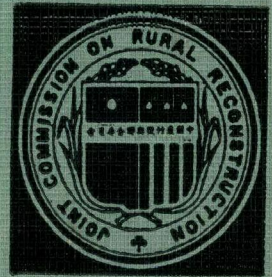


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Fishery Products of Taiwan

Taipei, Taiwan, Republic of China

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FISHERY PRODUCTS OF TAIWAN

Edited by

JAN-LUNG CHUANG, BONNIE SUN PAN AND GIN-CHEN CHEN



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Foreword

When I was Chief of the Fisheries Division, JCRR, before my retirement, I had often had encounters with visitors from other countries who wanted to know the status of fish processing in Taiwan, especially those who were interested in buying frozen fishery products. The present publication will answer many of their questions.

By far the great majority of the processed fishery products (including frozen products) in Taiwan is exported. However, with the increase in the standard of living in Taiwan, it is anticipated that more and more processed food products, including canned food and ready-to-cook packaged food, will be consumed locally. This applies especially to fishery products, which are highly perishable and some of the processed products, e. g. canned tuna and canned sardine, have already gained wide acceptance.

This book does not pretend to be comprehensive. Some products are left out or only briefly mentioned. But it does give a good picture of the modernization of the fishery product processing industry in Taiwan as well as the research activities that result in its improvement.

T. P. Chen
Advisor, JCRR

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- | | |
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Part 1

Introduction

I. Fisheries Development in Taiwan

WEN-TED CHANG* and JAN-LUNG CHUANG**

In Taiwan the supply of animal protein food is largely dependent on the fishery and livestock industries. The Fishery industry is particularly important because it provides the largest part of the animal protein food and does not compete with agriculture as far as land use is concerned.

Suitable Conditions for Fishery Development

The environmental conditions of Taiwan are favorable for the development of fisheries. The Islands are located in the sub-tropical zone, between the East China Sea and the Bashi Channel, with the Pacific Ocean to the east and the Taiwan Strait to the west. The total coastline is 1,566.3 km. Along the east coast there is the Kuroshio current which is rich in many pelagic species of fish. Off the west coast, the continental shelf between Taiwan and the China Mainland provides excellent grounds both for breeding and feeding of many demersal and pelagic species (Fig. 1-1).

The socio-economic factors are also suitable for the development of fisheries. Traditionally, seafood is considered as a delicacy. Therefore, the great demand for fishery products and the open access to everyone for the exploitation of fishery resources have formed a very attractive environment for investment. Meanwhile, the development of science and technology, and the relatively low cost of labor have also contributed much to the fishery development.

Classification of Taiwan's Fisheries

Traditionally, fisheries in Taiwan are divided into four categories, namely (1) deep-sea fisheries, (2) inshore fisheries, (3) coastal fisheries and (4) aquaculture. The deep-sea fisheries consist of all powered fishing vessels of 50 tons or more in gross tonnage. The inshore fisheries consist of all powered fishing boats smaller than 50 tons. The coastal fisheries include all non-powered fishing boats (such as sampans and rafts) and inland fisheries other than aquaculture, while aquaculture includes culture of aquatic animals and plants in brackish and fresh water ponds, reservoirs, paddy fields, and mariculture.

Fisheries production in Taiwan has significantly increased from 121,697 metric tons (mt) in 1942 to 810,475 mt in 1976 through a series of 4-year economic development plans successfully carried out by the Government of the Republic of China. The average value of production during these periods was 3.25% of the gross national product.

Deep-Sea Fisheries

The deep-sea fisheries consist of distant water trawling and distant water tuna long-lining. The former fishes exclusively the demersal species, such as squids, lizard fish, hairtail, croakers, shrimps, sea breams, big-eyes, red snapper, and gurnards, etc., while the latter is mainly for migratory species, such as albacore, yellowfin tuna, bluefin tuna, skipjack tuna, Spanish mackerel, marlins, sharks, etc. In 1976, there were 807 distant water trawlers in operation with a

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fishing. There were 10,382 inshore fishing boats operating within approximately 30 miles off the coast of Taiwan and landing 317,737 mt of fishery products in 1976. The fishing ground is shown in Figure 1-1. The composition of the major species in recent years has been very stable; their landings in 1976 were as follows:

Shrimps 49,950 mt; sharks 30,140 mt; sardines 22,678 mt; tunas 21,505 mt; bonitos 20,651 mt; gurnards 15,209 mt; squids 11,162 mt; Spanish mackerel 9,919 mt; lizard fish 7,256 mt; marlins 7,031 mt; horse mackerel 5,526 mt; hairtail 5,471 mt; and crab 5,338 mt. The individual catch of all the rest of the species was less than 5,338 mt.

Coastal Fisheries

The coastal fisheries make use of beach seines, gill nets, hand lines, long-lines, surrounding nets, swing bell nets, torch-light nets, etc. In 1976, there were 15,146 coastal fishing boats operating within 3 miles off the coast of Taiwan, landing 31,961 mt of fishery products. The main species and their landings were as follows:

Sardines 6,997 mt; bonitos 3,011 mt; hairtail 1,639 mt; shrimps 1,582 mt; sea breams 877 mt; Spanish mackerel 746 mt; horse mackerel 708 mt; sharks 567 mt; clams 534 mt; squids 483 mt, and crab 390 mt. The individual of all the rest of the species was under 390 mt.

Aquaculture

The aquaculture in 1976 made use of 30,540 ha of fish ponds for monoculture and 23,406 ha for polyculture, and produced 135,450 mt of aquatic products. Brackish water ponds were used for raising milkfish, tilapia, shrimps, mullet, *Gracilaria*, etc., resulting in a production of 39,819 mt. The fresh water ponds were used for raising eel, tilapia, Chinese carps, clams, mullet, etc., and produced 55,935 mt of fish. The products of mariculture were mainly oyster, clams, and *Gracilaria*. The paddy field, reservoirs and lakes were primarily used for

Tabel 1-1. Area and Production of Aquaculture in 1976

Types of aquaculture	Area (ha)			Production (mt)
	Monoculture	Polyculture	Sub-total	
Brackish water ponds	14,412	3,633	18,045	Milkfish 26,651 mt; tilapia 4,029 mt; clams 1,671 mt; shrimps 804 mt; mullet 179 mt; crab 176 mt; <i>gracilaria</i> 4,518 mt; misc. 1,790 mt; total 39,818 mt.
Fresh water ponds	2,031	10,664	12,695	Eel 18,694 mt; tilapia 16,257 mt; Chinese carps 13,750 mt; clams 2,535 mt; mullet 1,006 mt; misc. 3,693 mt; total 55,935 mt.
Mariculture	14,036	80	14,116	Oysters 13,493 mt; clams 14,262 mt; <i>gracilaria</i> 2,262 mt; misc. 919 mt; total 30,936 mt.
Paddy field	3	127	130	Tilapia 115 mt; Chinese carps 93 mt; misc. 43 mt; total 251 mt.
Reservoirs & lakes	58	8,902	8,960	Chinese carps 5,453 mt; tilapia 1,319 mt; clams 785 mt; misc. 953 mt; total 8,510 mt.
Total	30,540	23,406	53,946	Milkfish 26,852 mt; tilapia 21,719 mt; Chinese carps 19,296 mt; eel 18,739 mt; clams 17,147 mt; oyster 13,502 mt; mullet 1,225 mt; shrimps 894 mt; <i>gracilaria</i> 6,836 mt; misc. 9,240 mt; total 135,450 mt.

Data source: Compiled from the Fisheries Yearbook of Taiwan Area, 1976. TFB.

raising Chinese carps, tilapia and clams. The area and production of various types of aquaculture are shown in Table 1-1.

Importance of Processing Industry

Fishery industry is understood to mean the extraction of animal and plant organisms from the water, and the processing of the material thus obtained for conversion into food for men and animals, and into medical and industrial products.* Therefore, the catching and rearing of aquatic products are only the first step. The second step is the processing of these products. The processing industry is absolutely necessary for the completion of fishery development not only for retaining the freshness and improving the quality of the aquatic products, but also for maximizing the utilization and value in exchange of this raw material, and hence, to maximize the capital return of the investment in fishery.

