FOOD PROCESSING CONCEPTS FOR THE AUSTRALIAN BECHE-DE-MER INDUSTRY

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

DPI DEPARTMENT OF PRIMARY INDUSTRIES QUEENSLAND

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FOREWORD

In recent years, increased interest has been shown in the Queensland beche-de-mer industry. As a consequence, there has been a number of initiatives taken to ensure the industry will have a sustainable future.

The industry, traditionally a 'cottage' industry in the past, has not been able to access many of the practices employed in 'main stream' food manufacturing operations. However, with the adoption of modern technology and modern processing establishments coming on line, the industry is joining the 'main stream' of food processing.

With the use of modern equipment and the high capital outlay, it is important to produce products of as high a quality as possible and maximise returns.

This publication endeavours to cover issues which are relevant to the modernisation of this industry. By increasing awareness of factors influencing processing and product quality, it is hoped the Queensland beche-de-mer industry will establish a sustained future and reputation as a supplier of high quality products.

March, 1995 B.R. Rich

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CHAPTER 1

INTRODUCTION

Historical background

The drying of beche-de-mer or trepang is a traditional industry of Chinese origin. It has spread extensively and the dried product has become a dietary component of many countries including Korea, Japan, S.E. Asia and many of the Pacific islands.

For Australia, beche-de-mer has historical significance as the beche-de-mer industry of northern Australia carried out by Macassar fishermen was one of the reasons for colonisation of the north (Mulvaney, 1966).

Queensland also held prominence in this industry last century as indicated by Ward (1972, 99)

Cooktown, in northern Queensland, was the base for the trade in this area and it is probable that exports from Queensland, Torres Straits, and Papua in the years 1880 to 1890 were greater than from any other area in the Pacific (excluding the Philippines) for any decade in the previous century.

Australia's and Queensland's historical involvement in the industry may be summarised as follows.

1803	Sixty Macassan vessels sighted in the Gulf of Carpentaria collecting beche-de-mer.
1840	Beche-de-mer fishing on Great Barrier Reef.
1881	South Australian Government imposed "tax" on fishing vessels in the north.
1907	No further licences issued to Macassan fishermen.
1895 to 1948	Catches per annum for East Coast and Torres Strait ranged from 5.1 to 542 tonnes. Average annual export was 205 tonnes (dry), equivalent to 2000 tonnes (wet).

1940s to 1970's	No real activity in the beche-de-mer industry. Periodic revivals occurred 1969, 1978.
1979/80	Development of beche-de-mer to fishery status. No real activity established.
1986	Queensland Department of Primary Industries given jurisdiction over beche-de-mer industry on the East Coast and Torres Strait.
1994	Management of beche-de-mer fishery in Queensland transferred to Queensland Fish Management Authority.

Since the re-establishment of the industry, activity has remained low (Table 1) through a variety of reasons. The main ones having general effect are Government reviews, economic viability, conservation restraints as applied to the Great Barrier Reef, quality of products, and indigenous rights.

Table 1: Number of Permits and Reported Beche-de-mer Catches (East Coast)

Year	Number of Permits	Reported Catch (tonnes, wet)
1986-87	6	-
1987-88	13	218.0
1988-89	8	0.5
1989-90	10	1.5
1990-91	16	130.0
1991-92	29	40.0
1992-93	25	330.0
1993-94	28[1]	287.0*

Source: Queensland Department of Primary Industries - Fisheries Division.
[1] This figure comprises 24 individual permits and 4 community permits. * As at 23.6.94.

Management of the fishery

The Queensland beche-de-mer industry accounts for 75-80 % of the Australian activity and is undergoing a management review. The purpose of the review is to implement a management plan which will give the industry a long-term, economically viable and sustainable future.

Responsibility for management of the industry was transferred to the Queensland Fish Management Authority, a statutory body, in July 1994.

An industry working party has made a number of recommendations (Taylor-Moore, 1994; Taylor-Moore and Kerby, 1994) regarding the management of the Industry. The management plan developed and implemented by the QFMA has taken these into consideration. A synopsis of the management arrangements follows.

- All commercial participants in the beche-de-mer fishery should be licensed.

- The limited entry to the fishery which currently exists to be continued and restricted to 15 collectors.

- The sustainable levels of fishing for beche-de-mer at this stage are unknown; however there is general acceptance that the Total Allowable Catch (TAC) could be raised from 500 wet weight tonnes to 1000 wet weight tonnes provided limits are placed on the taking of *Holothuriidae nobilis* (black teatfish). Monitoring of species performance would be on-going.

- Size limits are to be recommended and contained in a Code of Practice to be developed in consultation with industry and management authorities. These would be based on the following:

H. scabra	Sandfish	16 cm
H. atra	Lollyfish	15 cm
H. nobilis	Black teatfish	25 cm
H. fuscgilva	White teatfish	32 cm
H. echinites	Deepwater redfish	12 cm
T. ananas	Prickly redfish	30 cm

- Authorisation to collect beche-de-mer should be endorsed on a maximum of two primary vessels. For the collection of sandfish a maximum of six dinghies could be used..

- A review of the management arrangements will be carried out during 1996.

The implementation of a management plan will put the industry on a firmer base for sustained activity. Collection however is only part of the beche-de-mer industry; processing with respect to practices employed, product quality and development are also of equal importance to the industry's survival.

It is the processing and value adding aspects of the industry on which this publication will focus.

CHAPTER 2

HOLOTHURIANS

by

L.R.G. Cannon and B.R. Rich

Holothurians are one of the major groups of the large invertebrate phylum Echinodermata, literally "spiny skinned" animals. A recent finding in the deep water has added a sixth class Concentricycloidea (sea daisies) to the phylum: five classes are well known, *viz.* the sea stars (starfish) Asteroidea, sea lilies and featherstars (Crinoidea), brittlestars (Ophioroidea), sea urchins (Echinoidea) and sea cucumbers (Holothurioidea).

Echinoderms are exclusively marine animals which, because of their "spiny skins"' are well represented in the fossil record. About twice as many extinct echinoderms are known as living forms of which there are around 6000 known species. Holothurians are an ancient group with records dating from the Ordovician; today about 1000 species are known.

The spiny skin of echinoderms contains calcium carbonate (calcite) plates which in sea cucumbers are usually reduced to intradermal ossicles or spicules. These are generally microscopic, two or three dimensional, quite diverse in form and in some species greatly reduced in number. Because sea cucumbers have a body wall without skeletal support to give it distinguishing shape or external characteristics, biologists have used the tiny calcareous spicules in the skin as a means of identifying species.

Echinoderms are fundamentally bilaterally symmetrical animals (Figure 1), but for a long time this has had superimposed upon it a pentaradial symmetry which is so characteristic of living echinoderms. Externally this is most obvious in the five rows of tube feet (the ambulacra) which extend along the arms or body. Interestingly, sea cucumbers have evolved further to overlay an external bilateral symmetry on the internal five armed symmetry. Holothurians are thus sausage shaped animals with a mouth at one end surrounded by feeding tentacles and an anus at the other with the gut and gonads lying within a fluid filled body cavity, the coelom. Compared with other echinoderms, they appear to lie on one side with, in some species, distinct upper and lower sides. The lower side (ventral) sometimes has three ambulacra and is known as a sole (e.g. Family Stichopodidae).

One of the most characteristic features of echinoderms is the water vascular system. This is a special development of the coelom which consists of a fluid filled circular vessel around the mouth and a system of five radiating vessels from which rows of tube feet arise. Water is drawn in from the sea (or in the case of holothurians from the main coelomic or body cavity) and its pressure is controlled by special bulbs (Polian vesicles). This hydraulic system controls the tube feet, enabling them to extend and retract, which provide the most important means of locomotion and feeding.

Although some holothurians can swim by undulating the whole body, or use such undulations to aid in crawling, most locomotion is achieved by the co-ordinated extension and retraction of the hundreds of tube feet along the five ambulacra. In holothurians the tentacles which surround the mouth are modified feet.

Holothurians feed in two ways: by extending the tentacles, which may be branched, to form a web which traps passing food in mucus, or by using the tentacles to gather sediment into the mouth. All those holothurians that are of commercial interest as trepang use this latter method and are members of the Aspidochirotida order (Table 2). The tentacles in this group are called peltate, i.e. they terminate in a small disk ringed by a fringe of finger-like projections. Ingested sediment passes slowly along the gut, the contained micro biota is digested and castings, not unlike those of a large earthworm, are discharged through the anus.

The sexes are indistinguishable externally and copulation does not occur. Male and female holothurians sometimes aggregate in response to seasonal rhythms, which on the Great Barrier Reef may coincide with the coral spawning in early summer, and release sperm and eggs into the sea. Aspidochirotes may raise their anterior body up at this time and gametes stream out from a pore just behind the anterior end on the upper surface. Fertilisation occurs in the sea, and a series of delicate larvae are formed (auricularia, doliolaria, pentacula) and disperse in the plankton before metamorphosis occurs and they settle in the sediments as small sea cucumbers.

A few sea cucumbers, notably members of the aspidochirote genus *Holothuria*, may reproduce asexually by autotomy (fissiparity), i.e. they divide in two. Sometimes a large proportion in one locality may adopt this strategy and this could account for the high numbers of some species subsequently found.

Growth and development has only been studied in a few species, e.g. *Stichopus japonicus* but generally sea cucumbers are not thought to live more than a few years. Their early life in the wild is difficult to study due to their small size. Presumably this is when they are most vulnerable to predation.

Although accurate identification relies on analysis of the spicules (Cannon & Silver, 1987; Cannon, 1994) which may be digested with bleach from snips of body wall, commercial species can be reliably recognised alive using such criteria as size, form, texture, colour and pattern. Only a handful of species, all aspidochirotes, are fished. These fall into the families Stichopodidae (e.g. *Thelenota* and *Stichopus*) and Holothuriidae (*Actinopyga, Holothuria*). Not all members of these families or even of these genera are favoured. *Thelenota ananas,* the "prickly redfish", is a target species and *Stichopus japonicus* is the major commercial species in the north-west Pacific. *S. chloronotus* is taken, but *S. horrens* is quite unsuitable as trepang. *Holothuria* is a large genus with several subgenera. Among these *H.* (*Microthele*) *nobilis*, the "teatfish", is probably the most prized of all trepang. *H.* (*Metrialyla*) *scabra*, the "sandfish", is taken commercially in some places and may be highly valued, but because of the density of spicules in the body wall, prices are dependent on how and to what extent these spicules are removed. Other species of *Holothuria* may not be acceptable at all, but all species of *Actinopyga* are actively sought.

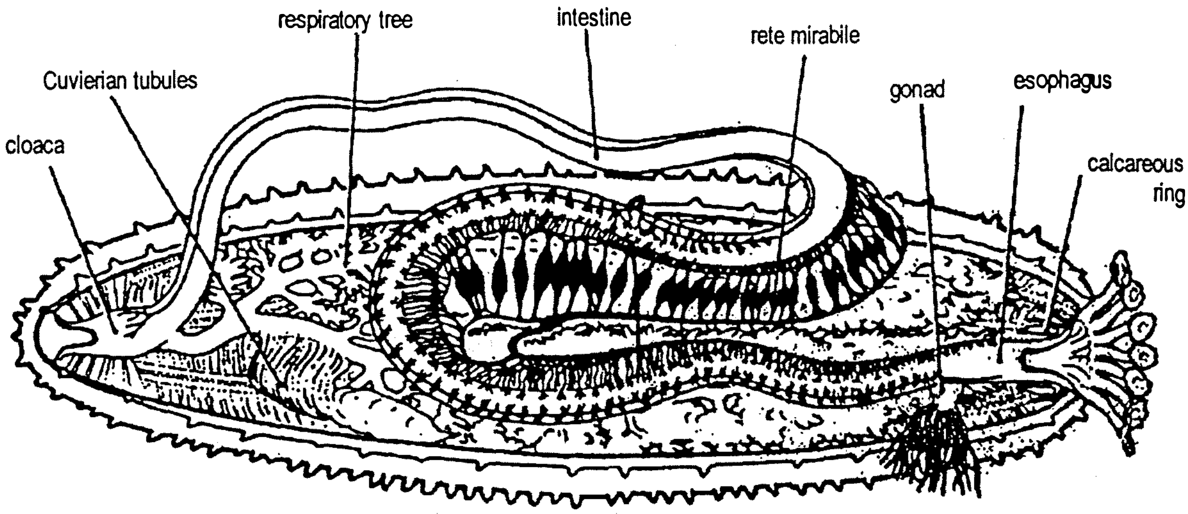


Figure 1: Anatomy of a Sea Cucumber

Source: Cannon and Silver (1987)

Table 2: Characteristics and Classification of Holothurians

Organs	Order: Aspidochirotida	Elasipoda	Dendrochirotida	Molpadida	Apodida
Tube feet	Numerous	Numerous	Numerous	Only as anal papillae	Numerous
Oral tentacles	Small, leaf-shaped	Small, leaf-shaped	Large, branching	Digitate	Variable
Oral retractor muscles	None	None	Present	None	Sometimes
Respiratory trees	Present	Present	Present	Present	Absent
Cuvieran tubules	Sometimes	None	None	None	None
Body wall	Thick, leathery	Thin or gelatinous	Thick, leathery	Thin, transparent	Thin, transparent
Families & Selected species	HOLOTHURIIDAE *Actinopyga sp.* *A. echinites* *A. mauritiana* Holothuria (sub-genera) *(Halodeima) atra* *(Metriatyla) scabra* *(Microthele) nobilis* *(M.) fuscogilva* STICHOPODIDAE *Thelenota ananas* *T. anax* SYNALLACTIDAE *Mesothuria parva*		PSOLIDAE CUCUMARIIDAE *Pentacta australis* PHYLLOPHORIDAE	MOLPADIIDAE CAUDINIDAE	SYNAPTIDAE CHIRIDOTIDAE

Source: Green Mottet, 1976; Cannon & Silver, 1986, 59-60.

The flesh of sea cucumbers differs somewhat from other animals as it is composed of connective tissue rather than muscle (Green Mottet, 1976). The flesh also contains a large percentage of water, which explains the dramatic loss of weight during processing.

The proximate compositions of three common species of dried sea cucumber found in northern Australian waters are shown in Tables 3-6.

Table 3: Proximate Composition of Dried Sea Cucumber

Composition %	*M. nobilis*	*A. mauritiana*	*H. atra*
Moisture	3.6	2.7	4.1
Fat	3.4	3.9	3.8
Protein	76.5	78.2	76.2
Ash	16.6	15.2	15.9
Salt	11.7	13.8	11.0
Nitrate Nitrogen (mg/kg)	75	80	60
Cholesterol	< 0.1	< 0.1	< 0.1

Table 4: Elemental Analysis

Element	*M. nobilis*	*A. mauritiana*	*H. atra*
Potassium (%)	0.33	0.28	0.62
Calcium (%)	2.2	3.1	1.1
Magnesium (%)	1.1	1.0	0.83
Sodium (%)	4.6	4.6	4.1
Copper (mg/kg)	1.2	2.4	2.2
Zinc (mg/kg)	180	140	630
Manganese (mg/kg)	1.2	1.4	0.79
Iron (mg/kg)	57	240	160
Aluminium (mg/kg)	12	8.5	9.6
Molybdenum (mg/kg)	4.6	2.4	1.9

Table 5: Fatty Acid and Phospholipid Content (mg/g)

Fatty Acid	***M. nobilis***	***A. mauritiana***	***H. atra***
Myristic (14:0)	0.06	0.07	0.06
Palmitic (16:0)	0.23	0.36	0.36
wp Palontoleic (16:1)	0.13	0.29	0.28
Stearic (18:0)	0.17	0.18	0.21
w9 Oleic (18:1)	0.05	0.05	0.06
w7 Oleic (18:1)	0.03	0.05	0.10
w6 Linoleic (18:2)	0.04	0.03	0.04
Nonodecanoic (19:0)	0.01	0.02	0.04
w3 Linolinic (18:3)	0.03	0.01	0.02
w3 (18:4)	0.02	0.01	0.02
Arachidic (20:0)	0.09	0.05	0.11
w11 Gadoleic (20:1)	0.32	0.18	0.67
w9 Gondoeic (20:1)	0.01	0.01	0.04
w7 (20:1)	0.01	0.01	0.02
w6 (20:2)	0.02	0.01	0.05
w6 Arachadonic (20:4)	0.41	0.30	1.17
w3 Eicosapentaenoic (20:5)	0.20	0.12	0.24
Behenic (22:0)	0.05	0.03	0.12
w6 Docosatetraenoic (22:4)	0.02	0.01	0.06
w3 Docosapentaenoic (22:5)	0.01	0.00	0.04
w3 Docosahexaenoic (22:6)	0.02	0.02	0.03
w9 cisatetracosanoeic (nervonic) (24:1)	0.12	0.08	0.35
Total	2.95	2.63	5.46
Phospholipid	2.94	1.89	6.83

Table 6: Amino Acid, Crude Protein, Ash, Phosphorus, Calcium and Gross Energy (GE) Contents (g/kg on dry matter basis)

Amino acid	*M. nobilis*	*A. mauritiana*	*H. atra*
Lysine	8.99	6.61	10.85
Histidine	1.57	1.04	2.27
Arginine	66.80	62.27	48.62
Aspartic acid	76.04	71.48	72.67
Threonine	32.39	28.52	32.48
Serine	31.20	29.98	27.30
Glutamic acid	108.73	102.87	109.19
Proline	77.99	78.92	60.07
Glycine	142.20	137.78	111.46
Alanine	79.83	72.70	57.76
Valine	26.20	24.21	21.63
Methionine	5.25	5.59	5.42
Isoleucine	14.43	10.55	13.45
Leucine	27.60	25.22	24.46
Tyrosine	14.14	13.17	16.46
Phenylalanine	13.12	13.48	16.65
Cystine	3.47	3.04	6.18
Tryptophan	1.78	4.03	5.64
Dry matter	952	962	953
Crude protein	811	806	711
Ash	194	236	172
Ether Extract	Nil	Nil	7.4
P	1.3	0.4	1.1
Ca	16.8	23.5	11.9
GE (MJ/kg)	17.02	16.42	18.48

Colour and pattern can be quite variable and much research needs to be done on the geographic and habitat correlations with these characters and with any commercial criteria. Holothurians are sought as trepang according to the thickness and texture of the body wall. Thin walled species or those with a body wall heavily impregnated with spicules cannot be expected to fetch economic returns. *H. (Metriatyla) scabra,* for example, requires additional processing (traditionally rotting the outer skin and scraping away the spicule rich skin) before marketing. *H. fuscogilva* also brings higher returns when the outer layer of spicules is removed.

