industry in the Solomon Islands: recent trends and suggestions for management. SPC Beche-de-mer Information Bulletin 6:2–9.

Kinch J. 2002. Overview of beche-de-mer industry in Milne Bay Province, Papua New Guinea. SPC Beche-de-mer Information Bulletin 17:2–15.

Li X. 2004. Fishery and resource management of tropical sea cucumbers in the islands of the South China Sea. p. 261–265. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management, FAO Fisheries Technical Paper. No. 463. Rome: FAO.

McElroy S. 1990. Beche-de-mer species of commercial value - An update. SPC Beche-de-mer Information Bulletin 2:2–7.

Pakoa K., Saladrau W., Lalavanua W., Valotu D., Tuinasavusavu I., Sharp M. and Bertram I. 2013. The status of sea cucumber resources and fisheries management in Fiji. Noumea, New Caledonia: Secretariat of the Pacific Community. 51 p.

Purcell S.W., Samyn Y. and Conand C. 2012. Commercially important sea cucumbers of the world. FAO Species Catalogue for Fishery Purposes. No. 6. Rome: FAO. 150 p. 30 colour plates.

Purcell S.W. 2014a. Processing sea cucumbers into beche-de-mer: A manual for Pacific Island fishers. Southern Cross University, Lismore, and the Secretariat of the Pacific Community, Noumea. 44 p.

Purcell S.W. 2014b. Value, market preferences and trade of beche-de-mer from Pacific Island sea cucumbers. Plos One 9(4): p. e95075.

Ram R., Chand R.V. and Southgate P.C. 2014a. Effect of harvest and post-harvest processing methods on quality of bêche-de-mer in the Fiji Islands. Journal of Marine Science: Research and Development 4(3): doi:10.4172/2155-9910.1000153.

Ram R., Chand R.V. and Southgate P.C. 2014b. Effects of processing methods on the value of bêche-de-mer from the Fiji Islands. Journal of Marine Science: Research and Development 4(3): doi:10.4172/2155-9910.1000152.

Ram R., Friedman K., Chand R.V., Sobey M.N. and Southgate P.C. 2014c. Harvesting and processing of tropical sea cucumbers in Fiji Islands. Asian Journal for Food and Agro Industry 7(1):35–46.

Reichenbach N. 1999. Ecology and fishery biology of *Holothuria fuscogilva* (Echinodermata: Holothuroidea) in the Maldives, Indian Ocean. Bulletin of Marine Science 64(1):103–103.

Sachithananthan K., Osman S.S., Mlay M. and Schoemaker R. 1985. Report on the National Workshop on Fish Handling in Zanzibar. United Republic of Tanzania and report on the Tanzania/SWIOP national workshop on beche-de-mer processing. 45–83.

Seeto J. 1999. Bêche-de-mer processing – A little more effort to get much more money while saving precious resources. SPC Beche-de-mer Information Bulletin 11:2–3.

SPC (South Pacific Commission). 1994. Sea cucumbers and beche-de-mer of the tropical Pacific. Handbook No. 18. Noumea, New Caledonia: South Pacific Commission. 51 p.