Development of Taiwan's Fish Processing Industry

There had not been any significant fishery processing industry in Taiwan until 1966 when the fish catch reached 400,000 metric tons. The annual production of processed fishery products from 1955 to 1976 is shown in Fig. 1-2.

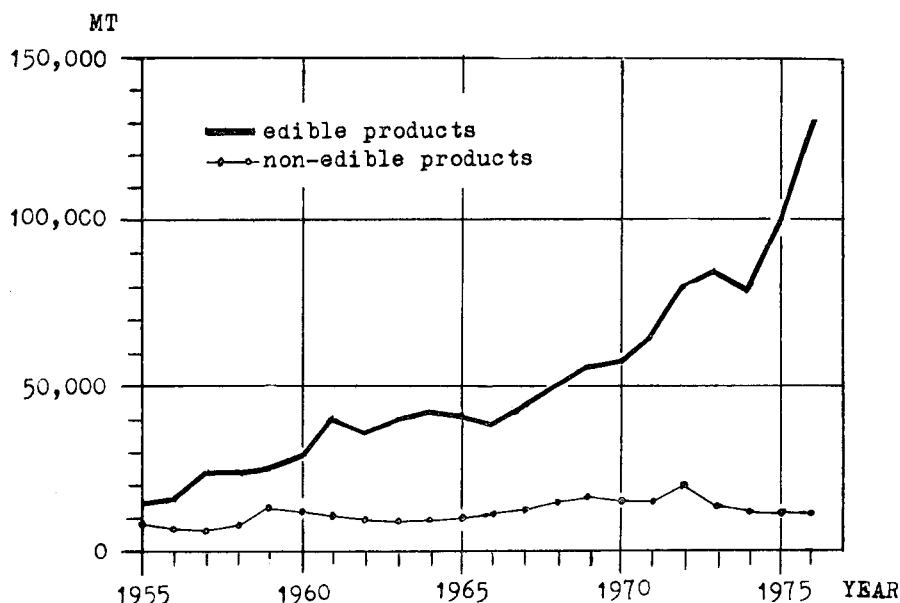


Fig. 1-2. The Annual Production of Processed Fishery Products of Taiwan

Fish production rises from 458,000 tons in 1967 to 810,475 tons in 1976. This rapid growth was responsible for the development of the seafood processing industry. In 1967, the total value of processed fishery products of Taiwan was NT\$ 854,996,000 (US\$ 22,500,000). This has dramatically increased since 1972 to the total value of NT\$ 8,180,883,000 (US\$ 215,286,000) in 1976 (Table 1-2).

Taiwan's fish production, being in excess of domestic needs, has to rely on the international market for its surplus. Except for 70 percent of our average annual tuna catch of about 90,000 metric tons which is sold at distant overseas base ports in the frozen state, and live eel exported in large quantity by air to Japan, most other seafoods are exported in processed or semi-processed forms. The export value of processed and semi-processed fishery products has

* Sysoev, N. P. 1970. Economics of the Soviet Fishing Industry. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1974. Pl.

Table 1-2. The Value of Processed Fishery Products of Taiwan, 1967-1976

Unit: NTS 1,000 (NTS 38=US\$ 1)

Year	The value of processed fishery products for domestic consumption				The value of processed fishery products for export			Total
	Canned product	Other edible	Nonedible	Subtotal	Frozen products	Others	Subtotal	
1967	110,339	559,513	29,379	699,231	147,043	8,722	155,765	854,996
1968	97,857	557,724	61,882	717,463	214,273	27,731	242,004	959,467
1969	93,378	602,557	63,646	759,581	339,459	109,128	448,587	1,208,168
1970	71,037	721,402	61,185	853,624	528,354	80,756	609,110	1,462,734
1971	65,439	858,847	71,681	995,967	763,230	152,534	915,764	1,911,731
1972	97,941	894,937	180,304	1,173,182	1,958,935	212,873	2,161,808	3,334,990
1973	89,339	1,322,994	146,425	1,558,758	2,134,994	772,799	2,907,793	4,466,551
1974	302,051	1,718,099	181,824	2,201,974	1,633,739	756,117	2,389,856	4,591,830
1975	143,714	1,603,244	165,965	1,912,926	4,061,457	896,012	4,957,469	6,870,395
1976	293,309	1,892,306	191,332	2,376,947	4,661,726	1,142,210	5,803,936	8,180,883

exceeded 60 percent of the total export value of fishery products (including non-processed products) since 1975.

The value of processed fishery products exported has been greater than that of those for domestic consumption since 1972.

The world-wide slump reduced the fish production in 1974 to 698,000 tons, which was the first decline in the past 30 years, but the total value of processed fishery products in 1974 was still higher than that in 1973. In 1976, the value of processed fishery products exceeded US\$ 215,286,000, and the fishery processing industry has already become very important in Taiwan's economy. It will become even more important, when the 200-mile-exclusive fishing zones are claimed by more and more countries in the future.

Numbers of Plants and Persons Involved in Fish Processing

There were some 3,600 fish processing plants in Taiwan in 1976 (Table 1-3), of which 2,800 were household processing works and only 830 plants were licensed. Among the 830 plants, 90 frozen seafood plants and 30 canned seafood plants had export licenses.

The above number of plants will tend to decrease, because many household processing works and old-fashioned plants will be definitely eliminated in the future.

Persons engaged in marine products processing as of the end of 1976 numbered 15,000; of this total 5,700 persons were full-time and 9,300 persons were part-time workers.

Table 1-3. Number of Fish Processing Plants in 1976

Categories	No. of plants	No. of household processing works
Frozen seafoods	100	—
Canned seafoods	38	—
Smoked & dried products	274	1,826
Minced fish products	239	277
Other edible products	77	565
Non-edible products	102	103
Total	830	2,771

Items of Processed Fishery Products

Processed fishery products can be classified into the following categories: (1) frozen seafoods, (2) canned seafoods, (3) dried and smoked seafoods, (4) minced fish products, (5) salted fish, (6) fermented fishery products, (7) non-edible processed fishery products, and so forth. Frozen seafoods are mainly for export. About half of the canned seafoods and smoked fish (mainly smoked skipjack stick) is exported, while the other half is for domestic consumption. Dehydrated seafoods, minced fish products, salted fish and fermented fishery products are mainly consumed locally. Non-edible processed fishery products are also mostly for domestic use.

Processed fishery products for export in 1976 totaled 66,290 metric tons, valued at NT\$ 5.80 billion (US\$ 153 million) (Table 1-4).

Table 1-4. A Comparison of the Quantity and Value of the Processed Fishery Products for Export in 1974, 1975, & 1976

Items	1974		1975		1976	
	Quantity (M. T.)	Value (US\$ 1,000)	Quantity (M. T.)	Value (US\$ 1,000)	Quantity (M. T.)	Value (US\$ 1,000)
Frozen fishery products (Subtotal)	21,225	42,993	43,634	106,880	51,432	122,677
Frozen fish	11,490	13,888	30,391	65,764	34,619	67,887
Frozen shrimp	6,900	21,414	8,127	25,736	8,151	31,028
Frozen roasted eel	640	4,640	896	6,923	1,236	9,734
Others	2,186	3,052	4,219	8,457	7,426	14,027
Canned & prepared fishery products (Subtotal)	6,834	16,575	6,502	11,488	10,798	20,072
Canned tuna, frigate mackerel, bonito & skipjack	2,673	4,570	4,015	5,933	9,130	14,394
Canned crab	1,286	5,486	757	2,195	779	2,970
Other canned & prepared fishery products	2,875	6,519	1,730	3,386	1,452	2,759
Dried and smoked fish	139	272	1,481	8,138	1,481	3,077
Salted fish	101	257	103	171	97	257
Salted or dried molluscs	191	1,759	226	1,808	441	2,408
Other processed seafoods	1,041	1,036	1,655	1,974	1,755	4,244
Total	29,531	62,891	53,601	130,460	66,290	152,735

The main items among exported processed fishery products are frozen fishery products, of which frozen fish are the most important in terms of value and quantity. Frozen roasted eel has become more important since 1974. These products are mostly exported to Japan, the U. S. A., Italy, Australia, etc.