Although some studies have been conducted on habitat requirements of sea cucumbers, we still know far too little about the conditions that induce large aggregations. Harriott (1985) found in the central Great Barrier Reef that populations of commercial species varied widely on different parts of the same reef complex. She found no obvious differences, however, between the geographic locations or the substrates to explain the differences in abundance. This is an area which needs further investigation. A collaborative approach with industry to identify food sources, geographic characteristics and seasonal considerations is a suggested approach.

The alternative to harvesting is farming. The Japanese successfully grow *S. japonicus.* However, the biology of tropical species such as *H.(Microthele) nobilis, H.(Metriatyla) scabra* and the *Actinopyga* spp. is not sufficiently known, although these are the favoured commercial species. Attempts in Fiji to grow-on wild caught holothurians in cages have not proven successful. Despite their evidently firm body wall, the peculiar catch-connective tissue does enable them to "flow" through cages set to contain them.

A further fruitful area of research concerns the methods of processing, much knowledge of which appears to have been lost. Despite there being only a handful of commercial species (around 10), the historical literature of trepang trading (Saville-Kent, 1893) provides hundreds of product names. These presumably reflected the combinations of species, localities, sizes and processing regimes used prior to trepang reaching the market.

CHAPTER 3

PROCESSING OF BECHE-DE-MER

In order to produce a premium quality product, good quality raw material must be supplied. A number of practices may be employed to ensure this raw material quality.

Collection without Processing Facilities

Where the sea cucumber is being collected off shore without access to processing facilities there are a number of practices that should be followed:

- Keep collected specimens out of the sun; preferably place directly into iced seawater (Ke *et al*, 1983). As self-evisceration may occur, it is important to give each specimen a thorough washing with clean seawater before transfer into iced holding tanks. This step is important in reducing the surface microbiological load and extending keeping quality. It is also important not to overload the chilling capacity of the holding tanks. Significant temperature fluctuations will stimulate psychrotrophic growth.

- Where possible keep different species separate from one another, as different species behave differently, such as in the ejection of cuvarian tubes (*Bohadschia argus*) and slow body disintegration (*Stichopus chloronatus*). It also assists when delivering to the processing facility in reducing handling time and costs.

- Due to temperature shock the sea cucumber will contract when exposed to the chill temperatures prior to death. By using flat, smooth surfaces in holding bins and tanks, and sufficient space, the specimens should maintain regular (cylindrical) shape. This assists in packing, helps to maintain the surface condition and quality of product.

- If evisceration is being carried out, this is best performed after initial temperature shock. Depending on market requirements and species collected, evisceration may be completed by a longitudinal cut, generally along the dorsal surface or by a slit made at one end and internal organs squeezed out. After evisceration a thorough washing in clean seawater is required prior to transfer to holding tanks.

Another means of preservation is salting, where the sea cucumbers following evisceration are packed in salt. High salt concentration limits microbial growth and acts as a desiccant by drawing out some of the water contained in the sea cucumber's body walls. If dry salting is used it is important to coat the internal cavity with salt. As the water removal progresses a slurry will form.

A further advantage of using salt is it can shorten cooking time and therefore shrinkage since it brings about partial desiccation. As the sea cucumbers become more dense the incidence of lamination (where the outer skin layer separates from the flesh) is less or if present helps in overcoming it's effects.

Collection with Limited Processing

Where collection occurs with limited processing available, good practice involves the above procedure; however before transfer to storage, the specimens generally receive at least one boiling. The following points apply:

- After initial temperature shock from the iced water, specimens should be grouped according to size. Group members are then placed into the cooker and boiled for 2-5 minutes, depending on size. At this stage the specimens will have taken on a swollen appearance, and have shrunk in size to some degree. They are then eviscerated and prepared for frozen storage or further boiling (if internal organs are not being further utilised, otherwise evisceration occurs prior to boiling).

- If freezing, it is recommended that rapid freezing take place (refer Chapter 5) in order to limit ice-crystal size and subsequent cell disruption.

- When in frozen storage the temperature should not vary by more than 5 °C to avoid crystal growth (commercial freezers generally operate between -25 to -40 °C).

- It is good practice to change the water in the cooker regularly and when processing different species.

- Regardless of how the specimens are packed for storage, they should be tagged with species name and date of packing for convenience of handling at the processing facility or consignment preparation.

Processing

The processing of sea cucumbers has slight variations according to the species being processed, and intended market and use of the product being produced. As there appears to be no absolute method for processing, a number of methods are given below. They are listed according to the end products formed.

Dried beche-de-mer products

- **Traditional Methods**

Species: **All except** *Metriatyla scabra.*

1. Place intact sea cucumbers into boiling water, ensuring complete coverage. Stir continuously and examine frequently. Time varies from a few minutes upwards. When animals swell up, remove from water and cool.
2. Slit along dorsal (back) side to within 2-3 cm of mouth and anus.
3. Place animals in boiling water for 15-30 minutes. Shrinkage and hardening will occur. Continue to cook until they become firm and rubber-like. (If they start to shrink and soften they are overcooked).
4. Remove the animals from the boiling water and place into cold sea-water.
5. Open the beche-de-mer and empty loose contents. Cut out organs that run through the centre without leaving stubs. Leave inner wall lining intact.
6. Smoke drying is achieved by placing the sea cucumbers split side down on trays and placing over heat. Spacers (sticks) may be required to keep body cavity open.
7. Drying usually takes between 24 to 48 hours.
8. Sun curing is then achieved by brushing off any adhering matter and placed in the sun to complete the drying process. This usually takes 4-5 days. On completion of drying a powdery substance will have formed on the surface of the beche-de-mer.

(Sachithananthan, 1974)

Species: **General except** *Metriatyla scabra*

1. Processing involves cleaning, boiling and smoke- or sun-drying.
2. Cleaning involves the removal of the guts and chalky epidermis if present.
3. Small thin walled species are degutted by being induced to eviscerate.
4. Large, thick walled species such as *Actinopyga mauritiana, A.miliaris, Microthele nobilis, Stichopus variegatus* * and *Thelenota ananas* are slit on the ventral side and internal organs removed.
5. The animals are then boiled in sea-water until they achieve a rubbery consistency.
6. Drying is achieved by smoking or drying the body walls in the sun, or both. Variations exist, such as racks of sea cucumber placed over burning coals to dry and then finished off with sun drying.

Note: Alum (Potassium aluminium sulphate, $K_2Al_2(SO_4)_4.24H_2O$) is sometimes added to the sea-water at the cooking stage. It is reported that it helps to prevent mould and fungi growth, shortens boiling time and hence minimises shrinkage.

* Should be kept immersed in sea-water until boiling.

(Trinidad-Roa, 1987;16)

Species: ***Stichopus japonicus; Holothuria argus; Pstsdyivhopud nigripunctatus*** and ***Cucumaria japonica***

1. The living sea cucumber is placed in fresh water for a short time (hours) in order to clean the intestinal tract.
2. Intestines are removed through the anus in dilute salt water using an eviscerating apparatus. The cavity is brush cleaned and drained.
3. The sea cucumbers are put into boiling salt water at Baumé 3°, and temperature lowered to 95° C and simmered for 1-1.5 hours. (Swollen bodies are deflated by piercing with a needle).
4. Animals are removed from the hot water and any adhering foam or scum removed. The animals straightened and placed into a basket.
5. After cooling, the bodies are roasted at 70° C until cooked, then dried in the shade for 5 days.
6. Dried beche-de-mer are placed into straw bags for 2-3 days for moisture equalisation.
7. They are then dried for a further 2-3 days.

Yield is approximately 5% of raw product.

(Tanikawa, 1985, 222)

Species: ***Microthele nobilis***

1. Animals are squeezed to remove any residual gut entrails (assuming evisceration occurred during storage).
2. They are then placed into boiling water and boiled for 30-45 minutes. Bloated animals are punctured at the mid-dorsal region to prevent breakage.
3. The animals are removed from the cooker and cooled on racks.
4. They are then cut open along the mid dorsal line leaving some portion at the anterior and posterior ends. Any remaining visceral portions are removed and the animals washed in lukewarm water.
5. They are placed in boiling water for a second cook for a further 15-20 minutes. The animals shrink and become hard, and are removed from the cooker.
6. Spacers are placed between the cut edges of the dorsal wall to expose the internal cavity.
7. The animals are sun dried on platforms.

Species: ***Metriatyla scabra***

1. Clean the sea cucumber in sea water.
2. Evisceration is achieved by making a 20-30 mm slit near the posterior end, and squeezing out the internal organs.
3. The sea cucumbers are then placed into boiling water at a rate which will allow the temperature to be maintained.

4. Stirring should continue for 45 minutes at intervals of 3 minutes during the first twenty minute period and then at 5 minute intervals for the remainder oi the cooking process.
5. Boiling is carried out until the animals become rubbery and bounce like a rubber ball.
6. The cooked animals are then placed inside moist pits and covered with sand. These pits dug in the sand are 100cm long, 75 cm wide and 20 cm deep with an even floor. Animals are placed next to one another in a single layer. The remain in the pit for 15-18 hours (Often buried in the evening and removed ii the morning). The purpose of this step is to bring about bacterial action on th skin of the animals in order to facilitate its removal along with adhering calcareous deposits, embedded mud etc.
7. On removal from the pits the animals are washed and cleaned in seawater, removing the outer layer of pasty material. The animals should be free from all chalky deposits (If not, the above procedure of boiling and burying is repeated) and should have a cylindrical appearance and rubber-like texture.
8. The animals are then boiled for a further 45 minutes, with thorough stirring.
9. They are then transferred to drying platforms.

In India (Gulf of Mannar and Palk Bay) species such as *Holothuria (Theelothuria) spinifera* and *Bohadschia marmorata* are also processed in this way.

(James 1989; 1

Species: ***Metriatyla scabra***

1. The sea cucumber are first slightly heated to induce the animals to disgorge their internal organs.
2. They are washed and heated strongly (boiled) for approximately 1 hour.
3. They are buried in sand and sprinkled with sea-water.
4. The outer skin is removed after 18 hours.
5. The animals are washed.
6. They are boiled for a few minutes.
7. The animals are laid out for sun drying.

(Jacob 1973; 2

Species: **General**

1. The sea cucumbers are cut on the ventral side starting at the anus and going halfway to the anterior end of the animal.
2. The internal organs are removed.
3. After cleaning and sorting by size they are boiled from 10 minutes to 1.5 hours, the large specimens taking the longer cooking time.
4. The animals are removed from the cooker when a characteristic cooked odour is given off. If the animals bloat up during cooking they should be pierced.
5. Following cooking, and while the animals are cooling, their bodies should be straightened.

6. If the species being processed have calcareous deposits in the skin, such as *Metriatyla scabra*, they are placed in moist sand for 12-18 hours.
7. The animals then have their outer layer peeled off, are rinsed and then re-boiled.
8. The sea cucumbers are then dried by sun drying, or partly sun dried and smoked over a wood fire, or, as in Japan, roasted at 70° C before drying.

(Green Mottet 1976; 20)

- **Modern Methods**

The Australian beche-de-mer processing industry over recent years has moved away from the traditional methods by employing modern processing equipment. Gas or steam jacketed cookers have replaced wooden fires and forty-four gallon drums (Plate No. 1). Tunnel, cabinet and heat pump dryers have replaced sun drying, although solar drying rooms are still used, mainly as a finishing stage.

Processing methods used can vary considerably as demonstrated by the above, and do vary from establishment to establishment. As a general guide the following methods are cited while acknowledging variations are employed.

Method 1

Species: **General** but mostly used on ***Microthele nobilis, M. axiologa, Thelenota ananus, Actinopyga mauritiana,*** and ***Halodeima atra.***

1. Place sea cucumber into boiling water and cook till animals swell up, usually 2 to 5 minutes.
2. Remove the animals from the cooker and cool until they are comfortable to handle (say 40° C).
3. Remove the internal organs by making a slit along the dorsal side to 2-3 cm from the anus and similarly to the cloaca. For smaller species, for example *H. atra* and *M. scabra* the slit is made at the posterior end.
4. The animals are then replaced in the cooker and boiled for 20 to 35 minutes. The time varies according to size and species but all are treated till their texture is rubbery and firm.
5. They are then placed on racks and put into the dryer (Plate Nos. 2 and 3). A typical cabinet dryer would operate with initial temperature around 70-75° C and 30-35 % relative humidity and then the temperature would be dropped to around 60° C. For heat pump dryers, initial operating conditions are typically 57-60° C and relative humidity of 24-35%. Drying is generally achieved in 48-72 hours.
6. Depending on market requirements, drying may also involve 2-3 days in a solar drying unit prior to packaging and shipment (Plate No. 4).

Plate No. 1: An Example Of A Modern Gas Cooker Used In Beche-de-mer Processing
(courtesy Trepang Fisheries)

Plate No. 2: Racks Of Beche-de-mer At Various Stages Of Drying

(courtesy Trepang fisheries)

Plate No. 3: Examples Of *M. Scabra* Laid Out On Racks For Drying
(courtesy Del Pty Ltd.)

Plate No. 4: An Example Of A Solar Drying Finishing Room
(courtesy Australia Lor Fisheries Pty Ltd.)

Method 2

Species: **as for method 1**

1. The sea cucumbers are induced to disgorge their internal organs.
2. They are then placed into boiling water and simmered for approximately 20 minutes, the internal pressure is released as required by piercing.
3. They are then cooled, and cleaned of any adhering matter.
4. The animals are then returned to the cooker for a second boiling for 20-35 minutes and cooked until shrinkage and firmness occurs (Plate No. 5).
5. They are then placed on racks and placed in dryers as for method one.
6. A third boiling or steaming is sometimes employed to overcome misshaping of animals that has occurred during the drying process.

Decalcification of *H.scabra* and *H. fuscogilva*

Traditional methods of removal of the outer coating of calcium from *H. scabra* has been mentioned previously (refer James, 1989, 16). Conventional approaches to this problem include chemical and enzymic removal..

Chemical removal

One method employed uses a solution of sodium hypochlorite (20-30% strength). The animals are immersed in the solution and allowed to stand for 20-60 minutes. The time of immersion depends on the solution strength, level of loading and thickness of deposit. They are then washed with a high pressure water hose, some manual handling still may be required A significant amount of the remaining adhering calcium deposits should detach during the cooking step. A further application of the high pressure hose may be necessary.

On removal from the cooker, rubbing with a firm bristled brush or by hand will help remove remaining deposits (Plate 6). Further removal occurs in drying.

When soaking the sea cucumbers in the sodium hypochlorite solution routine checks should be made to prevent surface pitting or bleaching from over exposure.

Any sodium hypochlorite residues should be removed during cooking and drying. It is recommended that trial samples be prepared and market assessment obtained before commercial lots are processed, to ensure flavour characteristics have not altered.

a

b

Plate No. 5: Sea Cucumbers Before (a) And After (b) Cooking With Resulting Physical Changes

(courtesy Trepang Fisheries Pty Ltd.)