Canned tuna, bonito and crab are the main items of canned seafoods for export. The quantity of smoked and dried fish (mainly smoked fish) for export has increased considerably since 1975. The quantity and value of processed fishery products for domestic consumption in 1974, 1975, and 1976 are detailed in Table 1-5.

In 1976, the total value of processed fishery products for domestic consumption was NT\$ 2.38 billion (US\$ 62.6 million), while the value of edible processed seafoods was about NT\$ 2.19 billion. The value of the dried fishery products, including dried, cooked and dried,

Table 1-5. The Quantity and Value of Processed Fishery Products for Domestic Consumption in 1974, 1975 and 1976

Items	1974		1975		1976	
	Quantity (M. T.)	Value (NTS 1,000)	Quantity (M. T.)	Value (NTS 1,000)	Quantity (M. T.)	Value (NTS 1,000)
Edible Products (Subtotal)	49,433	2,020,150	46,665	1,746,958	53,923	2,185,615
Cooked & dried	10,720	524,803	13,685	612,403	13,067	582,843
Dried	4,226	363,568	1,812	95,769	6,299	154,135
Salted & dried	2,879	117,648	2,604	103,188	3,318	128,092
Minced fish products	16,125	369,577	16,484	425,993	17,625	576,785
Canned fish	10,113	302,051	5,292	143,714	6,451	293,309
Smoked	1,002	60,116	902	67,398	997	87,935
Salted	1,939	45,311	1,738	32,948	1,805	36,895
Seasoned	461	39,669	813	62,303	1,022	86,992
Dried shark's fin	96	28,459	118	30,763	190	60,735
Dried mullet roe	19	16,020	33	25,100	35	32,650
Fish liver oil	265	7,511	612	21,519	262	8,518
Others	1,588	145,417	2,572	125,860	2,852	136,726
Non-edible Products (Subtotal)	11,897	181,824	11,979	165,965	10,633	191,332
Fish meal	3,912	83,118	3,620	80,722	3,406	74,003
Coral	7	52,000	9	32,760	16	74,300
Fish soluble	1,049	11,165	693	8,266	298	4,285
Fish oil	372	10,164	381	10,445	305	9,338
Fish cake	798	7,540	973	9,172	1,093	10,220
Shell lime	5,171	6,878	5,669	11,307	4,730	7,415
Others	588	10,959	634	13,293	785	11,771
Total	61,330	2,201,974	58,644	1,912,923	64,556	2,376,947

and salted and dried products, consisted over one half of that of total edible products.

The value of minced fish products mainly in the form of fish balls, increased from NT\$370 million in 1974 to NT\$577 million in 1976. The local consumption of canned seafood has been 5,000-6,500 tons in recent years. Dried shark's fin and mullet roe are delicacies to the Chinese people, but the servings are quite small in quantity. Fish liver oil is processed into capsules or emulsion for medical uses.

The production of fish meal, fish cake, and fish soluble is small and far below the domestic demand. This deficiency has to be made up by imports mainly from Japan, South America and Southeast Asia.

Coral production began only recently. More efforts are needed for local exporters to improve its sale on the international market.

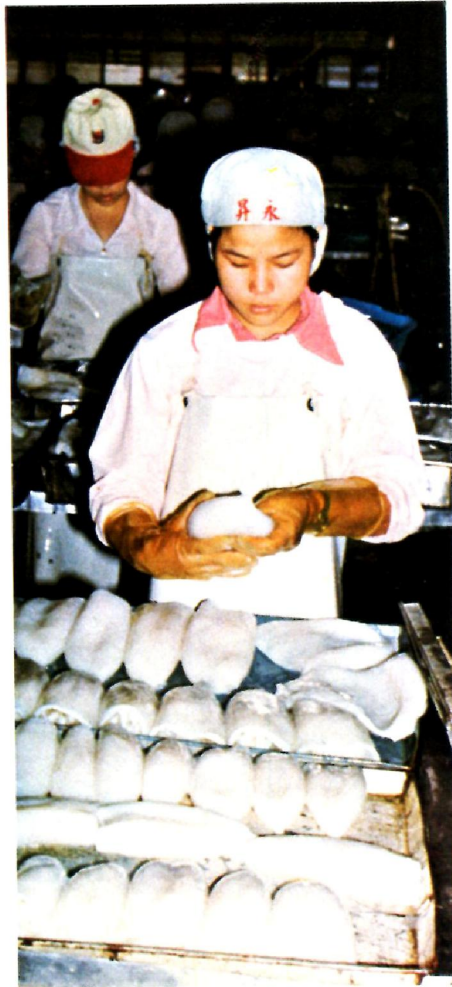
It can be seen that the quantity of the processed fishery products is increasing significantly every year, although it still cannot keep pace with the export demand.

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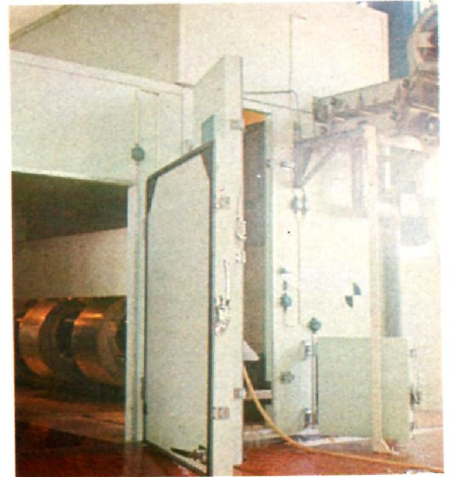
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Part 2

Well-Established Products



Processing of frozen cuttle fish



Fluidized I.Q.F. freezer



Inspection of frozen shrimp



Chinese fish stick recipe –
“fish sticks with black beans”

II. Frozen Fishery Product Industry In Taiwan

J. L. CHUANG*

Frozen fishery product industry has recently become very important to Taiwan's economy. In 1976, the export of frozen fishery products was 51,000 metric tons valued US\$ 118 million.

In discussing this subject, it is necessary to start with Taiwan's ice-making and cold storage industry which has been playing a very important role in Taiwan's frozen fishery product industry.

Background

After World War II, there were only several ice-making plants and some small-scale cold storages in the Keelung and Kaohsiung fishing harbor areas. Their functions were mainly (1) to supply ice for fishery and non-fishery uses and (2) to store fish for further transportation or processing. This situation remained unchanged for many years until there was some surplus fish catch for processing.

In the past, most of the fishing boats of capacity below 200 tons used ice to preserve the freshness of the fish catch. However, after 1968, because many 80-200 ton trawling vessels began to install refrigeration systems, the annual consumption of ice for fishery uses remained about the same from 1967 through 1971. (Table 2-1). The number of powered fishing vessels increased from 10,247 in 1971 to some 12,000 in 1976; thus the quantity of annual ice consumption for fishery uses again increased to 765,759 tons in 1976.

In order to exploit the international market for Taiwan's fish catch, JCRR, from 1963 through 1972, extended loans to some 16 ice-making and seafood freezing plants.

Table 2-1. Status of Ice Making, Cold Storage and Refrigeration Industry in Taiwan 1964-1976

Item	Year			
	1964	1967	1971	1976
A. Daily Capacity of Ice Production (mt/day)	2,783	3,572	4,413	4,802
B. Annual Consumption of Ice (mt) (Total)	463,274	681,701	890,074	1,069,506
For Fishery Uses	314,832	481,734	498,570	765,759
For Non-Fishery Uses	148,442	199,967	391,504	303,747
C. Freezing Capacity (mt/day)	106	278	517	2,273
D. Total Annual Quantity of Frozen Products	1,464	3,390	32,822	141,162
Fishery Products	1,464	3,072	25,400	95,262
Non-Fishery Products	—	318	7,422	45,900
E. Cold Storage Capacity (M ³)	79,025	172,516	152,786	322,528

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The daily freezing capacity increased from 106 tons in 1964 to 517 tons in 1971 and to 2,273 tons in 1976. The quantity of the fishery products handled by local freezing plants increased from 1,464 tons in 1964 to 95,262 tons in 1976.

The export of frozen seafoods started around 1967, and took a leap in 1972, when the total export value of frozen seafoods was 2.2 billion NT dollars (52 million U.S. dollars) (Table 1-2). In the same year, about 50 plants were involved in seafood freezing. This number continued to rise, and as of 1976 it increased to about 90.

The capacities, facilities and equipment of the plants

In 1976, the total number of ice-making, cold storage and seafoods freezing plants was 629*, among which some 90 frozen seafood plants had export licenses. The daily ice-making capacity was about 4,802 metric tons. The ice making plants of larger scale (e.g. daily production of about one hundred metric tons of ice) were concentrated in the Keelung area (Table 3-2). Those of medium scale were located in Kaohsiung, Taipei, Penhu and Ilan areas. The total cold storage space islandwide was 322,528 M³, with a capacity of about 150,000 metric tons, and the storage capacity in Kaohsiung city alone was about 45 percent of the total capacity. Both ice making plants and cold storages were well distributed islandwide.

In 1976, the total freezing capacity was about 2,273 metric tons per day which was 3.7 times that of 1972 (610 tons/day). In Kaohsiung city alone, the total freezing capacity exceeded 1,000 metric tons per day. Other freezing plants were mostly located in Kaohsiung prefecture, Keelung city, Penghu prefecture and Tainan prefecture.

Tbale 2-2. Ice Making, Cold Storage & Seafoods Freezing Industry 1976

Area & City	No. of Plants	Daily Capacity of Production (M. T.)	Ice Making		Cold Storage Capacity M ³	Seafood Freezing Industry		
			Consumption (mt)			Freezing Capacity ton/day	Quantity Handled	
			For Fisheries	Non Fisheries			For fishery Product	Non Fishery
Total	629	4,802	765,759	303,747	322,528	2,273	95,262	45,900
Taipei City	410	471	640	71,500	8,950	12		
Keelung City	22	931	201,115	20,050	34,647	188	7,083	484
Taichung City	12	113	1,700	9,959	4,552	—		
Tainan City	45	311	48,048	33,837	9,978	10	190	
Kaohsiung City	89	705	302,426	47,253	145,300	1,076	66,644	10,496
Northern Area (Ilan prefecture)	92 (24)	574 (173)	45,926 (32,647)	25,148 (313)	21,963 (6,056)	445 (84)	14,668 (12,420)	3,310 (—)
Central Western Area	128	436	26,401	42,914	42,978	13	310	20
Chia-nan Area	91	306	9,850	20,708	24,722	140	0	12,282
Southern Area (Kaohsiung)	90 (46)	682 (260)	103,865 (52,709)	29,060 (15,453)	24,124 (15,887)	376 (208)	3,887 (3,435)	19,308 (19,280)
Eastern Area	13	115	6,540	3,345	1,713	0	0	0
Penghu Prefecture	6	156	19,272	—	3,601	153	1,480	—

Note: Northern area includes Taipei, Ilan, Taoyuan, Hsin-chu, Miaoli prefectures.

Central western area includes Taichung, Changhwa, Nantou, Yunlin prefectures.

Chia-nan area includes Chia-yi, and Tainan prefectures.

Southern area includes Kaohsiung, and Ping-tung prefectures.

Eastern area includes Taitung, and Hwalien.

* Frozen food plants not involved in fishery products are excluded.

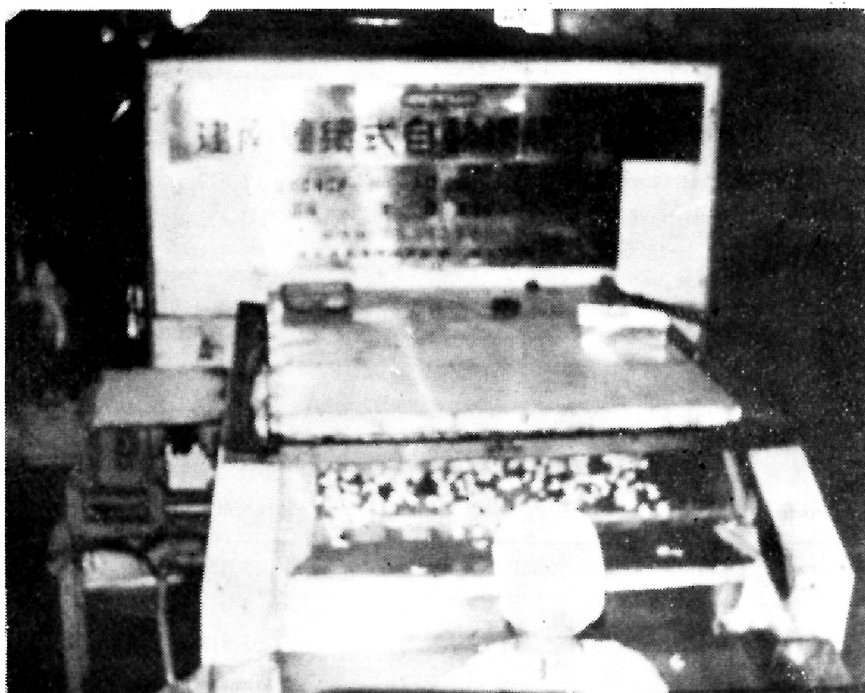


Fig. 2-1. Locally made I. Q. F. freezer.

In 1967, many ice-making and cold storage plants started to use their freezing facilities to process some frozen fishery products for trial export. The export quantity increased so rapidly that this industry soon drew the attention of the Industrial Bureau, and thus a standard of frozen seafood plant sanitation and safety was set up and enforced in 1972. There are now some 90 frozen seafood plants with export licenses. Most of these new plants are quite modernized. Their freezing temperature can reach -40°C and cold storage temperature, -20°C . The freezing capacity of the plants ranges from 10 to 50 tons per day and the storage capacity, 300-1,000 tons. Some of the plants have contact freezers or Gyro freezers. Most of them are using locally-designed-and-made I. Q. F.* freezers (fig. 2-1) or air blast freezers.

The construction, facilities and equipments of the plants must meet the Industrial Bureau's regulations.

Quantity and Value of Frozen Seafoods for Export

Because the local consumers prefer fresh fish to frozen fish (the frozen fish catch of deep-sea fishing must be thawed before it is put on sale on market shelves), frozen seafoods have a very limited local market. Most of these products are mainly for export. As shown in Table 1-4, the quantity of exported frozen seafoods increased from 21,225 tons in 1974 to 51,432 tons in 1976. Among the frozen seafoods, frozen fish increased from 11,490 tons in 1974 to 34,619 tons in 1976. The main reason for the continuous increase in quantity of frozen fish export was that various new fish species were exported each year.

The quantity and value of frozen seafoods exported in 1976 is shown in Table 2-3.

The quantity and value of frozen red snappers are estimated, because these numbers are not specified in custom's fishery product export statistics. Frozen red snappers (fig. 2-2) were mainly exported to U. S. A. in forms of whole fillet, natural whole cut, natural cut, one cut fillet, chunk style fillet or G/G,** Frozen dorado (dolphin fish), (fig. 2-3) also called mahi-mahi, was mainly exported to U. S. A. in forms of fillets or steaks.

In 1976, the export of frozen tuna, skipjack and bonitos, mostly in forms of G/G (some in frozen loin form), was about 1,710 metric tons. The frozen tuna was mostly exported to

* Individual quick frozen. ** Gilled & Gutted.

Table 2-3. Quantity and Value of Frozen Fishery Products Exported in 1976

Items	Quantity (M. T.)	Value (US\$ 1,000)
A. Frozen fish (subtotal)	34,619	67,887
Tunas (excluding that frozen on board)	1,679	2,284
Red snapper (<i>Lutjanus malabaricus</i>)	2,475	2,222
Marrlins & sailfish	543	1,142
Sharks (fillet)	690	561
Dorado (<i>Coryphaena hippurus</i>)	1,542	2,197
Seabreams (fillet) (mostly <i>Eynniscardinalis</i>)	613	789
Carps (<i>Cyprinus carpio</i> and <i>Ctenopharyngodon idellus</i>)	189	119
Milkfish (<i>Chanos chanos</i>)	7	55
Minced fish	65	68
Other frozen fish	—	—
B. Frozen crustacea & molluscs (subtotal)	15,577	45,055
Cuttlefish (<i>Sepia esculenta</i>)	2,631	8,424
Squid	3,819	4,419
Lobster (<i>Ibacus ciliatus</i>)	214	1,418
Striped prawn (<i>Penaeus Japonicus</i>)	673	5,238
Other prawns and shrimps	7,264	24,372
Crab	311	328
Other crustacea & molluscs	—	—
C. Frozen roasted eel	1,236	9,734
Total	51,432	122,677

Japan for further processing into canned tuna. It is believed that the export of frozen tuna may be substituted by that of canned tuna in the future. Frozen swordfish, (*xiphias gladius*) marlins and sailfish were exported to Japan to be served in raw as "sashimi". Frozen seabream and frozen minced fish were mainly exported to Japan. Frozen minced fish (surimi), was recently made from species such as sharp-toothed eel, sea catfish (*Tachysurus maculatus*), croakers, etc. In Japan, this semi-processed product was further processed into minced fish



Fig. 2-2. Frozen red snapper steak.