Plate No. 6: *H. Scabra* After Calcium Removal By Sodium Hypochlorite Solution

(courtesy Trepang Fisheries Pty.Ltd.)

Enzymic removal

Proteolytic enzymes, such as bromelain, an enzyme preparation isolated from the stem of ε pineapple, may be used. The enzyme acts on the outer skin by hydrolysing the protein. Commercial preparations, such as that supplied by Solvay Biosciences Pty. Ltd., are in the form of a amorphous powder. The enzyme optimum working conditions are:

pH range:	5.0 to 8.0
Temperature:	50 to 60 °C at pH 5.0
Inactivation:	high temperatures and outside pH range or combination of both.
Inhibitors:	the presence of oxidising agents, alkylating agents and heavy met: e.g. zinc and iron. Inhibitory effects can be reversed by the additi of L-cysteine.
Solubility:	readily soluble in water (Solvay Biosciences Pty Ltd).

Use level will depend on the degree of hydrolysis desired, pH, temperature and time. In general, increasing the concentration will increase the rate of hydrolysis.

It is recommended that trial runs be attempted first to establish solution strength, loading quantities, re-use characteristics and rate of activity. For example 15-20g bromelain in 20-: litres of water. Loading rate up to 20kg of sea cucumber. At 40°C approximately 15 minutes, at 30°C approximately 30 minutes is required. Over exposure may result in surfac pitting. (Plates 7 and 8).

A useful addition to the water to lower the pH to around 5.0 is vinegar (approximately 4% solution of acetic acid).

Reconstituted beche-de-mer products

Drying beche-de-mer is a means of producing a shelf stable product until ready for use. It offers a convenient way of handling and transporting the product from the various processin centres.

However before it can be consumed, it must first be reconstituted. Like the drying process, the reconstitution process has a number of different methods which could be followed. Thre of these methods are reproduced below:

Method 1

1. Immerse dried samples in cold water for 48 hours at refrigeration temperature (4° C).
2. Boil the soaked beche-de-mer for 10 minutes and allow to cool to room temperature in cooking water.
3. Re-boil for 10 minutes, cool and store in clean water for 16 hours at refrigeration temperature (4° C).

At this stage the meat should be firm, with the surface of the skin becoming gelatinous. If over reconstitution occurs the meat becomes gelatinous and begins to break apart.

(Robertson *et al* 1987).

Method 2

1. Cover the beche-de-mer with warm water (60° C). Leave to soak for 12-24 hours. Change the water frequently during soaking.
2. Drain the beche-de-mer, cover with warm water and bring to the boil for 10-20 minutes.
3. Drain and rinse the beche-de-mer with cold running water until able to be handled.
4. Using a firm brush, scrub each beche-de-mer under cold running water.
5. Repeat the boiling and cleaning steps until the beche-de-mer is completely soft and gelatinous.
6. When softened, ease open cavity and remove any internal organs.

(Lonimar Australia Pty. Ltd)

Method 3

1. Soak beche-de-mer for 4 hours in cold water. At the end of soaking scrub with a firm brush.
2. Place the beche-de-mer again in cold water and bring to the boil, cook for 5 minutes, and allow to cool in the water.
3. Repeat this process ten times.

On the completion of this soaking, boiling and cleaning process the meat is swollen and soft.

(Bruce, C. (1983; 21) based on the method by Schwabe)

Other products

Fresh consumption

Consumption of fresh sea cucumber has traditionally been by inhabitants of the Indo- and South Pacific countries (Trinidad-Roa, 1987); Japanese (Green Mottet, 1976) and Indians c the North-west Coast (North America) (Dassow, 1959; 1959).

Some species are prepared as salads and eaten fresh after removal of internal organs. They are used in a similar fashion to that of *Holothuria (Theelothuria) notabilis* which are usuall consumed with vinegar and salt (Trinidad-Roa, 1987; 15).

In Japan sea cucumbers are sold fresh in the market place (*Stichopus japonicus* is a commonly consumed species). For fresh consumption the animals are prepared in the following manner:

1. The animals have their viscera removed and the body wall cut into slices.
2. These slices may receive a quick boil to improve the colour.
3. The slices are then soaked in a sauce made of soy sauce and vinegar in equa parts. Monosodium glutamate is used to season the slices.

The vinegar (acetic acid) causes the meat proteins to coagulate and harden. This results in 1 product having a chewy texture (Green Mottet, 1976; Tanikawa; 1955).

Dassow (1959) refers to fresh sea cucumber being used in the North Pacific [Like those fou in Japanese waters, these species are non-tropical and less toxic than those found in tropical waters (Bakus, 1974)]. He describes their preparation as:

1. The white muscle is peeled or cut from the adhering skin and washed.
2. The muscle is then sliced into thin strips.
3. These strips are then simmered in a small amount of salted water for a few minutes.

These strips can then be used in the same way as raw clam meats, for example: minced and used to make chowder, fritters, and sea cucumber dip. The dip is prepared as for clam dip using fresh cream, cream cheese and seasoning.

Dassow (1959) also mentions an alternative preparation used by the Indians of the North-we coast where:

1. The sea cucumber is eviscerated.
2. The animal (with skin attached) is then boiled for approximately 20 minutes roasted in a fire pit.

Plate No. 7: *H. Scabra* After Enzymic (Bromelain) Treatment To Remove Calcium Deposits

(courtesy of Trepang Fisheries Pty.Ltd.)

Plate No. 8: An Example Of Severe Pitting And Surface Breakdown Due To Excessive Exposure To Bromelain Activity

Canned sea cucumber products

Another method of processing sea cucumber is canning. This involves the preparation of the meat and other ingredients, mixing and filling into metal cans or glass containers. Once filled and sealed, the containers are then heated in a retort to a predetermined time-temperature treatment which ensures that all the bacteria present are killed. These products should then be shelf stable with respect to microbiological activity. Two methods cited in the literature are shown below. A third method is given from trials conducted as part of this study.

Method 1

Species: ***Parastichopus californicus*** **and** ***P. parvimensis***

1. Eviscerate and wash sea cucumber.
2. Boil in a 3% citric acid/sodium citrate buffer solution at pH 3.5 for 1 hour.
3. The sea cucumbers are then placed into 473 ml glass jars in a 3% citric acid/sodium citrate solution at pH 3.5.
4. Processing is then carried out in a steam cabinet to an internal temperature of 90.6° C for 5 minutes.
5. The jars are then cooled in air to ambient temperature.

(Change-Lee *et al*, 1989).

Method 2

Species: **North Pacific species**

1. The sea cucumbers are eviscerated and cleaned.
2. The skin is peeled or cut from the flesh.
3. The flesh is then minced and placed in brine.
4. The minced sea cucumber and brine are then placed into ½ pound (225 g) cans with c-enamel, and vacuum-seam.
5. These cans are then processed for 35 minutes at 240° F (115.6° C) at 10 pounds (68.95 KPa) steam pressure.
6. This is followed by water cooling.

(Dassow, 1959)

Method 3

Species ***H. nobilis*** **and** ***T. ananas***

1. The sea cucumbers are placed into boiling water and blanched.
2. They are then eviscerated and cleaned.
3. The sea cucumbers are cooked for 15-20 minutes.
4. The skin is then peeled or cut off and the sea cucumbers sliced into approximately 1 cm thick slices (Plate No. 9).

5. The slices are then packed with brine into 450g cans using 250g of sea cucumber and 200g brine (3% saline).
6. The cans are then sealed under vacuum.
7. They are then retorted at 121^{0}C (250^{0}F) for 35 minutes and water cooled for approximately 35 minutes (Plate No. 10).

Fermented sea cucumber product - Konowata.

Species: **Japan environ species**

1. Prior to killing the sea cucumbers, they are kept in clean water for a short period of time in order to empty the intestines.
2. The animals are then gutted.
3. The intestines are squeezed out by hand, without causing breakage.
4. They are then washed in clean salt water and drained.
5. The viscera are then salted using 10-15% salt by weight to raw viscera.
6. One third of this salt is added first to the draining viscera (the salt increases the amount of water being extracted).
7. Following further draining the remainder of the salt is added.
8. The mixture is stirred frequently for 5½ hours.
9. When dripping ceases, the mixture is placed into a barrel and covered with a lid.
10. The mixture is then only stirred occasionally for approximately 1 week while fermentation occurs.
11. At the completion of fermentation, the Konowata is packed into small (65 g) glass bottles.

Long intestines are more highly prized than shorter ones.

(Green Mottet, 1976)

The collection of plates on pages 37 and 38, give a comparison of various species of beche-de-mer. Each frame depicts a specimen which has received a first cook and evisceration (Top), and a specimen in its finished dried form (Bottom) (courtesy of Trepang Fisheries Pty Ltd.) The last plate compares various dried species with one another (courtesy of Del Pty Ltd.)

Plate No. 9: Peeled And Sliced *H. Nobilis* Ready For Canning

Plate No. 10: Canned Product

CHAPTER 4

PRINCIPLES OF FREEZING DRYING

Principles of Freezing

The physical phenomena that occur when foodstuffs are frozen are:

solidification of a high proportion of the freezable water; and

volume increase due to ice-crystal structure

During freezing the following changes occur:

- The temperature is lowered due to the removal of sensible heat.
- Ice-crystals are formed. This stage proceeds in two parts:
  i) formation - where small ice-crystals are formed; and
  ii) crystal growth - where the individual nuclei increase in size.

These changes are both temperature dependent (Figure 2) and so temperature control offers a means of controlling the process and limiting disruption to the food's cellular structure. As can be seen by the graphs, the rate at which these proceed differ. Initially, rate of growth is faster than rate of formation (A). As the temperature decreases the rate of crystal formation is peaking while the rate of growth is beginning to decline (B). This divergence continues as the temperature continues to fall.

Therefore to avoid large crystal formation and possible cell structure damage, rapid freezing is required. By quickly lowering the temperature to that range where the rate of crystal formation is greater than that of growth, a large population of small crystals will develop.

When freezing a product, the measured temperature depends on time of freezing and the position of the measuring point. The point in the product at the end of the freezing process which has the highest temperature is termed the thermal centre (t_c). In homogeneous and isotropic materials, the thermal centre lies in the geometrical centre of the product.

Freezing is considered to be completed when the average temperature of the product is about equal to that at which it is to be stored (-20 - -25°C).
[t_c should not be more than 3 to 5 °C higher than the storage temperature].

When dealing with a pure substance, that substance has a freezing point. However when dealing with a mixture (such as sea water) it has a freezing range. In the instance of a salt and water solution the salt exerts a lowering effect on the freezing point. As ice crystals form, the solute (salt) in solution becomes more concentrated, and thus lowers the freezing point further. This phenomenon is best demonstrated by a phase diagram (Figure 3). The freezing point is being progressively depressed along the AC line. This depression effect continues until the point is reached where the whole freezes (C). This point is known as the eutectic point and from this point on everything freezes. The frozen mass is a mechanical mixture and no longer a true solution. The curve depicted by the line BC is the solubility curve of the salt, since the solid is in equilibrium with solutions that are obviously saturated with this salt.

Although freezing is continued, the temperature will be stable till all solution is solid then proceeds to decrease. This constant temperature is the result of the removal of latent heat of fusion.

The rate of freezing is dependent on a number of outside influences:

- Temperature difference between food and refrigerant.
- Thickness of the food item. Heat transfer through the frozen food is slow, therefore the larger the mass the greater the time taken to complete freezing.
- The degree and type of packaging.
- Cooling medium used. Heat is rapidly removed by conduction through metal.

Therefore the aim when freezing is to have the beche-de-mer at as low a temperature as possible before entry into the freezer. The freezing process should be carried out as quickly as possible in order to promote the formation of a large number of nuclei. Finally, in order to minimise crystal growth the storage area should not have large temperature fluctuations.

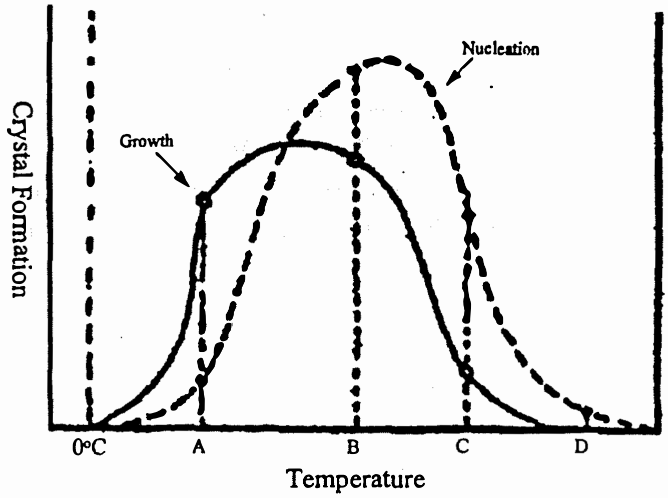


Figure 2: Ice-crystal Formation and Growth

Source: Schoonens (1981)

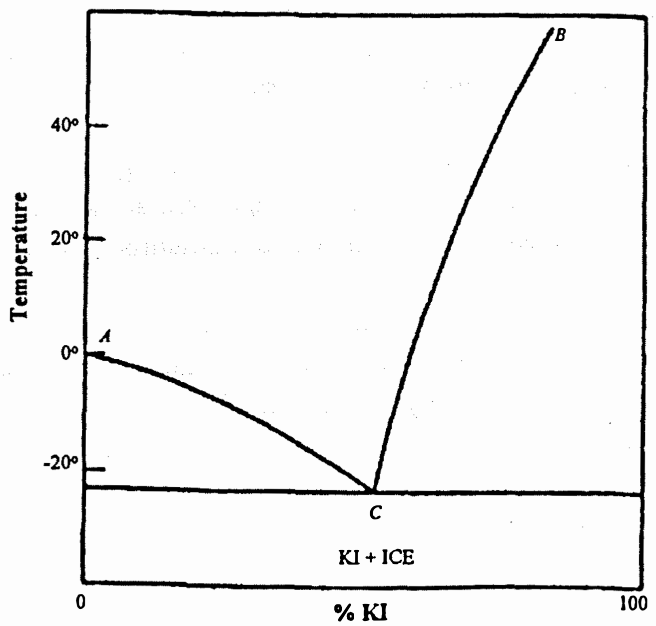


Figure 3: Salt-water Phase Diagram

Principles of Drying

The drying of sea cucumbers is an ancient practice used to extend shelf-life and aid in transportation, and to also bring about structural/textural changes when the dried products are reconstituted.

The production of dried sea cucumber is practised by many countries. This processing has in the past been carried out by solar drying with minimal application of modern technology. This is still the practice in many countries; however the situation has changed in Australia, with the industry's re-introduction. Modern, state-of-the-art artificial drying plants are now being used.

Whether traditional methods or modern equipment is being used, the principles of drying remain the same. The drying process involves two distinct stages (Figure 4):

1) Heat or energy transfer

2) Mass transfer

Energy in the form of heat must be transferred to the food material in order to bring about water migration to the free surface. This migration is influenced by the rate of heat transfer into the food material from the outside environment. This step is shown in Figure 4 as stage 1.

Mass transfer occurs when the water on the surface of the food material is vaporised and transferred into the environment. This step is shown in Figure 4 as stage 2.

Both of these processes in drying are interrelated and occur simultaneously. The amount of water vapour removed in stage 2 must equal the amount of water vaporised as a result of the latent heat transfer in stage 1 (Kyle & Rich, 1986, 59).

When both of these stages are in balance drying is occurring at a constant rate (Figure 5). This is an optimum state as the water is being evaporated at the same rate at which it is arriving. This leads to efficient use of energy and maintains product quality.

As drying proceeds there will come a point (critical point) where these two stages move out of balance. From this point the drying rate decreases (falling rate phase). This is due to the moisture no longer being able to freely evaporate. Drying continues until an equilibrium point is reached. At this point, the drying process is complete.

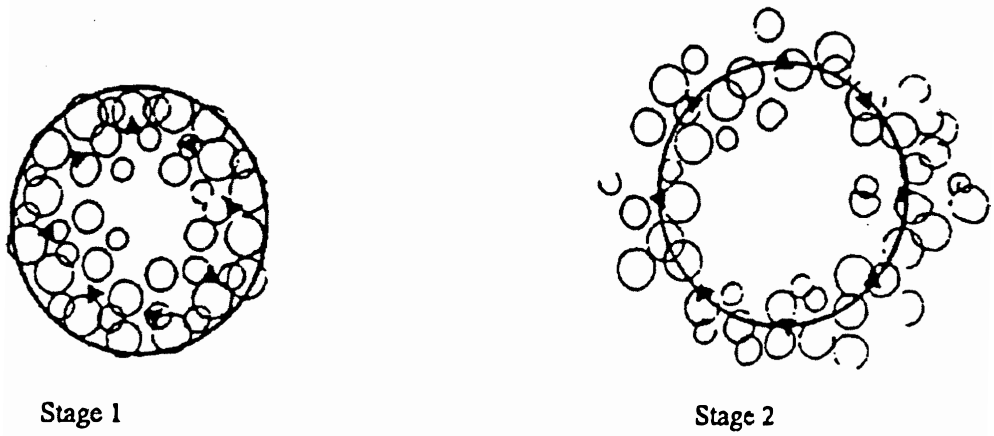


Figure 4: The Drying Process

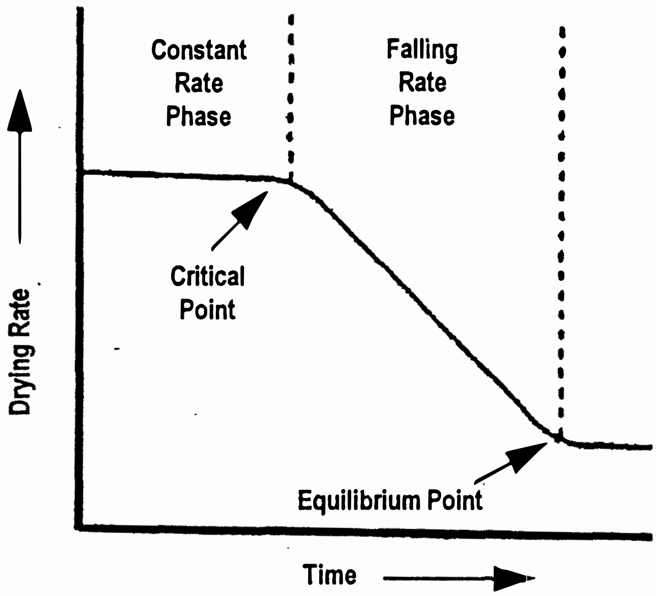


Figure 5: Critical Drying Rate Aspects

CHAPTER 5

FOOD HANDLING AND HYGIENE

As with all food products, it is the responsibility of all personnel who come in direct contact with product to ensure proper practice is followed. Proper practice involves handling the product in such a way as to ensure the maximum shelf-life possible. It also involves the adoption of sound hygienic practices.

Food products are prone to physical degradation and spoilage through microbiological activity or chemical reactions. The control, retardation or prevention of these activities is vital if product of high quality is to be produced.

Microbiological Spoilage of Food

Microorganisms which affect the food industry can be classified as bacteria, moulds, yeasts and viruses. Those of most concern to the seafood sector are bacteria and viruses.

Bacterial contamination

Bacteria are microscopic organisms from 0.2 to 2 microns in width and 0.5 to 10 microns in length (1 micron = 10^{-6} metres). They are present in soil, in water, in air, on our skin, in our noses, throat, intestines and food.

They are single-celled microorganisms which differ in shape (Figure 6), size, optimal growth requirements and habitat. Some bacteria like *Bacillus* and *Clostridium* have the ability to form spores. These are oval or spherical shaped cells that are more resistant to destructive effects by physical or chemical agents than normal vegetative cells. Under suitable conditions the spores germinate and produce new vegetative cells and subsequent growth.

The term growth in bacteriology refers to an increase in the number of bacteria present not an increase in size of a bacterium. Given suitable conditions, a typical growth cycle for a closed system (such as a piece of food) is shown in Figure 7.

Suitable conditions include access to an appropriate nutrient source; the availability of water; the correct pH and temperature range; and the presence or absence of oxygen.
Growth requirements have been used to classify bacteria into various groups. For instance, those requiring the presence of oxygen are termed aerobes whereas those that do not are referred to as anaerobes.

A common classification is based on optimal growth temperature. The psychrophiles (cold loving) grow best at temperatures below 15° C. Thus, these bacteria are potential spoilage organisms in chilled food products.

The mesophile group contains those microorganisms which have their optimal growth temperature between 25° C and 45° C. Most of the pathogenic (disease causing) bacteria along with the vast majority of organisms belong to this group.

The thermophiles are those bacteria with an optimal growth temperature above 45° C. They have minimum temperatures of 25° C to 45° C and a maximum temperature of 60° C to 85° C (Dommett, 1992,9)

A further grouping is that of the psychrotrophs. Members in this group are able to grow relatively rapidly at 7° C or less (refrigeration temperatures). This grouping includes all the psychrophiles and some members of the mesophile group. Psychrotrophs are the major spoilage bacteria in chilled foods.

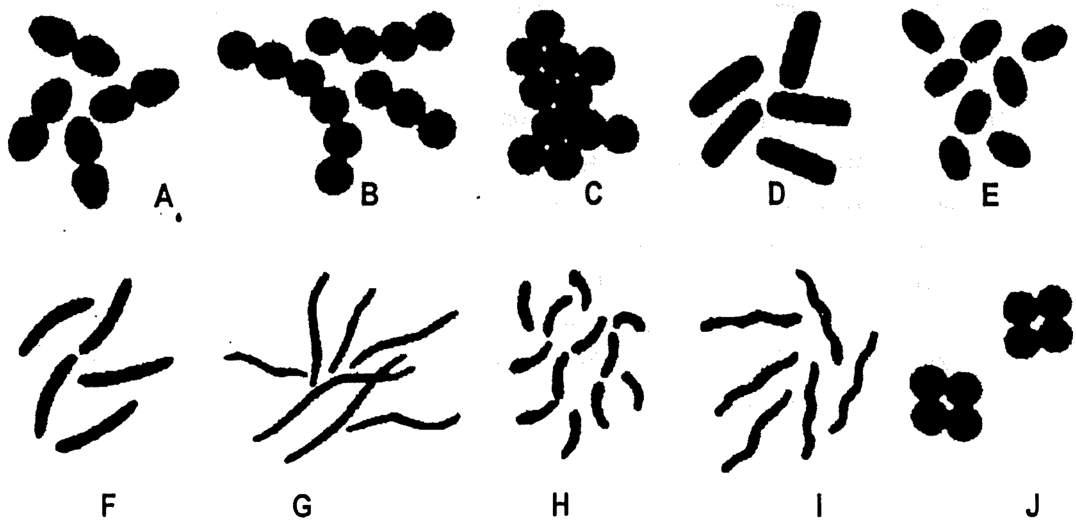
Food spoilage occurs when bacteria are able to grow to sufficient numbers to cause physical and chemical breakdown of food components such as proteins (proteolysis), fat (lipolysis) or sugars (fermentation). Spoilage may also occur through the production and accumulation of waste materials (toxins) which cause illness and possibly death if consumed.

To increase the time for spoilage to occur it is necessary to control the growth of bacteria. This may be achieved in several ways:

- temperature control - high temperature application or low temperature storage
- removal of moisture
- change gas composition of the atmosphere
- pH control
- introduce known growth inhibitors (eg. salt, chemical agents)

Over the past sixty years, the number of bacterial agents implicated in food borne diseases has increased from that of the *Salmonella* and *Shigella* groups to include:

Staphylococcus aureus, Clostridium perfringens, Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Listeria, Campylobacter and certain *Streptoccocci.*



A. diplococci
B. streptococci
C. staphylococci
D. bacilli
E. coccobacilli
F. fusiform bacilli
G. filamentous bacillary forms
H. vibrios
I. spirilla
J. sarcinae

Figure 6: Bacterial Forms

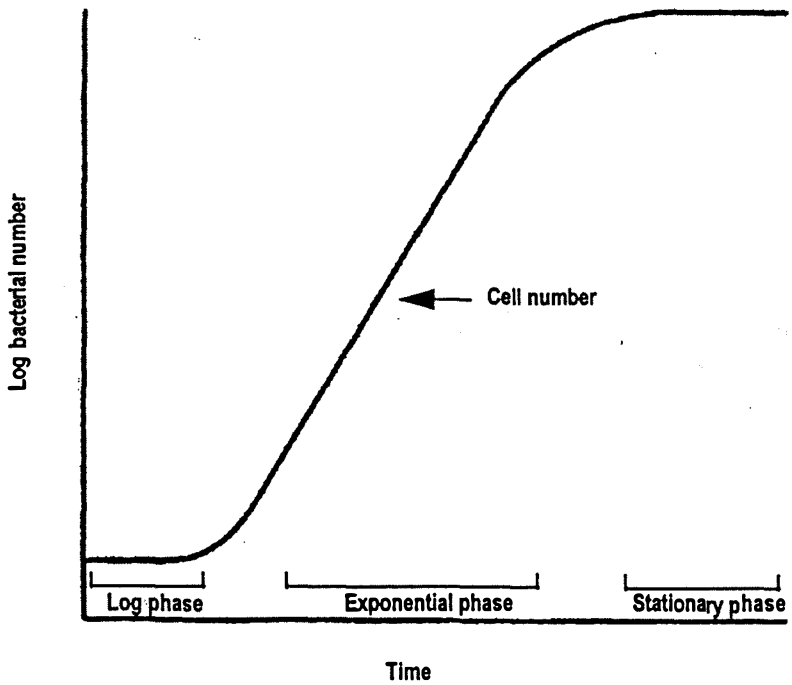


Figure 7: Typical Bacterial Growth Curve

Each of these organisms has been responsible for food poisoning outbreaks (Considine, 1982, 737).

The origins (in relation to public health) or likely sources for contamination by these bacteria vary quite markedly. The enterotoxin-producing staphylococci are mainly sourced from food handlers' fingers. They may also be found in nasal passages or infected lesions. *Salmonellae* are generally associated with meat and poultry surfaces during carcase dressing. They may also derive from contamination from gut contents. *Clostridium perfringens* and *Bacillus cereus* are ubiquitous, being found in soil and dust, faeces and on cereals. *Clostridium botulinum* types A and B are also soil borne whereas *C. botulinum* type E and *Vibrio parahaemolyticus* are associated with fish and sea foods (Christian, 1976). A summary of each of these organisms is shown in Table 7.

Food transmitted diseases may occur in a number of ways (Table 8).

Viral contamination

Viruses are infecting agents which have a number of distinguishable attributes:

- They are very small ranging in size from 200 to 3000 Angstroms (A^{o}).
  [1 $A^{o} = 10^{-10}$ metres].

- Obligatory intracellular parasites.

- Simple in structure

- Are not able to multiply in their own right but employ host cell facilities to replicate their own substance.

(Harvey *et al*, 1972,1009)

One of the viral diseases of most concern associated with contaminated food is infectious Hepatitis (Hepatitis A). It has an incubation period of between 10 and 50 days. The duration of the illness generally ranges from a few weeks to several months (Harvey *et al*, 1972; Considine, 1982).

Holothuria fuscglva
(White teat fish)

Holothuria nobilis
(Black teat fish)

Holothuria echinites
(Deep water red fish)

Holothuria miliaris
(Black fish)

Holothuria scabra
(Sand fish)

Thelenota ananas
(Prickly red fish)

Stichopus variegatus
(Curry fish)

Microthele axiologa
(Elephants' trunk fish)

Plate No. 11 to 18: Commercial Species of Beche-de-mer

Table 7: Food Poisoning Bacteria

Bacteria	Characteristics[a]	Symptoms[b,c]	Prevention[a,c]
Salmonella spp	Cannot tolerate relatively unfavourable conditions, but can compete with other organisms under mild conditions. Are heat sensitive.	Enteric fever, abdominal pain, watery diarrhoea, vomiting - to varying degrees.	Adequate cooking . Ensure cooked products are not recontaminated by contact with utensils or surfaces which have been in contact with uncooked material.
Staphylococcus aureus	Poor competitor. Tolerates low water activity levels.	Produces exotoxins which are preformed in the food. Causes diarrhoea and vomiting.	Ensure food (cooked, cured meats) is not recontaminated. Refrigerate.
Clostridium perfringens	Spore forming. Spores survive cooking. Vegetative cells have rapid growth in relatively anaerobic conditions over wide temperature range.	Produces toxins causing gastroenteritis. Can also attack body wounds.	Does not grow below 15° C so use rapid cooling and refrigeration.
Bacillus cereus	Readily sporulates in foodstuffs (custards, cereals, sauces, meat loaf).	Causes nausea, abdominal cramps, watery diarrhoea, and vomiting.	Chill food rapidly. Excellent personal hygiene and housekeeping.
Clostridium botulinum	Most serious of food poisoning. Types A and B have heat resistant spores(soil-bome associated with meat and vegetables). The spores of type E are less heat resistant and are important in raw or lightly preserved (smoked, pickled or salted) fish.	May cause fatalities. Symptoms including nausea, vomiting, abdominal pain, and diarrhoea are early signs. Headache, vertigo, lassitude, double vision, respiratory stress or paralysis may develop. When disease is fatal death usually occurs in 3-10 days.	Proper heat treatment of any canned or preserved foods. Toxins of all types are heat labile and so thorough cooking inactivates.
Vibrio parahaemolyticus	A marine sourced bacterium which is sensitive to heat. Growth is inhibited by temperatures between 5-8° C. Displays relative sensitivity to acid.	One or more of abdominal pain, diarrhoea (watery stools) which may contain blood and mucus, nausea and vomiting, mild fever, chills, headache , and prostration.	Thorough cooking, rapid chilling of raw or mildly salted fish. Avoid cross contamination from raw fish or the use of seawater to rinse foods to be eaten raw, or for cleaning.

Source: [a] Christian, (1976)
[b] Harvey *et al* (1972)
[c] Considine *et al* (1982)

Table 8: Food Transmitted Diseases

Food Borne Disease	Contaminating organism	Means of contamination	Prevention
Salmonellosis	*Salmonella* spp	Many animals are hosts: transmitted in fish, meat, poultry or dairy products.	Ensure products receive adequate heat treatment. Prevent recontamination from raw product or associated surfaces and utensils.
Enteric fever (typhoid, paratyphoid)	*S. typhi*	Man is only host, spread by food contamination by carrier, or sewage contamination of water.	Exclude infected personnel from processing areas. Ensure water quality.
Infectious Hepatitis	Virus	Usually transmitted by the faecal-oral route.	Exclude infected personnel from processing areas.
Staphylococcal poisoning	*Staphylococci* spp.	Surface contact with non-sterile skin, utensils, preparation surfaces, sneezing and coughing.	Good hygienic practices and handling procedures. Must prevent incidence of contamination and prevent growth and toxin production. Personal hygiene is essential.

Many of these diseases are reportable (e.g. Hepatitis A, Salmonellosis). The statistics for selected National Notifiable Diseases for Australia 1985 to 1992, of which some (number unknown) cases would have derived from food contamination, are shown in Table 9.

Table 9: National Notifiable Diseases (Selected Diseases Only)

Disease	1992	1991	1990	1989	1988	1987	1986	1985
Brucellosis	29	28	46	20	16	12	12	22
Campylo-bacteriosis	9135	8672	5683	4279	4082	2923	2922	2343
Hepatitis A	2109	2195	530	460	600	715	1685	848
Listeriosis	38	44	-	-	-	-	-	-
Salmonellosis	4614	5440	4564	4492	3484	2739	2494	2668
Shigellosis	694	902	610	779	581	586	833	734
Typhoid	50	89	70	57	40	47	45	31
Vibrio para-haemolyticus	-	-	23	10	2	6	6	4
Yersiniosis	567	515	433	241	172	122	78	60

Source: Hargreaves, (1993) Communicable Diseases Intelligence

Chemical Spoilage of Food

Chemical spoilage of food largely falls into two main categories; enzymatic degradation and oxidative degradation.

Enzymatic degradation

Enzymes are molecules which has the ability to speed up the rate of a chemical reaction. They are proteins and are produced by all living organisms.

Enzymes may be divided into two groups a) simple protein enzymes, b) complex protein enzymes. The complex enzyme group in addition to a protein component also has attached a prosthetic group (ie another component other than a protein) (West *et al*, 1966).

Enzymatic degradation of food is basically associated with the breakdown of complex molecules such as proteins, fats and carbohydrates to smaller, simpler molecules. These simpler molecules, for example, ammonia, nitrates, aldehydes and ketones, impart off-flavours and odours to the food, thus making the food inedible.

Like all biological/biochemical reactions, optimal conditions exist. These generally involve a variety of factors: the appropriate pH, temperature, substrate concentration, product concentration, time, and the presence or absence of activators and inhibitors.

Of these factors, from a food handling perspective, temperature is the most easily controlled. As a general rule, chemical reactions, both catalysed and non-catalysed proceed at a faster rate as the temperature increases to 50° C. Above this temperature heat inactivation of enzymes is prominent. In all but a small number of exception cases enzyme activity ceases around 80° C (West *et al*, 1966).

Therefore to prevent enzymic activity, temperatures should be kept as low as possible for as long a time as possible. Alternatively, exposure to high temperatures for the appropriate length of time can be used to inactivate the enzymes.