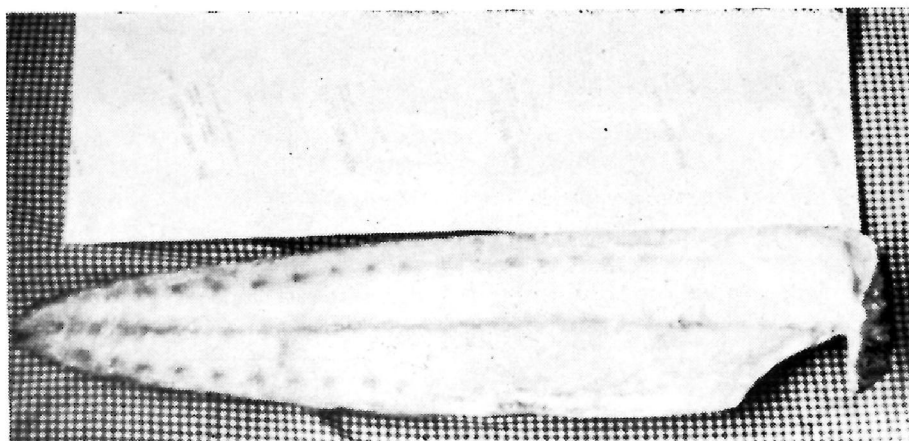


Fig. 2-3. Frozen Mahi-mahi (dolphin fish) fillet and its packaging material.

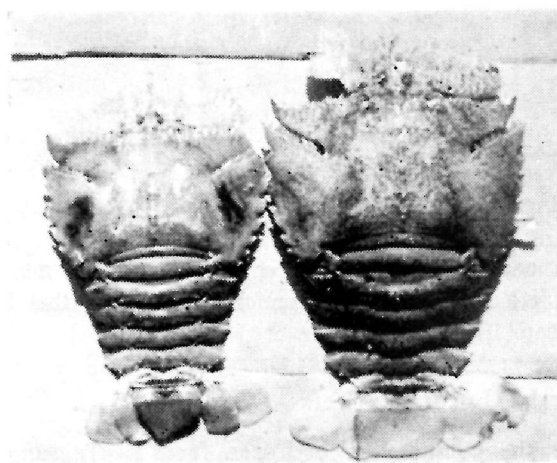


Fig. 2-4. Slipper lobster

products (such as kamaboko and fish sausage). Frozen shark was exported in large quantity to Italy and Australia.

Carp, tilapia (*T. mossambica* × *T. nilotica*), and milkfish are important cultured fish in Taiwan. Their export in a frozen state was mainly to Hong Kong and U. S. A., where overseas Chinese consumed these fishes. Other species of fish such as horse mackerel (*Megalaspis cordyla*), pomfret (*Pampus sargenteus*), tile fish, and kisu fish were also exported frozen. Export of frozen shrimps (including lobsters) did not increase in large quantity because the raw materials were limited. In Taiwan, the total production of lobster and shrimp reached 63,000 tons in 1976. Almost all of the slipper lobster catch (fig. 2-4) was exported to U. S. A. frozen. Two frozen forms, namely slipper lobster tail (headless, deveined, shell-on) and slipper lobster meat (headless, deveined, shell-off) were exported. In 1976, its export quantity was 214 metric tons valued US\$ 1,418,000.

About one third of the striped prawn catch (fig. 2-5) was exported to Japan in frozen state (either round or headless and deveined). And about 40 percent of the other shrimp catch was exported to USA, Japan, and European countries frozen (round, tail, dressed, peeled, peeled and deveined or peeled, deveined and cooked.)

Frozen cuttle fish and squid were also important export items. Other frozen molluscs for export included hard clam and *Turbo marmoratus*.

The export of frozen roasted eel to Japan in large quantity started in 1974 when the

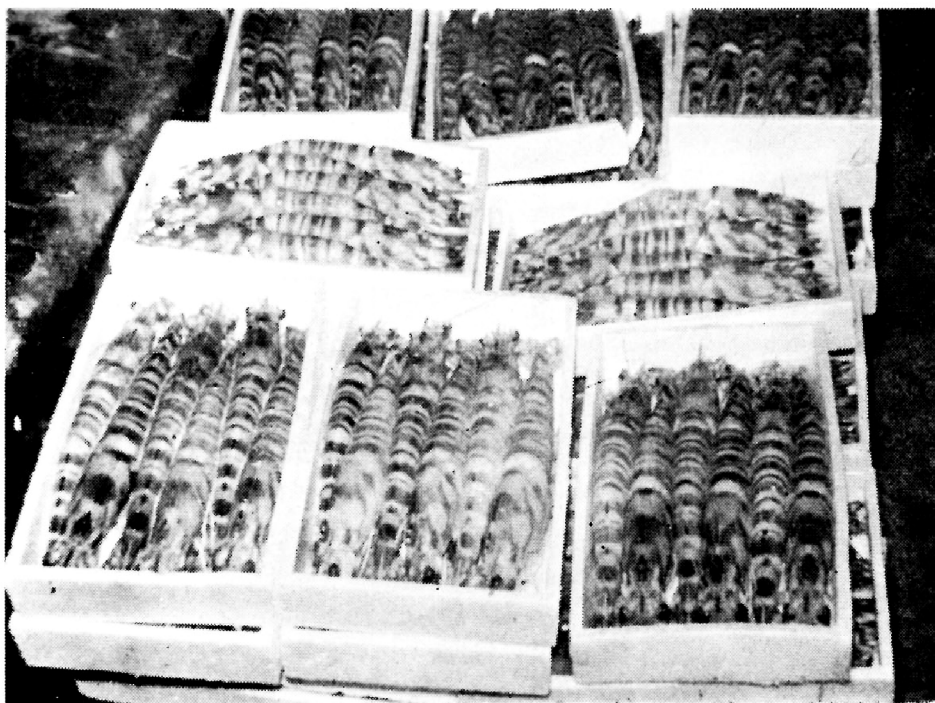


Fig. 2-5. Frozen plawn and its packaging material.

export quantity was 640 metric tons. This number jumped to 1,236 metric tons in 1976. The frozen roasted eel industry has become so economically important that it deserves further detailed description (see chap. III).

Frozen Seafoods in the Local Markets

As mentioned above, the consumption of frozen foods in Taiwan is still at a beginning stage. Unless the price of frozen foods is low enough to compensate for the feeling of consuming "unfresh" foods, most of the local consumers are not interested in buying frozen foods.

Even so, the consumption patterns varies widely from place to place. People living in big cities like Taipei, Kaohsiung, and Taichung tend much more to buy frozen and prepared seafoods than those living in the rural areas.

In the past 4 years, some frozen seafood plants successfully promoted a new ready-to-cook frozen product, "fish dumpling" in the local market. The dumpling's skin is made of minced fish and its stuffing is the mix of ground pork, dried mushroom and other seasoning. Now this new product is an indispensable ingredient for dinners such as "Assorted fire pot" (Chinese sukiyaki) and Korean Bar-B-Q.

In June 1975, JCRR also promoted another new ready-to-cook product, fish stick, in the local market. The product was modified from American frozen fish stick according to Chinese taste. In order to attract local consumers, recipes were also prepared. Although this new product is not very popular in the local market, it is on sale in most of the big cities. Among the consumers, children like it the most*.