Oxidative degradation

Oxidative degradation of food is usually associated with fats (oxidative rancidity). Rancidity occurs through the exposure of fat to air (oxygen), and is accelerated by exposure to heat and light. It is also catalysed by the presence of certain metals (eg copper, iron or nickel). The greater the degree of unsaturation of the fat the greater is the susceptibility to oxidative rancidity (Pearson, 1970). As sea cucumbers have a very low fat content, this type of spoilage is minimal.

Housekeeping Practices

Good housekeeping practices are important in controlling the environment in which processing occurs and in imparting the desired attitude for cleanliness amongst processing staff.

Good housekeeping practice involves:

- Keeping all areas neat and tidy;
- Assigning storage areas for all raw materials, in-process and finished product, packaging and cleaning materials;
- Removing any waste materials from the processing area as soon as practicable;
- Promptly cleaning any spills and discarding wastes in appropriate receptacles;
- Ensuring all surfaces are free from extraneous matter. (Plate No. 19), and refinishing surfaces (eg paintwork) on a regular basis;
- Ensuring the external environment is properly maintained in order to minimise dust, insects, rodents and microbiological contamination; (refer Plate No. 1).
- Employing formal cleaning and sanitising practices on a routine basis (this should occur at change of product, extended processing times, upon the resumption of processing after an extended break, at the beginning and completion of daily operation);
- Inspecting all areas regularly.

The implementation of sound practices is best achieved by considering each designated area separately and determining individual requirements (Table 10). In this way, allocation of responsibilities and integration into daily work practices is simply achieved.

Table 10: Industrial Housekeeping

Designated Area	Sound Practice
Work Area	Efficiency and comfort can be achieved by maintaining a clean and orderly working environment. For this to occur a schedule needs to be implemented, with identified responsibilities. The availability of cleaning materials conveniently stored is essential. Understanding of purpose and potential hazards conveys importance and justification for the completion of the various tasks.
Receival and Storage	All in-coming materials should be checked for defects, foreign materials and/or pest infestation. The correct storage conditions for raw materials is essential in maintaining product quality and preventing microbial outbreaks. Strict cleaning regimes need to be followed. Only single direction material flow should occur in this area.
Plant	In addition to general requirements in work areas plant and equipment have specific requirements. Manufacturers' guidelines for cleaning and maintenance should be conveniently displayed. Detailed routine procedures are employed. Selection of detergents and sanitisers depends on type of material soiling the surface, the type of surface being cleaned and the type of product being produced. Thorough rinsing using water of potable quality is required to prevent chemical contamination of product or recontamination by microbial organisms.
Food Preparation Tables	Hygienic practices in this work area are essential. All dirty or used utensils should be placed in an appropriate receptacle. Surfaces should be cleaned frequently with appropriate materials. Surfaces should be smooth, free of cracks or cavities, non-porous and non-absorbent.
Factory	The building should be constructed in such a manner that entry of microbes, pests and foreign matter is minimised. Entry should be restricted to certain controlled areas where footbaths, appropriate protective clothing and curtains or airlocks are available. Floor surfaces need to be routinely inspected and maintained in a sealed state. Drains need to be maintained in a free flowing state and monitored for potential environment contamination. Walls and ceilings should be regularly cleaned and sanitised.

Source: Rich and McMillan (1986)

Employing good housekeeping practices results in a number of immediate benefits, such as:

- The elimination of areas where vermin can multiply and so diminishes their ability to contaminate the factory environment or product with disease inducing microorganisms or extraneous matter.

- Reduces the chance of re-contamination of processed products with unprocessed material.

- Assists in operating efficiency as materials and equipment all have a designated place. Subsequently the incidence of mistakes is reduced.

- Improves the aesthetics of the work environment while making the area safer.

- Assists in the overall cleaning of the processing equipment and environment and its maintenance.

Personal Hygiene

Personal hygiene is paramount for public health considerations. By employing good practice the quality of product being produced is enhanced as well as the processor's reputation.

From a personal hygiene perspective good practice involves:

- The use of protective clothing. This should be of a light colour and changed at least on a daily basis. Its use should be restricted to the processing or work area. Facilities should be available for changing. Often work areas (large establishments) are colour coded to control staff movements and the potential of contamination. Hair coverings are an important item. They should be used to enclose all hair. Beard masks should also be worn where a beard, and/or sideburns which extend lower than the lobe of the ear, and/or a moustache which extends lower than the upper lip, are present.

- All footwear should be kept clean. On entry into a processing area a footbath or protective plastic covers should be used. Prevention of foreign matter entering the processing facility is important in maintaining a clean work environment.

- Any person known to be a carrier of disease or is suffering from any infectious disease, open sores or communicable infection of the skin should not be engaged in or enter a room where food is being handled.

- Frequent sneezing, coughing, unnecessary handling, scratching, wiping of perspiration, eating, drinking, use of tobacco or expectorating should all be avoided.

- Before any contact with food products is made, hands and forearms should be thoroughly washed and sanitised. This should be repeated each time contact activity is halted or hands become soiled. Washing facilities should be conveniently located with disposable towels and waste receptacle (Plate No. 20).

- All jewellery other than ear sleepers and cleanable finger rings should be removed prior to entering a processing area. Clothing with breast pockets should be avoided or, at least pockets should not used.

Compliance with sound practice reduces the likelihood of microbial contamination of food by pathogenic or food spoilage organisms which derive from the process worker.

Plate No.19: Food Processing Standards Require Easily Cleaned (e.g. Stainless Steel) Work Benches

(courtesy Del Pty. Ltd.)

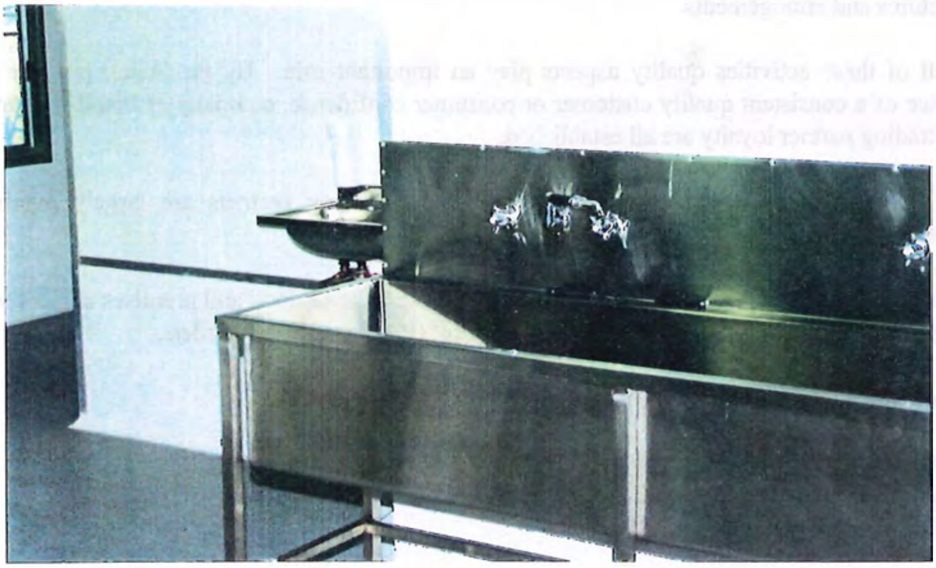


Plate No. 20: Hand Washing Facility Conveniently Located And Accessible To Work Area

(courtesy Trepang Fisheries Pty. Ltd.)

CHAPTER 6

QUALITY CONTROL and MANAGEMENT

by
D.B. Mahoney, S.J. Thrower & B.R. Rich

This chapter concentrates on one aspect of Quality Assurance, namely Hazard Analysis Critical Control Point (HACCP), because it is practical and easily implemented.

Like all commercial operations, the food processing and manufacturing industry is concerned with profits and loss and long term viability. To gain or maintain profitability various strategies may be employed such as; economies of scale, brand or niche marketing, value adding or trade structures and arrangements.

In all of these activities quality aspects play an important role. By producing product and service of a consistent quality customer or consumer confidence, company or brand reputation and trading partner loyalty are all established.

For the beche-de-mer industry, whose customers or trading partners are largely overseas, reliability and quality are prime considerations.

The export of seafood from Australia is prohibited unless the seafood and premises comply with the conditions and restrictions of the Export Control (Processed Food) Orders..

These Orders control the export of seafood and set:

- standards controlling the structure of seafood processing premises;
- standards on the way the premises are operated and
- food product standards.

Under these Orders a phasing out of the previous Product Monitoring System (effective from early 1994) occurred. Seafood prepared at a registered establishment for export will now be required to be inspected in accordance with:

- a Food Processing Accreditation (FPA) system of inspection

or

- an Approved Quality Assurance (AQA) system of inspection.

This has been brought about by consumer demands for assurances regarding the quality and safety of seafood products and increasing competitiveness for the consumer dollar.

By developing and implementing a quality assured system, loss of product through spoilage is minimised and customer expectations are achieved.

Quality Assurance

As food processing has grown in scale of throughput product inspections become less practical and more expensive. The outmoded end-product inspection system is inefficient and costly. This system determines whether or not a product meets specifications at the completion of any value adding. As an item advances through any value adding process it becomes more valuable and more costly to the processor if found defective. The Product Monitoring System is based on this end-product inspection approach.

The alternative is to build quality into the beche-de-mer products by using ***Quality Assurance***. Quality assurance is a tool used by producers and processors to produce products of consistent quality. It requires a good understanding of all the steps in the beche-de-mer collection, handling, processing, and marketing chain.

Effective quality assurance will depend on attitude ***-your attitude-*** to producing product which is safe, wholesome, and meets trade description and product standards. These requirements must be met and maintained.

Quality assurance also requires a high degree of coordination of activities - from the moment the sea cucumber is collected till customer purchase. The development of a quality assurance system requires the following:

- the establishment of quality and safety standards
- description of the product chain (all stages from collection to consumption)
- identification of those steps where product quality may be lost, or where safety may be compromised
- a description of procedures for preventing quality loss at these steps
- a programme for monitoring and recording quality at the various steps in the product chain.

The following notes provide assistance for beche-de-mer processors and exporters wishing to implement the FPA system of inspection.

Hazard Analysis Critical Control Point

The hazard analysis critical control point system can be used as a tool for developing quality assurance programmes in the seafood industry. It is widely used in the food industry in Australia and overseas, and is the basis of the FPA system of inspection.

The system is based on anticipating hazards which may occur at various points in the processing chain and then identifying control points and procedures. The HACCP system is a rational and logical means of controlling food hazards, and avoids the limitations of finished product inspection and testing.

HACCP consists of seven principles which require the beche-de-mer processor to:

Conduct hazard analysis and risk assessment

Determine the critical control points (CCP)

Establish specifications for each CCP

Monitor each CCP

Establish corrective action when a deviation occurs at a CCP

Establish a record keeping system

Establish verification procedures

Considering each principle in more detail they involve:

Conduct Hazard Analysis and Risk Assessment

A hazard is classified as any feature of the beche-de-mer product that may cause a threat to public health e.g. disease causing bacteria or their toxins, chemical residues, physical hazards.

Hazard analysis involves evaluating all activities associated with the production, processing, storage, distribution, and marketing of a beche-de-mer product to determine:

- the identity of potentially hazardous raw materials that may be contaminated with pathogenic microorganisms or their toxins.
- the sources of contamination and specific points where contamination may occur.

- the potential risks of microorganisms surviving, growing, and/or producing toxins. Any products which are consumed raw (such as in South Korea or Japan) or which receive no further heat treatment after processing represent a significant hazard to health.

Determine Critical Control Points (CCP)

A critical control point is a location, practice, process, or procedure where a lack of control may result in the development of hazards described above. For example, if a CCP is correctly controlled the contamination of a foodstuff by disease-causing microorganisms will be minimised or prevented, OR the growth or survival of these organisms will be minimised or prevented.

A CCP will be established for each hazard identified. Incoming raw materials often represent a critical control point, as unwholesome specimens can be rejected before they enter the processing plant. However, heat processing operations (cooking, boiling, steaming, etc) are usually the most important critical control points as they eliminate many of the disease-causing microorganisms.

Establish Specifications for each Critical Control Point

Document the specifications for each critical control point, defining product and process variables and their range. For example, the specifications for operating a freezer may be -25 ± 2 ^{o}C.

Specifications will include variables such as: product temperature and time combinations; chlorine levels; maximum moisture content; maximum residue levels (sand, intestines), etc.

Monitor the Critical Control Points

It is necessary to establish monitoring systems to ensure each critical control point is under control. This involves:

- selecting the most suitable monitoring method
- documenting the procedures to be used
- specifying the frequency of testing.

It is essential that monitoring is by procedures which provide rapid results, so that appropriate corrective action may be promptly enacted. Therefore measurements of temperatures, time, pH, water activity (a_w), and physical and chemical parameters are favoured over complicated laboratory techniques e.g. microbiological tests.

Furthermore, monitoring programmes must be developed around reliable sampling plans. So that any samples taken are representative of the batch being processed.

When the monitoring programme has been established, all monitoring procedures must be documented and the personnel responsible for carrying out the tests clearly identified. These staff must be suitably trained to perform the analyses and interpret the results, and must ensure the results of all monitoring activities are satisfactorily recorded.

Corrective Action when a Deviation occurs at a Critical Control Point

If the results of routine monitoring of a critical control point indicate a deviation from the specified range, the operator must initiate corrective action.

Corrective actions must be clearly defined beforehand, so the operator knows how and when to respond to any deviation. There is also the need to establish procedures which undertake a review of corrective action to prevent the recurrence of a non conformance (hazard).

Establish a Record Keeping System

The beche-de-mer processor must maintain critical control point documentation including records of raw materials, in-line processing data, and quality control activities. This data may be used to determine product history in the event of a customer complaint, to identify production deficiencies, for data analysis, or be evaluated during a verification.

Verification Procedures

It is essential that the HACCP system is periodically checked to ensure it achieves its goals. Verification can involve the review of documentation and supplementary laboratory checks to ensure processing operations are fully controlled.

HACCP systems constantly evolve, and the verification process leads to fine tuning and a more efficient system. If there is any change in processing equipment or operations, product formulation, or handling procedures the HACCP system must be reassessed because the hazards may have changed and this necessitates a review of the critical control points.

Developing a HACCP System

There are no rules or regulations that must be followed when developing a HACCP system However the first stage does require a review of quality and safety parameters of the products being produced in order to define the hazards. Hence the processor should scrutinise the finished product specification to help identify the hazards associated with their product (refer Finished Product Specifications).

The processor should also thoroughly review processing operations. A visual inspection of the processing environment should be combined with the collection of data and information about the process. When complete, the information should be assembled in the form of a process flow chart (refer Process Flow Charts).

Evaluation of specifications and process flow charts enables the processor to identify the hazards and to determine the critical control points.

To further complicate matters, the importance of the hazard and the probability of its occurrence must also be assessed at this stage. For example, the presence of *Salmonellae* is a far more significant hazard than a level of 3% crushed, mutilated or torn specimens in a batch of chilled *Halodeima atra.*

With this part completed, the major tasks involve the:

- definition of appropriate CCP specifications
- development of in-line monitoring procedures and testing programmes
- identification of key staff and
- the corrective action they must implement in the event of a deviation.

All the information may be conveniently recorded in a HACCP table. A HACCP table (Table 14) is a multi-column pro-forma where information developed under the HACCP system is listed. It is an efficient method of recording key information and is useful for operators. Preparation of tables will be dealt with later in this chapter.

Finished Product Specifications

One of the first steps in the establishment of a quality management system is the development of specifications. Specifications represent those characteristics of a product that ensure its safety and legality, and also lead to consumer satisfaction and loyalty.

Most processors should have a finished product specification as it represents the *blueprint* that describes in detail the product being handled and processed. It will contain details about physical, chemical, microbiological, and organoleptic properties of the beche-de-mer.

Writing Specifications

When preparing specifications it is necessary to gather information and take advice from a wide range of sources. This task is best performed by a team which should see quality assurance or laboratory personnel working with processing, and marketing and sales people. As beche-de-mer processing establishments in Australia are small this step may be best performed by the involvement of the collectors, processors, transporters and buyers.

The specifications 'team' must identify all safety parameters, trade description requirements, and product standards as well as establish which specifications meet consumer needs. Specifications which ensure the safety of the product and its ability to meet legislative and Australian Quarantine Inspection Service (AQIS) requirements are the most important.

When all safety and quality parameters have been identified and specifications developed, it is important that they should be prioritised. This enables the processor to focus on the more important specifications and develop process controls using the HACCP system.

Unfortunately the development of a final product specification is not sufficient to guarantee products of consistent quality. The beche-de-mer processor must put in place procedures that ensure final product specifications can be achieved from the start of production. This requires the development of:

- raw material specifications
- packaging specifications
- work instructions
- intermediate product specifications
- manufacturing instructions, etc.

The beche-de-mer processor must develop these types of specifications in order to have control over incoming goods and materials, and to ensure control over product quality at all stages during production.

Inputs

In developing finished product specifications, the processor must consider the following:

- Customer requirements:

  A sound quality management system will continually assess the needs of the marketplace and regularly seek input from customers. Feedback from customers must be regularly reviewed so product specifications may be fine tuned to reflect changes in consumer requirements and preferences.

- Safety requirements:

  The safety of the consumer must be considered at all times. The processor must ensure that the safety and wholesomeness of the product is guaranteed.

- Legal requirements:

  Where legal requirements govern the composition, quality or safety of a product the processor must meet these standards. Finished product specifications must always exceed the legal minima.

- Management requirements:

  Management will also have an input into setting final specifications. This is particularly relevant when financial considerations are addressed i.e. cost of production, quality of raw materials, packaging materials, etc. Management must ensure that the cost and quality of goods is suited to the market.

For beche-de-mer exporters the most valuable source of information when developing finished product specifications is the Export Control (Processed Food) Orders. The Orders contain Product Standards for a range of seafood products in Schedule 4 (pages 81-111).

The following (Table 11) is an example of what a product specification for a dried beche-de-mer product might contain. The information in this table is incomplete; however it provides a guide on what needs to be considered when developing a finished product specification. While the Orders will state standards, the processor must be more stringent to allow for fluctuations.

The processor may develop a final specification based on the information in the standards. However, the needs of the marketplace may also be important e.g. the absence of surface cuts or lesions; how the organisms are cut for evisceration and the amount of calcium on the surface.

Specifications are an essential component of a quality management programme. Final product specifications represent an important starting point for the HACCP system, but they must be supported by specifications covering factors such as incoming raw materials, packaging, and in-line processing conditions.

Table 11: Dried Beche-de-mer

Condition	Tolerance
Unwholesome material	Nil
Abnormal colour, texture, odour or flavour	Nil
Foreign material	Practically free Sand < 3%
Prohibited additive	Nil
Excess permitted additive	Nil
Damaged packaging	Practically free
Incorrect minimum net contents	Nil
Beche-de-mer not of declared species	Maximum of 5% by number
Moisture	< 15%

Process Flow Charts

The process flow chart is an invaluable aid for recording information about a processing operation. Using a standardised format, information can be presented in a manner which may be readily interpreted by production staff, quality assurance personnel, engineers and AQIS personnel.

Process flow charts may be presented in various forms using diagrams and symbols, but the most common and easiest to develop employ the block diagram. Block diagrams use a set of five standard symbols to represent the stages and major operations involved in converting raw material into finished product.

These symbols should be used where practicable when developing process flow charts for FPA documentation.

The symbols used are described in Table 12.

Developing a Process Flow Chart

In order to construct a process flow chart it is necessary to visually inspect the process line and thoroughly review all steps in the process.

As the process steps are identified they should be recorded and relevant details (temperatures, times, ingredients, etc.) should also be recorded. This information is then used to construct a process chart. The general direction of flow should be from top to bottom from left to right. An example of a typical process flow chart describing the processing of beche-de-mer is shown in Figure 8.

Preparing the HACCP Table

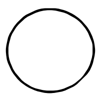
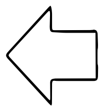
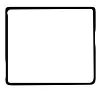
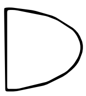
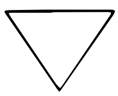
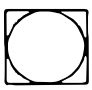
Both the FPA and the AQA systems are based around the use of the HACCP technique.

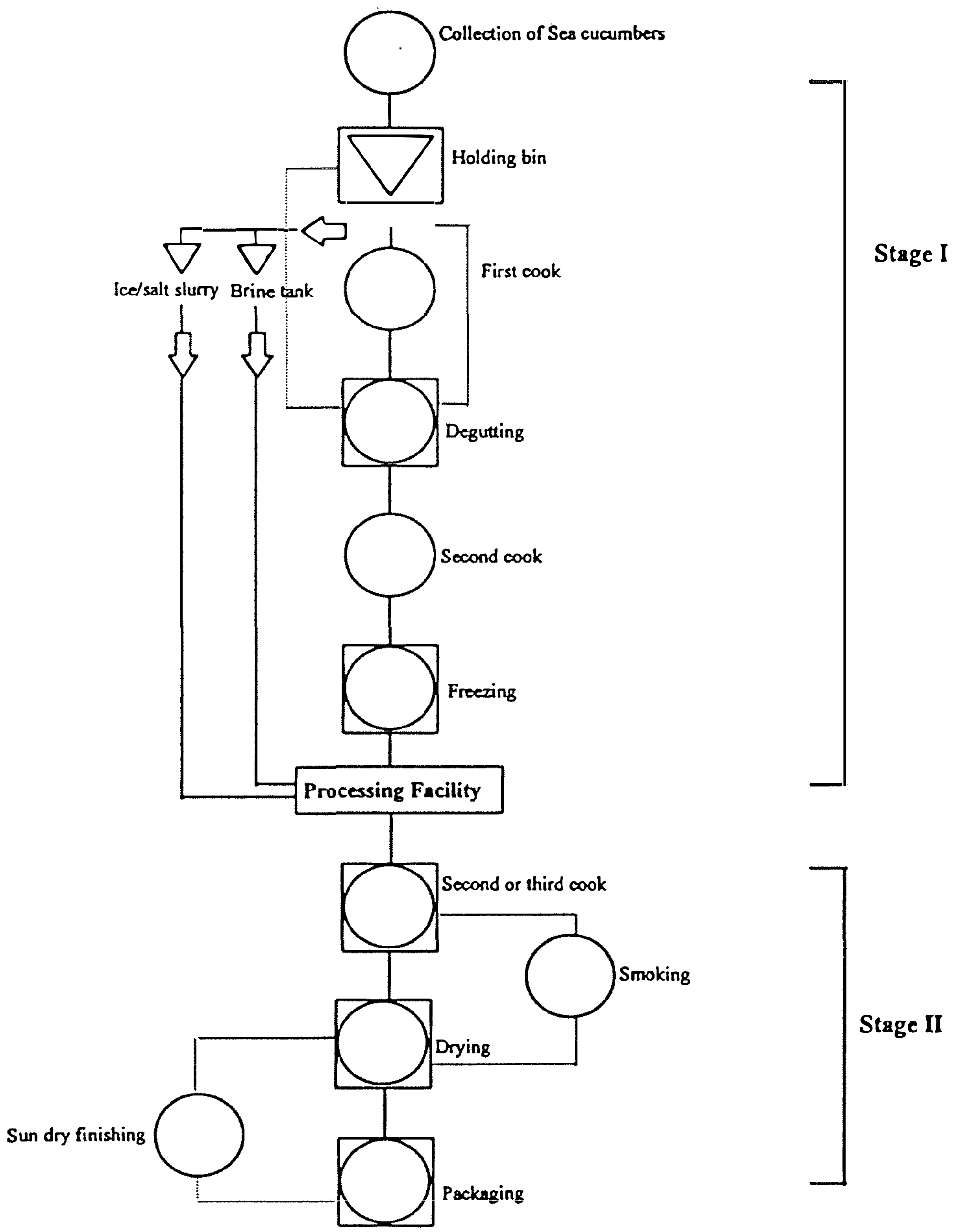
HACCP is a system of error prevention rather than error detection. End-point inspection is an example of error detection. Error prevention techniques attempt to find out where problems occur (their source) then, using the HACCP technique, strive to:

- eliminate them;
- minimise their impact; or
- prevent their occurrence.

So if the hazard is excessive levels of calcium remaining on the skin surface of sandfish, the problem is prevented by reviewing and controlling the conditions of treatment of surface denaturation.

Table 12: Process Flow Chart Symbols

Symbol	Description	Example
OPERATION 	This symbol represents any type of operation where a material undergoes changes in any of its chemical, microbiological, or physical properties.	Washing beche-de-mer Freezing beche-de-mer Receival of raw material Evisceration
TRANSFORMATION 	Material is moved from one location to another with no change in its properties. Transportation is not part of an operation or inspection	Conveying beche-de-mer from a dinghy to mother ship, or from ship to processing plant. Movement of packaged product in cold or dry store.
INSPECTION 	Stage where material is inspected. May involve sampling and examination of product quality or quantity, followed by some form of decision.	Measuring temperature in a chiller. Inspecting animals for internal organ remains. Determining percentage of sand.
DELAY 	Represents either a stage where conditions do not allow immediate performance of the next operation or a terminal point in a flow chart.	Waiting for a batch to be processed, interruption, etc.
STORAGE 	Material is kept under controlled conditions. Includes warehousing.	Holding raw material in chiller before processing. Cold storage of frozen product. Dry storage of dried product.
COMBINED ACTIVITY 	Where two (or more) activities are performed concurrently.	Combined operation and inspection. Combined storage and inspection.


Collection of Sea cucumbers
Holding bin
First cook
Ice/salt slurry
Brine tank
Degutting
Second cook
Freezing
Processing Facility
Stage I
Second or third cook
Smoking
Drying
Sun dry finishing
Packaging
Stage II

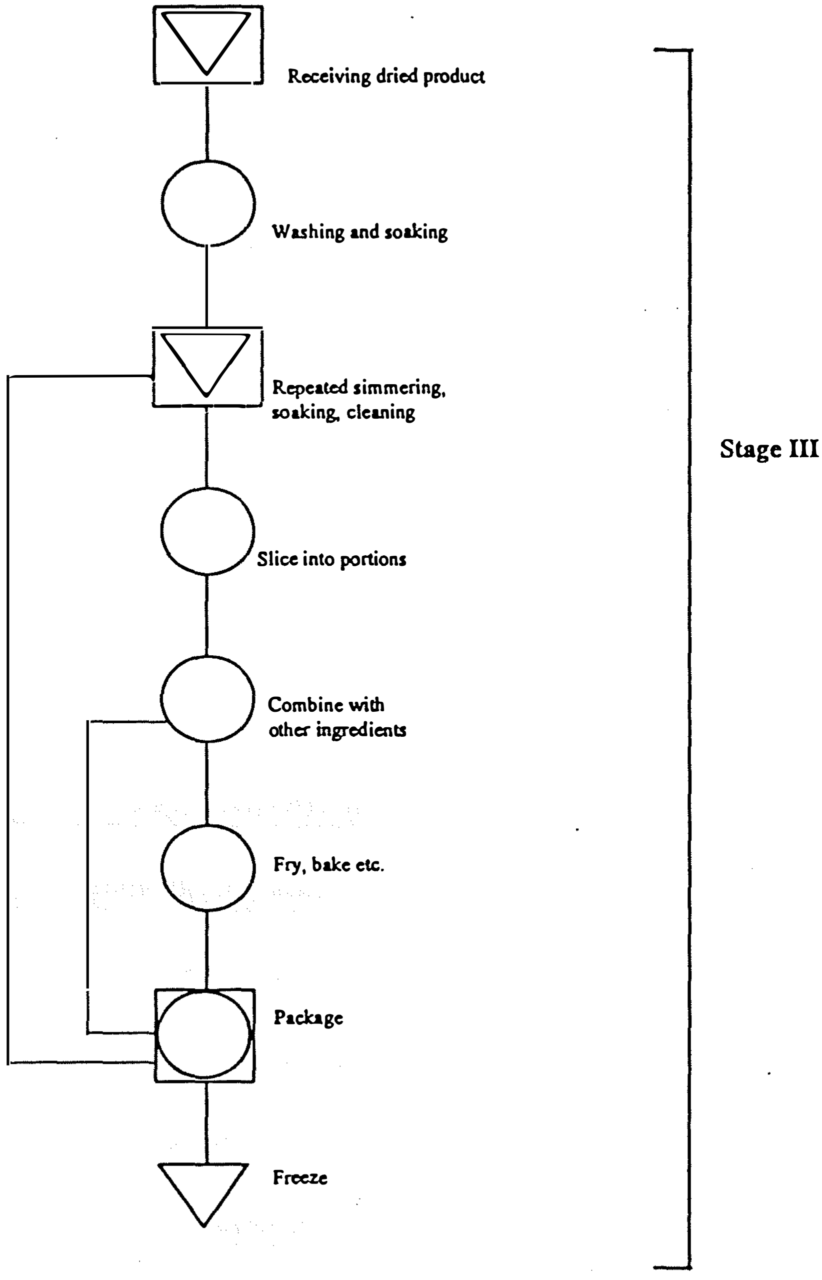


Figure 8: Process Flow Chart for Collecting and Handling Sea Cucumber, Stage I; Producing Dried Product, Stage II; and Reconstitution and Value Adding, Stage III

Applying HACCP

The HACCP system is applied in a logical fashion (Figure 9) with the processor completing the various steps (refer HACCP principles) described at the beginning of this chapter.

One key area to consider when analysing hazards and risks, is the risk category of the establishment. In the Orders, AQIS classifies establishments as either low, medium, and high risks (refer schedule 7, page 141). Hence a low risk category establishment is involved in handling live fish or dried beche-de-mer, while a high risk category includes all oysters, chilled smoked fish, cooked prawns, vacuum packed seafoods, etc.

The rating is important as it will impact on the frequency of inspection of the establishment. Furthermore, the FPA system developed for an establishment in the high risk category must adequately address those risks.

The information that is developed during this application of the HACCP technique is collated in the HACCP Table. The type of information that should be included in the HACCP table is described in Tables 13 &14.

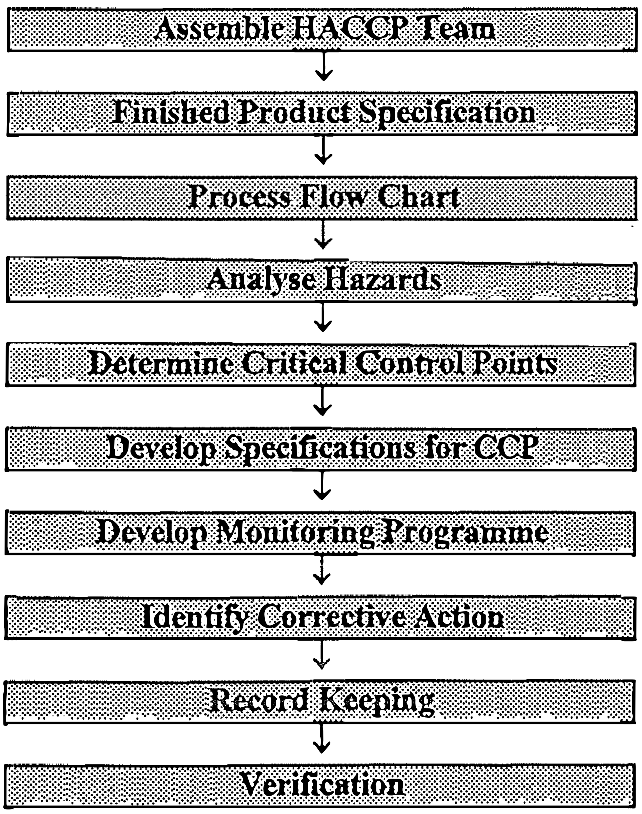


Figure 9: How to Apply the HACCP Technique

Table 13: HACCP Table Description

CRITICAL STEP	POTENTIAL HAZARD	CRITICAL CONTROL POINT (Factor)	PREVENTIVE, CONTROL & MONITORING MEASURES		
			MONITORING PROCEDURE (Include frequency, person responsible, where recorded.)	TARGET LEVEL & TOLERANCES (In-line specifications)	CORRECTIVE ACTION (Include where recorded.)
A step from a process flow chart that is associated with a CCP, which if not controlled may give rise to a hazard (but does not include steps controlled by application of GMP*). Each step must be numbered according to the step in the Process Flow Chart to which it refers.	Something that is a threat to the safety, wholesomeness, or legality of the processed food. ("Legality" includes trade description and product standards.) (This does not include hazards addressed by application of GMP.)	A point or factor in the process that can be manipulated to prevent, reduce, or eliminate a hazard, or lower the chance of it occurring.	The methods, procedures, checks, precautions, or other actions that relate to the control of the CCP. The frequency that such measures are taken, and details of where they are recorded. The location of where the measures are recorded, and the designation of the recorder.	Any specifications, legal requirements, standards, or other requirements that relate to the CCP. Numerical values must include units, and maximum and minimum tolerances.	The corrective action that takes place when a target level or tolerance is exceeded. The person designated to ensure the corrective action takes place, and where any such action is recorded.