Frozen fish fillets, steaks and frozen shrimp, are also on sale in the big cities' supermarket-shelves. Frozen antarctic krill in blocks is very recently on trial sale in the local markets. The Chinese government is making an effort to promote its consumption in the local market.

* CHUANG, J. L. 1975 Acceptability Study of Fish Stick in Taiwan, *Food Industry* 7(8), 35-37.

Quality of the Frozen Seafoods

Generally speaking, the quality of Taiwan's frozen seafoods is quite satisfactory.

Because the raw material (cultured eel) is very fresh and the sanitation of the processing plants is good, the quality of locally produced frozen roasted eel is excellent. The processing procedures of this product will be further discussed in the next Chapter.

Frozen marlin, sailfish, cuttlefish, and squid are mainly exported to Japan to be served in the raw form (as sashimi). Their qualities are good enough to meet the importing country's standard.

The quality of exported frozen lobster and prawns is acceptable, and their foreign market prices are good. An agreement on the minimum export prices of these two products has been made among exporters.

Frozen marfret and kisu (*Sillago sihama*), although in small export quantities, are winning popularity among foreign buyers because of their good quality.

Discoloration of frozen red-snapper and dolphin fish during storage may occur sometimes. The disappearance of desirable red color of frozen red-snapper is due to the chemical changes of the pigments, carotenoids, present in the fish. This may be remedied by using antioxidants and proper glazing. Green discoloration in the abdominal area of frozen dolphin fish may also occur. In order to keep the good quality of this product during shipment, the abdominal part of the fillet is always trimmed off before packing into shipping containers. JCRR has supported local research institutes to study the causes and remedies of this green discoloration. It is reported that this is due to bacterial contamination (*pseudomonas putrefaciens*)*. However, these two frozen fish items are still well received by foreign buyers.

The quality of frozen shrimp of medium and small size is not uniform. The main reason is that a large number of small-sized shrimp trawlers can not supply raw materials of desirable freshness. It is still technically difficult to install freezing equipment on small fishing boats of capacity under 30 tons.

Quality control of raw material at the purchasing stage should be thoroughly enforced by the plants.

Prospect of Frozen Seafood Industry

As a whole, the frozen fishery product industry has good prospects. Their export quantity and value will definitely increase by adding new export items every year. However this industry has its dark side—over-investment of the industry. The total freezing capacity of the 90 plants with export licenses is about 2,300 tons a day. If the volume of the frozen seafoods for export remains the same as in 1976, say 50,000 tons, each plant will be running an average of less than a month in a year.

To solve this problem, the related governmental agencies such as the Bureau of Commodity Inspection and Quarantine, Industrial Bureau, the Board of Foreign Trade, Department of Health, and Taiwan Fisheries Bureau should first jointly set up a sound regulation and inspection system to eliminate the poorly managed plants.

Secondly, the local processors should profit by exporting more valuable prepared frozen seafoods instead of semi-processed ones. For example, frozen breaded shrimp, and fish steak can be processed for export. Better and more attractive packaging material should be adopted. As matter of fact the recent exportation of frozen roasted eel and fish dumpling is the first step toward this goal.

Meanwhile the plants should try harder to exploit local markets and to store surplus fish catch for off-season consumption.

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* CHEN, H. C., personal communication.



Processing of frozen roasted eel



Grading and packaging of frozen roasted eel



Test of microbial quality of roasted eel



Seasoned roasted eel (Kabayaki), ready for table use

III. Frozen Roasted Eel Processing Industry in Taiwan

H. C. CHEN*

Frozen roasted eel processing has recently (since 1974) become very important to both Taiwan's economy and seafood technology. The export value of frozen roasted eel was US\$ 10,000,000. Its finely sanitized processing plants have become the models for other processed seafood plants.

Introduction

Eel culture is one of the prosperous businesses in the present decade, although it started only forty years ago here in Taiwan. The species of eel cultured here is mainly *Anguilla japonica*. Young eels are caught along the coasts of Ilan, Taipei, Taoyuan, Changhua and Pingtung. Eel ponds with a total area of 1,600 hectares existed in the rural areas of Taiwan except the east coast in 1976. Because of the mild climate, it is possible for the eel to grow throughout the year.

Eel is a high-price fish. The market price in Taiwan is four times that of tuna. In Taiwan, there are several ways for cooking eels. One is the braised eels, which is prepared by broiling meat, mushrooms and deep-fry eel, stirring in corn starch paste evenly into the mixtures. The other is called steamed eel with eight-ingredients, which is prepared by steaming eel on glutinous rice and then pouring corn starch paste mixing with shrimp, mushroom etc., onto the eel. A soup prepared by steaming eel, *Lycium chinensis* fruit and water in stew pan is a favorite of the Chinese. Roasted eel (see page 20) is not popular in this country, but it is one of the favorite dish of the Japanese and is called kabayaki in Japan. However, because of the large consumption of this food in Japan, domestic production is not enough. Therefore, Japan imports frozen roasted eel (sirayaki, Fig. 3-1) from Taiwan. In 1976, 17.8% of the

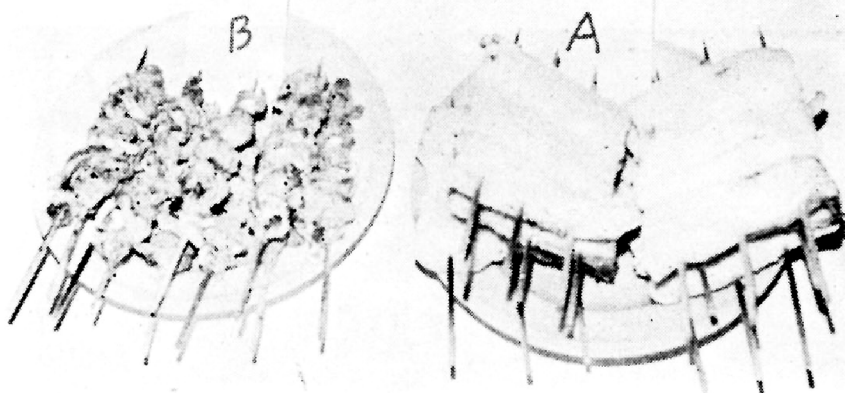


Fig. 3-1. (A) roasted eel without seasoning (or sirayaki).
(B) roasted eel viscera (or kimoyaki).

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total weight of eel exported to Japan from Taiwan was processed eel consisting mostly of frozen roasted eel.

July 31, is called Wusinohi (Ox's day) in Japan. Every Japanese eats roasted eel on this day. This custom is handed down from generation to generation because they believe that eel is so nutritious that it can make up for overexhaustion during the summer. By dint of this fact, export of frozen roasted eel in Taiwan shows a periodic curve that reaches its maximum in June and decreases sharply after that, but it increases again gradually after September.

Variety of frozen roasted eel

Frozen roasted eel is a pre-cooked food without seasoning, including the bled and un-bled products. They are either whole or in sections. The products exported from Taiwan to Japan are mainly bled sectional. In addition, there are roasted eel viscera (Fig. 3-1) and eel heads which are called kimoyaki and capital-yaki respectively, but not much of these two products are exported from Taiwan. In Taiwan, now, there are more than ten frozen roasted eel processing factories which can process two-tons of final products each day.

Materials

Live eels are used to process into frozen roasted eel. Most of the factories have their own eel farms. Eels processed are from their own ponds. If the yield is not enough to supply their own use, they will buy eels from other eel farms. The eel in the size of 3 to 4 eels to one kg is used. When eels are moved into the processing plants, they are kept in holding tanks without feeding for two days, to clean the gut contents before they are processed.

Conventional processing method

The eels are cooled before killing to reduce their activity. Generally, they are put in plastic baskets. Cold water of about 5°C flows down from the top for 2 to 3 hours. The other cooling method uses shredded ice mixed with the eel in the basket. This treatment not only reduces motility of the eel making removal of the viscera easier but also cleanses the eel skin more effectively. For bled products, a deep cut behind the head of the eel with a knife is made and the eel is put into water for ten minutes for bleeding.

The eels are then fixed with a stainless nail on the head (Fig. 3-2). Viscera are removed from the back or abdomen with a specially designed knife which is triangular at the end.