*GMP = Good Manufacturing Practice

CRITICAL STEP	POTENTIAL HAZARD	CRITICAL CONTROL POINT (Factor)	PREVENTIVE, CONTROL & MONITORING MEASURES		
			MONITORING PROCEDURE (Include frequency, person responsible, where recorded.	TARGET LEVEL & TOLERANCES (In-line specifications)	CORRECTIVE ACTION (Include where recorded)
Collection & storage	Microbial growth & spoiling..	Holding time, temperature, water/ice volume	Each bin hourly. Divers.	Water temperature <°5	Do not overload bin with sea cucumbers to seawater/ice slurry. Keep shaded.
First cook	Splitting	Cooking time	Each batch. Processor.	2-5 minutes	Separate specimens into similar sizes and species prior to cooking.
Degutting	Downgrading of product	Cutting body wall. Removal of all appropriate organs.	Cook batch. Processor.	<2% registered as seconds.	Ensure clean single cuts. Avoid tearings or over squeezing of animals.
Second cooking	Overcooking, splitting, deformation	Cooking time. Animal surface condition. Length and position of cut.	Each batch. Processor. Production sheets.	<2% second grade.	Process like species and sizes together. Ensure animal surfaces remain in tact. Make clean, straight cuts. Stir cooker in order to keep animals from making prolonged contact with heating surface.
Freezing	Cell rupture. Freezer burn.	Freezing time. Animal surface protection.	Each batch. Processor. Production sheets.	Do not exceed freezer manufacturer's specification.	Lower product temperature as low as possible before introduction to freezer. Protect product surface with an over wrap.
Second or third cook	Overcooking	Cooking time	Each batch. Processor. Processing sheets.	<2% second grade.	Separate species and sizes. Avoid prolonged contact of animals with heating surface. Monitor physical changes.
Smoking	Off flavours. Degradation of flesh.	Smoke intensity. Temperature. Time.	Each batch. Processor. Processing sheet.	<2% second grade.	Use acceptable materials for smoke source or smoke flavouring additive. If dry smoking ensure appropriate temperature is maintained - too high may cause blistering; too low may cause degeneration of the posterior & anterior ends of the body.
Drying	Microbiological growth. Flesh putrefaction.	Time - temperature	Each batch. Processor. Processing sheets.	<2% second grade product. Operating temperature within ±2°C	Commence drying at operating temperature. If using an electrical dryer reduce temperature as moisture decreases. Ensure adequate internal air movement to each animal.
Sun dry finishing	Infestation. Reabsorption and putrefaction	External barriers. Relative humidity.	Each batch. Processor. Processing sheets.	Zero infections. Moisture uptake <2%.	Screen processing area from external environment. Dehumidify processing area, or only carry out when ambient relative humidity allows.
Packaging	Moisture uptake. Microbial growth. Mechanical damage.	Moisture barrier materials. Appropriate strength. Dimensions of container.	Batch. Processor. Processing sheets.	100% compliance.	Checks on materials. Sample checks on product.

Checklist for FPA

Documentation Must Include

Name

Postal Address

Location of Establishment

Export Registration Number of Establishment

Details of Processed Food to be Prepared

Methods of Preparation

Operations for which Approval is Sought

Scope of these Operations

Declaration signed by the Occupier - to Comply with FPA Documentation and System of Inspection

Process Flow Chart

CHAPTER 7

MARKETING

by Anton Kriz

This is a condensed version of 'Marketing of South Pacific Seafood, A case study of Sea Cucumbers' (May 1994). The report was made available by the courtesy of South Pacific Forum Fisheries Agency.

The Market Demand For Sea Cucumber

International trade in sea cucumber is dominated by two markets, Hong Kong and Singapore. However, final consumer demand is much more widespread with mainland China, Taiwan, Malaysia and Korea significant consumers of the product. The changing face of Asia, particularly in mainland China, is likely to have far reaching impacts on the future demand for sea cucumber.

Hong Kong

Hong Kong dominates the trade in sea cucumber, importing more than 6700 t during 1992-1993. Hong Kong's dominance of the market is demonstrated by the fact that it is also the largest importer of sea cucumber from Singapore, the second most important trading nation.

The two leading suppliers to Hong Kong in 1992-93 were Indonesia (33 per cent) and the Philippines (21 per cent). Three Pacific island countries - the Solomon Islands, Papua New Guinea and Fiji - supplied around 930 t, or 14 per cent of total imports. The Solomon Islands was the largest Pacific island supplier, with close to 500 t, while Fiji and Papua New Guinea exported 218 and 216 t respectively (see Table 15).

Table 15: Hong Kong Imports and Re-exports From Pacific Island Countries 1992-93

	Imports		Re-exports	
	quantity (t)	average price (US$/kg) (a)	quantity (t)	average price (US$/kg) (a)
Fiji	218	6.80	78	11.40
PNG	216	5.50	30	6.60
Solomon Islands	499	4.80	182	2.10
Indonesia	2235	4.00	1660	5.40
Philippines	1420	1.90	906	2.10
Total (b)	6738	4.10	3438	3.50

(a) based on an exchange rate of US$1 = HK$7.75;
(b) includes other countries

According to the official trade statistics, over 3400 t of sea cucumber were exported from Hong Kong in the 12 months to June 1993. Given that domestic production is minimal, this implies that around half of the sea cucumber imported into Hong Kong is subsequently re-exported to other countries.

If the import/export figures reported in Table 15 are accurate, the remaining 3300 t were either consumed in the domestic market or added to the stocks of the trading companies. There is no information available on changes in inventories, but it does seem reasonable to assume that any build-up in stock would have represented only a small proportion of the total. On this basis, it is likely that the majority of the 3300 t that remained in Hong Kong were consumed in the domestic market. This, however, is quite different from previous estimates of local consumption in Hong Kong of around 500-600 t each year (van Eys and Philipson 1989; Conand, 1990). This discrepancy is difficult to reconcile, even allowing for the expected increase in local consumption resulting from the strong growth in the Hong Kong economy over recent years. Although this adds uncertainty to the accuracy of the trade figures, there is little option but to use these figures owing to the lack of alternative information.

Based on the Hong Kong trade data, 70 per cent of the sea cucumber imported from the Pacific during 1992-93 was retained and, presumably, consumed in Hong Kong. It is not possible from the data to identify the countries to which the remaining 30 per cent of Pacific island sourced product were re-exported. However, given that more than 80 per cent of the re-exports from Hong Kong went to mainland China and a further 10 per cent to Taiwan, it seems reasonable to assume that re-exports of product from the Pacific islands would have followed a similar pattern.

Singapore

Sea cucumber imports into Singapore totalled 1381 t in 1992, making it the second largest importing country. As with Hong Kong, most of this is subsequently re-exported, with re-exports in 1992 totalling nearly 1200 t. Of this, 800 t went to Hong Kong. The other main buyers from Singapore during 1992 were Taiwan and Malaysia, with 169 t and 153 t respectively.

Other markets

China is the dominant consumer of product re-exported from Hong Kong, as shown in Table 16. Trade figures indicate that the average price of product re-exported to China is considerably lower than the average price of product imported into Hong Kong. This suggests that lower value products are sorted out of the mix of grades and species imported to Hong Kong and re-exported to China. This also suggests that many of the lower value species are consumed in China and that the other main markets favour higher value species. Such a finding would be expected given the markedly different levels of economic development - and personal disposable incomes - between China and the other consuming nations. This does not necessarily mean that all the product exported to China is low value, for there may well be niche markets for higher priced species in some of the rapidly developing regions such as Guandong and the other Chinese Special Economic Development Zones. However, any high value segment of the market would simply be too small to substantially influence the average price.

Table 16: Re-exports from Hong Kong, 1992-92

	Quantity (t)	Average price ($US/kg) (a)
China	2857	2.60
Taiwan	378	5.00
Korea	99	11.40
Singapore	44	13.70

(a) based on an exchange rate of USD1 = HK$7.75

According to industry sources, the Taiwanese market favours sandfish while curry fish is the preferred species in Korea.

Desirable product characteristics

With sea cucumber predominantly consumed in mainland China or by people of Chinese descent, an understanding of traditional Chinese culture is a prerequisite to improved marketing. A greater understanding of what the consumer wants in the product may enable Pacific island exporters to tailor their product to meet market requirements. Similarly, exporters may be better able to target the timing of their shipments if they are aware of the peak consumption times such as festivals.

According to the importers interviewed, the most important attributes for a first grade dried product are:

- large size (not as important for sandfish);
- firm and dry (particularly important);
- consistent and full shape with thick wall;
- slight sea smell;
- smoky smell;
- no rot or holes; and
- properly gutted

Of these attributes, the importers interviewed considered size, quality and species as the main factors determining price.

Seasonality in demand

Festivals and celebrations are an important part of Chinese life and represent peak times for the consumption of traditional foods such as sea cucumber. The festivals are, to a large extent, based around the Chinese lunar calendar. Chun Jie or Chinese New Year is the most important of all Chinese celebrations. Often referred to as the 'spring festival', it is a time for visiting relatives and friends and exchanging gifts. The timing of Chun Jie ranges from late January to mid February, depending on the year, and, although focused on two days, celebrations may continue for up to a month.

Ching Ming, in early April, is traditionally a time for families to get-together in honour of their deceased relatives. Dragon Boat festival, in the middle of the year, and Zhong Qiu Jie, a mid autumn festival around September/October, are other important celebrations in the Chinese culture. The latter is a customary time for wedding festivals and sea cucumber is a traditional wedding food. Another festival, Dong Zhi or Winter Solstice, is celebrated around the 22nd of December and again is a time for celebration and eating traditional foods. The pattern of Chinese festivals is presented below (Figure 10).

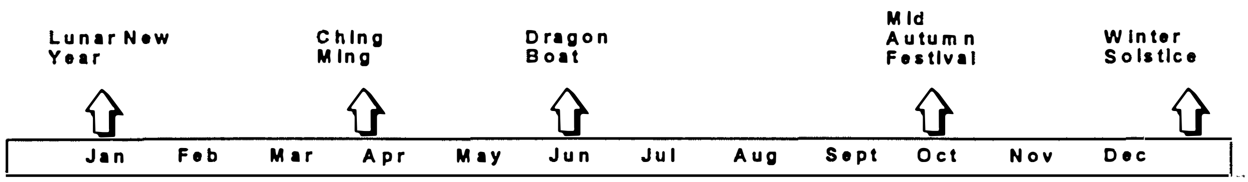


Figure 10: Occurrence of Chinese Festivals

The monthly pattern of re-exports and apparent consumption for Hong Kong,(Figure 11), broadly reflects the timing of the festivals outlined above. Local consumption has pronounced peaks in January and May and a more gradual build-up from September through to November, while re-exports peak in December and February.

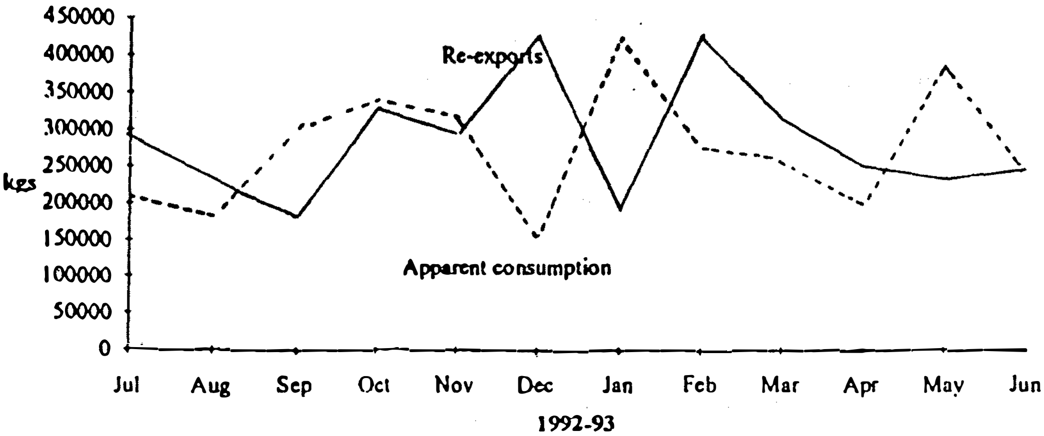


Figure 11: Apparent consumption and re-exports, Hong Kong, 1992-93

The effect of these changes in quantities on the prices is examined in a later section.

Trends in consumption

China at present is not a big purchaser of South Pacific product, but this could change should the economic reforms currently under way in China - and the resulting increases in disposable income - continue. Most of the sea cucumber consumed in China tend to be low quality species. Continued economic growth and higher household incomes should boost demand for some of the higher valued species. Demand for the lower valued species may also rise if the product becomes more affordable to an increasing number of people. Provided economic growth continues, demand in the Chinese market is likely to strengthen.

The market outlook is less clear in other sea cucumber consuming countries. Household consumption is unlikely to increase, given the increasing number of meals being consumed away from home, while for those meals that are consumed at home, the trend is towards easy-to-prepare, convenient foods. Double income families are now common in many Asian societies with the result that dining out is more affordable. In addition, the working woman lacks the time to prepare labour intensive and time consuming dishes. Even if the time is available, the method used to prepare sea cucumber is neither simple nor well known. Industry sources suggested that only a small percentage of Chinese people (outside of mainland China) under the age of 30 know the correct preparation method.

Food consumption patterns in many Asian countries are changing as a result of rising income levels and increased exposure to Western culture. These changes are most pronounced among the under 30s living in Taiwan, Hong Kong, Singapore, Korea and Malaysia. A survey conducted by the Singapore Federation of Chinese Clan Associations in 1988 showed that younger Singaporeans are losing interest in Chinese festivals, customs and rites, traditional times for eating sea cucumber. Taiwan, Korea and Hong Kong also appear to be following this pattern.

The impact of these changes on the demand for sea cucumber is not clear. Most consumers of sea cucumber are in the over-50 age group (JETRO 1991) and, in the longer term, the level of demand will depend upon whether today's younger generation revert to eating traditional foods as they grow older. If they do, demand is likely to remain strong. However, if the young people continue with their more 'westernised' eating habits as they age, future generations of 50 year olds will not be accustomed to eating sea cucumber. Under this scenario, demand in the more developed Asian countries may begin to weaken.

Despite this area of uncertainty, the market outlook appears firm. Continued high levels of economic growth are forecast for the south east Asian region in the next few years, and this should ensure that the demand for sea cucumber remains strong. In the longer term, demand from the more developed Asian countries may weaken in response to changing consumption patterns, but any downturn from these markets is likely to be offset by increased demand from China if the reforms taking place in the Chinese economy are continued.

Market Price Information

There are two difficulties that must be overcome in order to obtain meaningful price information for sea cucumber. The first problem is determining what represents a representative price. Sea cucumbers differ in size, colour and texture according to the species, the age and condition of each animal. Differences in handling and processing standards also affect product quality. Because of this variety, identifying representative market prices is not straightforward.

The second, and perhaps more difficult, obstacle to obtaining realistic price information is caused by the structure of the market. Specifically, there is no centralised market from which average prices can be obtained. Price information must be obtained directly from either buyers or sellers. Given the variety in species and quality, a reasonable number of traders would need to be sampled to obtain any impression of what are representative prices. This situation is made more difficult given the relatively small number of traders, for each individual may be reluctant to provide what they perceive as commercially sensitive information. As a result, published prices for sea cucumber should always be treated with caution.

Sourcing of regular market information

From a producer's perspective, regular and reliable pricing information allows them to assess the competitiveness of the prices that they are receiving against those being paid elsewhere. Based on this comparison, producers may, where appropriate, reconsider the manner in which they market and/or produce their product.

In the case of sea cucumber, price data is difficult to interpret given the variation in species and quality and the 'thinness' of the market, as already discussed. The benefits from providing such information are therefore uncertain. In any case, there are likely to be problems in identifying traders in Hong Kong and Singapore willing to provide reliable price information on a regular basis.

Non-species specific import and export information, by month, is available for both the Singapore and Hong Kong markets. This information is useful in identifying general market trends and product flows, but it is too general to be of much use to individual exporters wanting to compare returns from alternative markets. Such information would be best obtained from those directly involved in the trade - the importers from Hong Kong and Singapore. A list of sea cucumber importers is provided in Table 18.

The main markets and indicative 1992 prices for the key commercial species are presented in Table17. This information was provided by Hong Kong and Singapore importers.

Table 17: Main commercial species of sea cucumber

Common Name	Main Markets	Value in 1992, $US/kg (large size)	
		Hong Kong	Singapore
White teatfish	Hong Kong, Singapore, Taiwan	22	17
Sandfish	Taiwan, Hong Kong, Singapore, Malaysia	24	22
Prickly redfish	Mainland China	13	12
Greenfish	Mainland China	13	10
Stonefish	Taiwan, Mainland China	11	8
Curryfish	Korea, Mainland China	10	10
Surf redfish	Mainland China	9	6
Black teatfish	Malaysia, Singapore	8	11
Blackfish	Thailand, Singapore, Hong Kong	8	7
Chalkfish	Mainland China	8	5
Leopard fish	Mainland China	6	5
Brown sandfish	Mainland China	4	4
Amberfish	Mainland China	4	3
Deep surf redfish	Mainland China	3	2
Elephant's trunk	Mainland China	2	2
Lollyfish	Mainland China	2	3

Opportunities For Pacific Island Exporters To Increase Their Returns

Circumventing existing distribution channels

Based on the Hong Kong trade data considered previously, 70 per cent of the Pacific island product exported to Hong Kong is consumed in the local market. For product consumed locally, the Hong Kong importer usually sells to a secondary wholesaler who in turn sells to the retailer. The remaining 30 per cent of Pacific island product is re-exported to other countries for final consumption. The prospects of using a more direct distribution system, reducing the number of middlemen and so reducing marketing costs, warrants examination in both instances.

In considering the feasibility of such a move, it needs to be kept in mind that only experienced traders understand the vagaries of the dried seafood market. The lack of a centralised market and the consequent problems in obtaining price information hinder potential new entrants to the market. The lack of information is an effective barrier to entry.

It should also be noted that few, if any, businesses deal exclusively with sea cucumber. Any wholesaler/retailer that circumvents existing marketing channels and sources sea cucumber directly from Pacific island exporters runs the risk of severing their ties with their established suppliers of their other dried seafood products.

Most of the product re-exported from Hong Kong is sent to China. However, the practical and cultural difficulties associated with trading directly with China are not to be underestimated. China is not a market for someone who has no knowledge of the culture, the method of doing business and who is averse to risk. The Chinese trade is built on personal relationships, established through time, and it would be naive for Pacific islanders or westerners to expect an equal footing from day one.

Without a Chinese partner or at least a reliable agent, direct distribution by Pacific island exporters would be almost impossible. Rather than direct distribution, Pacific island exporters should choose one or two importers capable of accepting all their product.

Improved product quality and grading

Australia and the South Pacific are generally regarded favourably by the trade, though product quality is considered to be inconsistent. The importers interviewed in Singapore and Hong Kong were convinced that the samples used in this study were of above average quality for the south Pacific. According to those interviewed, the variation in south Pacific product quality is a major problem.

Consistency in providing the same product on a regular basis may be more important than providing occasional high grade product. A problem in shape and colour caused by local conditions may be minimised if the buyer receives the same variation consistently.

Proper processing of high value products such as white teatfish and sandfish also appears critical. In the high value segment of the market particularly, quality control in processing and grading can increase returns.

To maximise the return of fishermen in the Pacific islands, the practice of bulk packing should be discouraged. From a brand identity aspect (country of origin and company) this practice is also not in the exporter's or producer's long term interests. This will become even more important in the future should producers seek to use more direct marketing channels as direct distributors would expect the product to be well graded and sorted.

Product developments

Fresh and frozen product

The lengthy preparation required before serving dried product on the diner's plate suggests that other more user-friendly forms may have appeal to consumers. The use of dried sea cucumber which has been reconstituted by soaking in water and then frozen was anticipated as early as 1991 (JETRO, 1991). A market survey of Singapore, Malaysia and Hong Kong seemed to indicate that this method is being used quite successfully in Singapore.

For white teatfish in particular, a recent development is to place the animal in salt water for some time during the initial post harvest processing to remove the outer layer of skin or coating. This apparently makes final preparation of the product easier and less time consuming. Presented in a form similar to sandfish, this product is gaining popularity in Singapore.

Importers were asked whether they would consider importing sea cucumber in frozen or fresh form rather than dried. The responses varied, with a number suggesting the taste of dried product is different. Others thought the idea had merit, given that product quality may be more consistent and that final processing might be less arduous. Apparently, some suppliers from the United States are beginning to establish small niche markets in Asia for fresh product. The price is reputedly considerably higher than for dried product.

Suppliers of fresh product would need to ensure a constant supply and have access to regular air transport. Improved product handling and possibly more direct distribution channels may also be required.

Given that much of the Pacific island catch is taken from remote areas, the increased perishability of fresh product compared to the dried form is likely to be a major constraint. Similarly, freezing the product will be constrained by the limited refrigeration facilities. Even if the price differential is sufficient to cover the increased transportation and handling costs, the logistics of operating a fresh/frozen operation are likely to be difficult to overcome.

Canned product

A major development in the Singapore market is the introduction of canned product. An Australian company has developed a canned sea cucumber in brine and an up market canned sea cucumber in abalone sauce. Under the brand "Sea Prince", the canned sea cucumber in abalone sauce is sold in a decorative, Chinese labelled box and heavily promoted as being easy to prepare and cook. The reaction to the product, particularly from the busy but more traditional Chinese and under 30s, is apparently quite positive. The success of canned abalone in virtually the same market is likely to have encouraged such an approach.

Given that some canning facilities are available in the South Pacific, developments in the canned sea cucumber market should be monitored.

Better utilisation of by-products

The main variety of sea cucumber preferred by Japanese consumers, *Stichopus japonicus,* is not found in Pacific Island or Australian waters. As well as the meat, by-products such as the ovaries, the intestines and the respiratory trees are in high demand. For example, the average price in 1988 of *Stichopus japonicus* intestines was approximately 12,000 yen per kilogram.

There may be potential to market by-products from other species in the Japanese market and among other Asian nations providing increasing returns to the Australian - Pacific island region.

Increased production

The limited availability of the resource is perhaps the single most limiting factor in the sea cucumber fishery. Natural production is limited by the biological nature of the animal and the effectiveness of the existing harvesting methods. Preston (1993) notes that there is limited biological understanding of growth, recruitment and mortality patterns of sea cucumber. As a result, it is difficult to make reliable population assessments and identify sustainable harvest levels. In terms of harvesting techniques, the animal is usually caught by hand, either by gleaning, free-diving or in some cases using hookah or SCUBA gear. These techniques are very effective and sea cucumber stocks are prone to over-exploitation at least on a local scale.

Fishing pressure on existing stocks is likely to intensify in the future as demand remains strong and highlights the need for resource management of the fishery.

Considerable biological research is being undertaken in a number of high valued fisheries products such as abalone, scallops and southern bluefin tuna to develop breeding programs for either stock enhancement or actual cultivation. The prospects for initiating a similar program for sea cucumber are not promising given the limited biological understanding of the species. Furthermore, such information is likely to be difficult and expensive to obtain, given a number of difficulties involved in studying the animal (Preston 1993).

The International Center for Living Aquatic Resources Management (ICLARM) is soon to commence a study designed to improve understanding of the biology of sea cucumbers. If successful, this study may provide an indication of the technical feasibility of sea cucumber aquaculture. The opportunity may exist to successfully cultivate some species of sea cucumber but at this stage such a development is a long term prospect.

Conclusions

Developing an effective marketing strategy for sea cucumber from the Pacific region is difficult given that the suppliers come from different islands, backgrounds and cultures. Finding a common approach to marketing is difficult amongst villages, let alone amongst several countries. This lack of co-ordination of supply of sea cucumber amongst member countries limits the scope of possible marketing strategies.

The lack of a central market in Hong Kong or Singapore, the variation in species and product quality traded and the 'thinness' of the market make it difficult to source and interpret price information. Published prices, therefore, are subject to wide fluctuations and distortions. Spot prices, including those cited in this chapter, should always be treated with caution.

Table 18: List of Importers of Sea Cucumber

Hong Kong

Chung Hing Co.	111-117 Des Voeux Road, West Hong Kong
Good Unit Development Co. Ltd	Blk B 13/F Flat 28, Hi-Tech Industry Centre, 491-581 Castle Peak Road, Hong Kong
Heep Tung Hong Sanchon Co., Ltd.	13th & 17th Floor Wing Yue Building, 60-64 Des Voeux Road West, Hong Kong
Hong Kong Pacific	11M-111 Mount Butler Road, Hong Kong
Kasco & Co.	7/C8, Cleaveland Street, Causeway, Hong Kong
Messrs Leung Kai Hong, Yan tak Tai Kee Co.	82 Des Voeux Road West, Hong Kong
Ricardo Trading Co.	Room 604 Kincheng, Commercial Centre, 412-420 Castle Peak Road, Kowlow, Hong Kong
Tat & Company Limited (Hong Kong) Tat Hing Sharkfins Company Limited	Room 102, Crocodile House, 50-53 Connaught Road Central, Hong Kong
Teng Fuh Holdings Ltd.	26-28 Bonham Strand West Nam Pak Hong Bldg. Sheung Wan, Hong Kong
Universal Crown Ent. Ltd.	416 King Road, Metro Building, Block D 1642 Rm, Hong Kong
Wang Yip Shark's fin and Sea Products	G/F., 122 Des Voeux Road West, Hong Kong
Yan Tak Tai Kee Co.	82 Des Voeux Road West, Hong Kong
Yip Trading Co.	Shop 7 Grand F/Manison., 1 Davis Street, Kennedy town, Hong Kong
Yip Union Trading Co.	188A Des Voeux Road, West Third Floor, GPO 11641, Hong Kong
Yu Ton Trading Co. Ltd.	Room 1401 Herms Commercial Building 4-4A Hillwood Road, Tsim Sha Tsui, Kowlow, Hong Kong

Singapore

Chiap Tat Enterprise Company	BLK 1036, #01-52 Enos Avenue 4, Singapore 1440
Chip chiang	No 28 Hong Kong Street Singapore
Hui (Sing) Pte Ltd.	Tannery Lawe Singapore
J-C Cheryl Pte Ltd	66 Tannery Lane #03-03 Sinclo Building Singapore 1334
Jack Mae Food Trading Pte Ltd	No. 19 Lorong Telok Singapore 0104
Ming Tai Trading	Blk 34, Upper Cross Street, #01-150, Singapore 0105
Sun Kee Private Limited	3 Ellenborough Street #01-103 Singapore 0105
Weisoon Marketing Pte Limited	Block 1057, Eunos Ave. 3, #04-69, Singapore 9115
Yong Kok Tong Trading P/L	Pte Ltd 10 Sungai Kaput Street 2, Singapore 2572

Other

Atlasic (Malaysia Sdn. Bhd.)	No. 7, Jalan Raja Lumu, Kawasan M.E.I.L. Pandamaran Industrial Estate, 42000 Port Klang, Selangor Darul Ehsan, Malaysia
Heng Brothers Enterprise	18, Jalan SU 33, Taman Selayang Utama, 68100, Batu Caves, Selangor

CHAPTER 8

FUTURE DIRECTIONS

Value added products

Pharmaceuticals

An area which has potential for high value products is pharmaceuticals. Biological or physiological activity has been well documented in the literature with respect to the toxin found in holothurians. With increased focus on compounds of natural origin this area may provide an alternative use for sea cucumbers.

Background

Holothurin is a saponin (steroid saponin or steroid glycoside) found in four of five orders in the class Holothuroidea (Nigrelli and Jakowska,1960).

Tursch (1972) carried out a review on the distribution and biochemistry of echinoderm saponins. Holothurin appears to have a direct effect on muscle contraction and exhibit a nerve-blocking effect similar to that of cocaine, procaine, and physostigmine in laboratory animals (Halstead, 1969). Hodgson (1981) suggests it may block sodium ion movement across excitable membranes. A further physiological action these compounds possess is that they can act as a very powerful haemolytic agent (Jones and Endean, 1973).

Extracts of steroid glycosides have been isolated from Holothurians which have displayed highly active antifungal properties (Shimada,1969). Nigrelli *et al* (1967) also discovered antitumural and neurotropic substances derived from echinoderms.

Saponins structure

Saponins are complex compounds composed of sugars and steroid or triterpenoid moieties. They are widely distributed in plants but less commonly found in animals.

On analysis of holothurin extract, Nigrelli *et al* (1955) and Chanley *et al* (1955) obtained a mixture of sugars and several aglycones (refers to the groups attached to the sugar unit in a glycoside) and sulfuric acid upon hydrolysis. Chanley *et al* further isolated the saponin in crystalline form, calling it Holothurin A. Its empirical formula was determined to be **C50-52H81-85O25-26SNa**. Acid hydrolysis yields several aglycones, one mole of sulfate and one mole each of D-glucose, D-xylose, D-quinovose, and 3-O-methyl-D-glucose.

Yamanouchi (1955) also isolated a holothurin which appears to be the same as the one above. Hashimoto and colleagues (1979) using column chromatography, isolated a saponin, which also appears to be Holothurin A, with an empirical formula of **C55H99O29SNa**. A second saponin, Holothurin B was also isolated having a empirical formula of **C45H75O20SNa**. The properties of both holothurins are summarised in Table 19.

Table 19: Properties of Holothurins A and B*

Property	Holothurin A	Holothurin B
Melting point	224-226° C (dec.)	213-216° C (dec.)
Specific rotation $[\alpha]^{20}_{D}$	-14.4°	-7.3°
Hemolytic index	187,000	125,000
Empirical formula	$C_{55}H_{99}O_{29}SNa$	$C_{45}H_{75}O_{20}SNa$
UV absorption	None	None
IR absorption	1745, 1640 cm^{-1}	1745, 1640 cm^{-1}
Sulfate group	One mole	One mole
Sugar	3-*O*-Methyl-D-glucose, D-Quinovose, D-Xylose, D-Glucose (1:1:1)	D-Quinovose, D-Xylose (1:1)
Ability to form adduct with cholesterol	+	+
Aglycone	Mixture	Genin-I, II, III

Based on Yasumoto *et al* (1967)
Source: Hashimoto, 1979.

Saponins named holotoxin, stichoposide, cucumarioside and thelothurin have also been isolated from sea cucumbers. Their properties and structures are shown in Table 20 and Figure 12. It is thought that the holotoxins might be a desulfated glycoside closely related to the holothurins. Holotoxins exhibit inhibitory action on pathogenic bacteria (Shimada, 1969). Kitagawa (1976) also observed intense antimicrobial activity.

Table 20: Properties of Holotoxins A, B and C*

Property	Holotoxin A	Holotoxin B	Holotoxin C
Melting point	248-252 °C	236-239 °C	
Specific rotation	$[\alpha]_D^{24}$ -53	$[\alpha]_D^{29}$ -52	
Empirical formula	$C_{59}H_{94}O_{27}.2H_2O$	$C_{65}H_{104}O_{33}$.2H2O	
UV absorption	None	None	None
IR absorption	1750 cm^{-1}(br)	1750 cm^{-1}(br)	1750 cm^{-1} (br)
Sulfate group	None	None	
Sugar	D-Xylose, D-quinovose, 3-*O*-methyl-D-glucose, D-glucose (2:1:1:1)	D-Xylose, D-quinovose, 3-*O*-methyl-D-glucose, D-glucose (2:1:1:2)	D-Xylose, D-quinovose, 3-*O*-methyl-D-glucose, D-glucose
Aglycone	Genin-1, 2	Genin-1, 2	Genin-1, 2

*Based on Kitagawa *et al* (1976)
Source: Hashimoto, 1979.

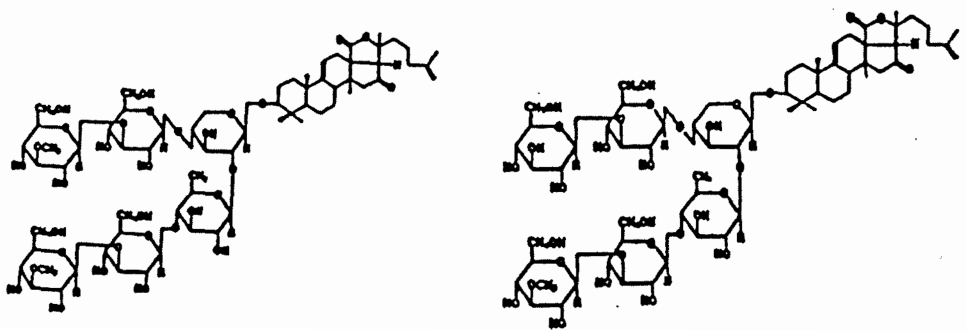


Figure 12: Holotoxin A and B Structure

Aquaculture

Like the majority of fishing industries, one of the concerns in the beche-de-mer industry is supply of raw material. Many areas which have traditionally supplied sea cucumbers have experienced diminishing stocks and smaller sized specimens being collected.

Stock management practices such as those employed in the Washington dive fishery and controlled by the Department of Fisheries (Bradbury, 1990) are seen as being essential.

One approach to relieve the pressures placed on wild stocks is by developing an aquaculture industry, or an artificial breeding program to re-stock growing areas. Interest in this is evident by investigations conducted by: Liu *et al*, 1991; Zhang, 1991; Sui *et al*, 1991; Sui, 1989; James *et al*, 1988; James, 1987; Yon, 1988; Ikeda, 1988 and Silas, 1983.

The potential of companion cropping with existing aquaculture ventures could also present opportunities.

The aquaculture - mariculture approach is one which will need support from research and development organisations and institutes, Government departments, industry and investors. Given the global interest in this area it would make sense to establish collaborative projects.

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