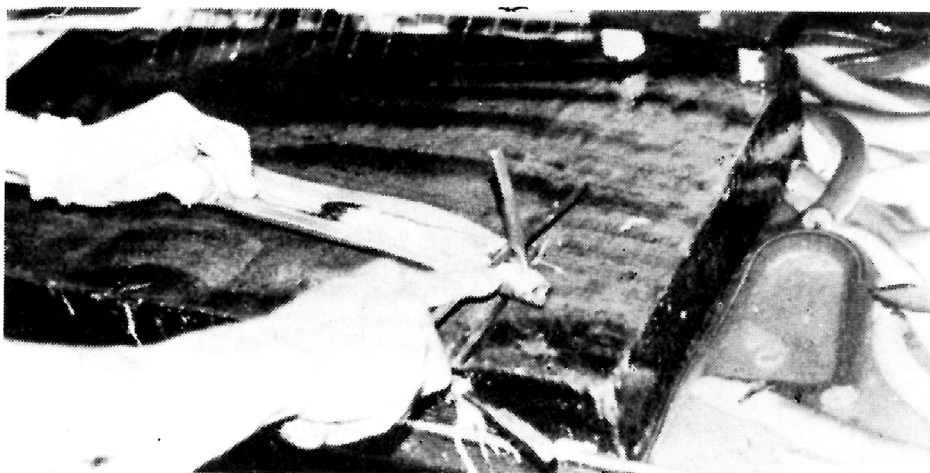


Fig. 3-2. Eel heads and vertebrae are removed after evisceration.

Vertebrate and heads are removed after evisceration (Fig. 3-2).

The above treated eels are washed thoroughly with tap water and then cut into fillets (about 7.5×4.0 cm) as bled products. For unbled products, the washing procedure is omitted. Commonly, the eviscerated eel is cut into three sections. The tail section is then cut into two parts. Each part together with one of the other two sections are stretched with three bamboo sticks by hands or by a stretching machine (Fig. 3-3), and then heated in the roasting machine which contains two heating boxes with burners on the top side only (Fig. 3-4). Fillets are roasted with the skin side upward in the first box, and with the skin down in the second box.

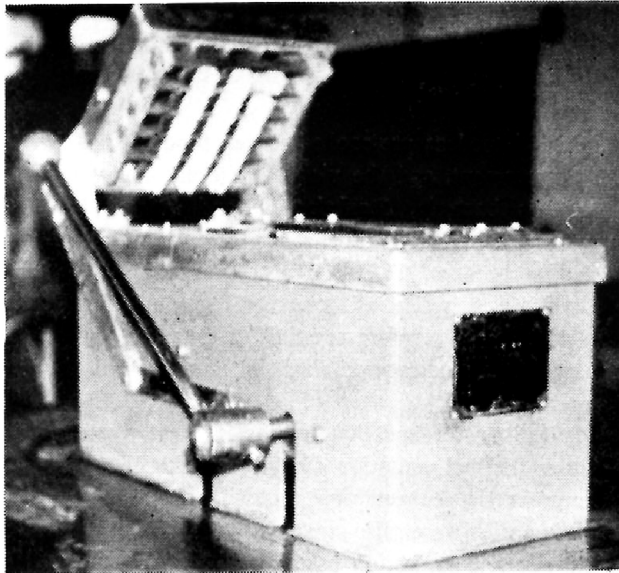


Fig. 3-3. Machine used for stretching eel with bamboo sticks.

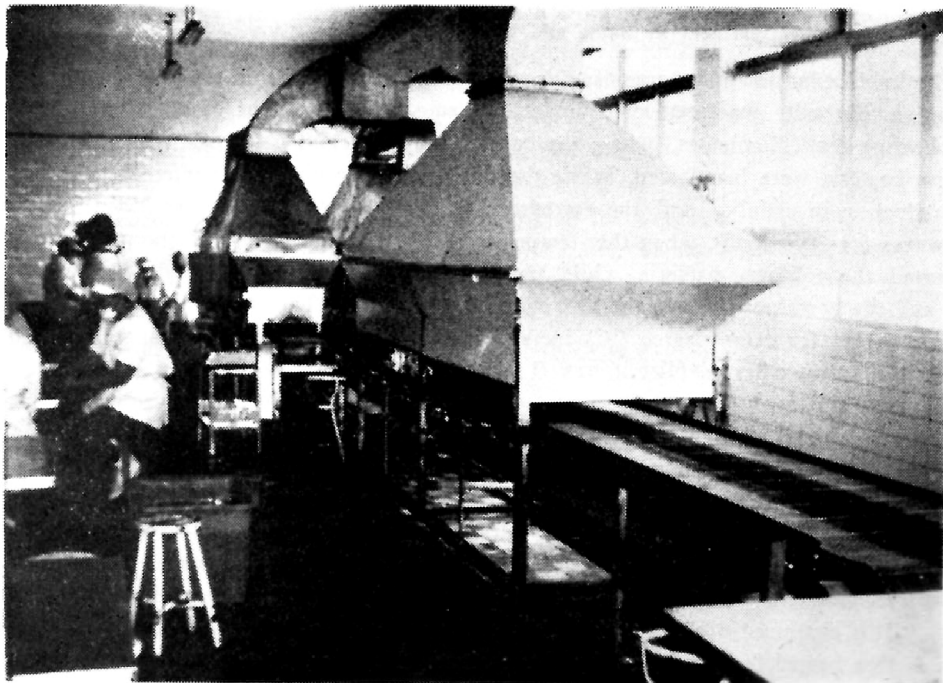


Fig. 3-4. Roasting machine used for frozen roasted eel processing.

Transfer between two boxes is made by workers. The other kind of machine contains only one heating box with burners on both top and bottom sides. Heating time is controlled by adjusting the rotary speed of the conveyor. In general, heating time is determined by the time required for making two or three scorched spots on the skin. In order to prevent blocking of the gas hole on the burner and contacting with flame on fillets, pieces of heat-proof glass are placed between flame and conveyor or fillets. After roasting, the fillets are transferred aseptically into the cold room or cooling tunnel until the center temperature of fillet is lower than 20°C. Every twenty of these fillets are packed in two layers into a small carton which is covered with PE* film inside, and frozen at -40°C overnight. Some factories transfer fillets into IQF equipment right after roasting. These frozen roasted eel are then packed in cartons and stored at -20°C ready for shipping.

Sanitation for frozen roasted eel

Frozen roasted eel is considered as pre-cooked frozen food by the Ministry of Health and Welfare of the Japanese Government, and the viable microbial count in it should be less than 1×10^5 per gram, and coliform bacteria, *Staphylococci*, and *Salmonella* should be absent. To meet these requirements, the processors in Taiwan pay great attention to the problems of microbiological sanitation in the product. H.C. Chen, supported by the Joint Commission on Rural Reconstruction conducted a series of investigations, including heating by microwaves and soaking in sodium chloride solution before roasting, to improve the conventional method of frozen roasted eel processing. The studies were aimed at improvements in yield and commercial value of the product.

In a preliminary study⁽¹⁾, it was found that insufficient heat treatment and recontamination after heating were the causes for bad sanitation condition of frozen roasted eel. Therefore, two methods were tested to improve the conventional method or to ensure proper heat treatment. Disinfectants used in the factories were also investigated to evaluate their effectiveness and subsequently to develop an effective sanitation practice.

Modification of conventional method for processing frozen roasted eel

1. Combined heat treatment by flame and microwaves

The lethal effect on microorganisms in eel fillets treated by flame was higher than that of microwaves if results were evaluated under the same rate of weight loss⁽²⁾. In conventional flame heating for 5.2 minutes, when the center temperature of the eel fillet reached 74°C, coliform bacteria were inactivated, while the total microorganisms encountered about a 5 log cycle reduction in viability, and the corresponding weight loss of fillet was 25%. Heating in microwaves for 30 seconds, when the temperature index in the center of the fillet was 87°C, inactivated the coliform bacteria while the total microorganisms were reduced only a 3 log cycle, and the corresponding weight loss of fillet was 25%. The weight loss of flame-heated fillet was 0.43% for every degree (°C) increase in temperature within the range from 50° to 80°C. For microwave-heated fillet it was 0.44% between 42° and 87°C. This difference is not significant within these temperature ranges. However, because of the decrease in rate of heating of microwave energy at high temperature, the rate of weight loss was more in microwave-heated fillet than flame-heated one.

By virtue of the above facts, heating by combined use of flame and microwaves is applied for frozen roasted eel processing. The combination of heating for 2 minutes over flame following 15 seconds in microwaves, for instance, can inactivate coliform bacteria and effect about a 4 log cycle reduction in viability of the total microorganisms (Table 3-1). Its weight loss is 24.35%. This combined treatment has almost the same effect in weight loss and microbial counts as that heated for 5 minutes by flame alone. However, the former creates a desirable

* Polyethylene film

Table 3-1. Effect of combination flame and microwave heating on eel fillet

Time over flame (min)	Time in microwaves (sec)	Center temp. after exposing to microwaves (°C)	Weight loss (%)	Viable bacterial counts after heat treatment (no./g)* ¹	Coliform test after heat treatment* ²
1.0	5	61.5	13.96	1.7×10^7	+
	10	68.8	16.96	1.9×10^6	+
	15	84.5	22.45	4.0×10^5	+
1.5	5	63.0	14.29	4.8×10^6	+
	10	81.0	21.38	3.0×10^5	-
	15	90.0	23.16	4.7×10^4	-
2.0	5	68.5	17.80	6.3×10^5	-
	10	86.3	23.40	4.5×10^4	-
	15	91.1	24.35	4.0×10^3	-

*1. Control: 7.2×10^7 .

*2. Coliform counts on desoxycholate agar less than 0.5×10^2 are considered as negative.

appearance in the products. Because microwave oven used in the food industry is not popular in Taiwan and the price of the oven is expensive, this modification may not be accepted readily. However, from the result of this test, to meet the sanitary requirements of the finished products, it is necessary to heat eel fillet by flame alone for 3.5 to 4.5 minutes until the center temperature reaches at least 78°C.

2. Soaking in sodium chloride solution before roasting

Weight loss of frozen roasted eel can be reduced by shortening heating time. It is also commonly known that the effect of salt on the thermal inactivation of microorganisms is significant. Therefore, an investigation was started on the thermal resistance of *E. coli* in eel bouillion with varied pH values and NaCl concentration⁽⁹⁾. The resistance of *E. coli* decreased at acid and alkaline pH values and also decreased with increasing NaCl concentration at pH 7.0 in all tested eel bouillions. However, the decrease was gradual when the concentration was higher than 10%. From these results, the effect of NaCl concentration, baking and freezing on the weight loss and survival of microorganisms in eel fillets was then studied in a frozen roasted eel processing factory. The processing method can be modified as follows: Before

Table 3-2: Effect of brine treatments on the weight loss and survival of microorganisms in eel fillets after baking and freezing

Treatments (3 sec. for soaking)	After baking			After freezing		
	Weight loss (%)	Survival of organ. (%) ^{*1}		Weight loss (%)	Survival of organ. (%)	
		Viable	Coliform		Viable	Coliform
Without soaking	15.88	8.23	0 ^{*2}	20.58	0.57	0
Soaking in distd. H ₂ O	15.67	7.81	0	20.14	0.63	0
Soaking in soln. A ^{*3}	15.02	6.88	0	20.05	0.13	0
Soaking in soln. B ^{*4}	15.51	6.14	0	20.23	0.22	0

*1. Counts of microorganisms in fillets before baking were used as base.

*2. When coliform count per gram of baked fillet is less than 50.

*3. Solution with pH 3.5 and 10% NaCl.

*4. Solution with pH 9.5 and 10% NaCl.

roasting, eel fillets are soaked in 10% brine (pH 3.5) for 3 seconds and then heated in the roasting machine, and transferred immediately into IQF equipment. This treatment reduces weight loss of products at least 0.35%, as compared with the conventional method (Table 3-2). And the decrease in microbial counts is significant after freezing.

Since the sodium chloride content in fillets soaked in brine for 3 seconds does not affect the taste of the seasoned roasted eel, this modification is applicable in the industry provided that suitable brine treatment is employed.

Selection of disinfectants and sanitation practice in frozen roasted eel processing factory

Natural flora of microorganisms recontaminated on fillets during handling was considered to be the cause of microbial spoilage of frozen roasted eel⁽¹⁾. In addition to sufficient heat treatment, proper sanitation practice is required to prevent contamination.

In the frozen roasted eel processing factory, sodium hypochlorite is generally used for disinfection. Other disinfectants like Antiseptol* and Tego-51** are also used occasionally. In order to evaluate these disinfectants, minimum inhibition concentration and effects of pH and organic matters on the microbial inactivations of these disinfectants were studied⁽⁴⁾. In conclusion, sodium hypochlorite dissolved in water with no organic matters to bring about 100 ppm of available chlorine can inhibit the growth of *E. coli*, *Aeromonas hydrophila*, and *Staphylococcus aureus* within 5 minute contact at 30°C. But the effect disappeared when the water contained 0.03% (w/v) fullcream milk powder. However, Antiseptol and Tego-51 with concentration not higher than 1/200, can inhibit the three microorganisms in water with or without the powder, the effect of Antiseptol being better than Tego-51.

Facilities in frozen roasted eel processing factories, therefore, can be washed first by using detergent and rinsed by water with or without chlorination, and subsequently soaked or covered with 1/200 Antiseptol solution for 5 minutes. Finally, the facilities can be washed by using chlorinated water containing 50 ppm available chlorine. The effectiveness of this sanitation practice appeared to be highly significant (Table 3-3).

Table 3-3. Effect of sterilizing practice on the survival of microorganisms on treatment table in a frozen baked eel processing factory

Sterilization	Survival of microorganisms (counts/cm ²)	
	Viable bacteria	Coliform bacteria
Before	4.2 × 10 ⁴	4.0 × 10 ²
After	0	0

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* Antiseptol, effective ingredient: benzethonium chloride, manufactured by US pharmaceuticals.

** Tego-51, effective ingredient: dodecyl-diaminoethyl-glycine, manufactured by TH Gddschmidt AG. West Germany.

IV. Canned Seafood Industry in Taiwan

J. L. CHUANG

Taiwan has experience in seafood canning for more than forty five years. This industry keeps on expanding. The export quantity of canned seafood was 600 thousand standard cases in 1976, and is expected to reach one million standard cases in 1977.

Background

Seafood canning was originally started by the Japanese in 1931 when tuna (both in oil and in brine) was canned mainly for export. After World War II, the development of purse seining enabled the canneries in Su-ao to revive in 1961. These plants mainly produced canned mackerels and sardines for domestic consumption. The average annual production of canned fish was about 200,000-300,000 cases.

In 1970, canned crab and frigate mackerel (*Auxis tapeinosoma*) were first produced for export to U. S. A. and European countries. Later in 1974, the sluggish sale of frozen tuna due to low international market demand encouraged the local canneries to buy the inexpensive raw material to produce canned tuna. Since then the production and the export quantity of canned tuna have increased year by year.

The canneries, their facilities and equipment

In Taiwan, there are some 240 canneries, of which seafood canneries number is 38. Ilan was the center of canned seafood industry since 1930's. After World War II, many small-scale canneries were automatically done away with, and now there are only 13 seafood canneries left in this area. (Table 4-1)

Recently Tainan and Kaohsiung Prefectures are becoming other centers of seafood canning. The seafood canneries in these areas are much larger and more modernized than those in the Ilan area.

As to the facilities and equipment of Taiwan's canned seafood plants, many of them have 400-ton cold storages. The majority of the plants use Model 5 M & 301 automatic vacuum seamers (Fig 4-1) instead of non-vacuum seamers. Most of the retorts used are well equipped with the accessories which meet U. S. FDA's regulations for low-acid food processing. All the plants which process canned crab have horizontal or vertical roller type crab meat separators (Fig 4-2). Some plants which process canned tuna have automatic shaping machines.

Table 4-1. Distribution of Seafood Canneries in Taiwan 1976

Prefecture (Hsien) or City	No. of Plant
Ilan Prefecture	13
Tainan Prefecture	10
Kaohsiung Prefecture	3
Keelung City	3
Other Prefecture & Cities	9
Total	38



Inside a modern seafood cannery – crab processing



Automatic pack-shaper for tuna canning



Storage of canned seafood



Exhausting tunnels

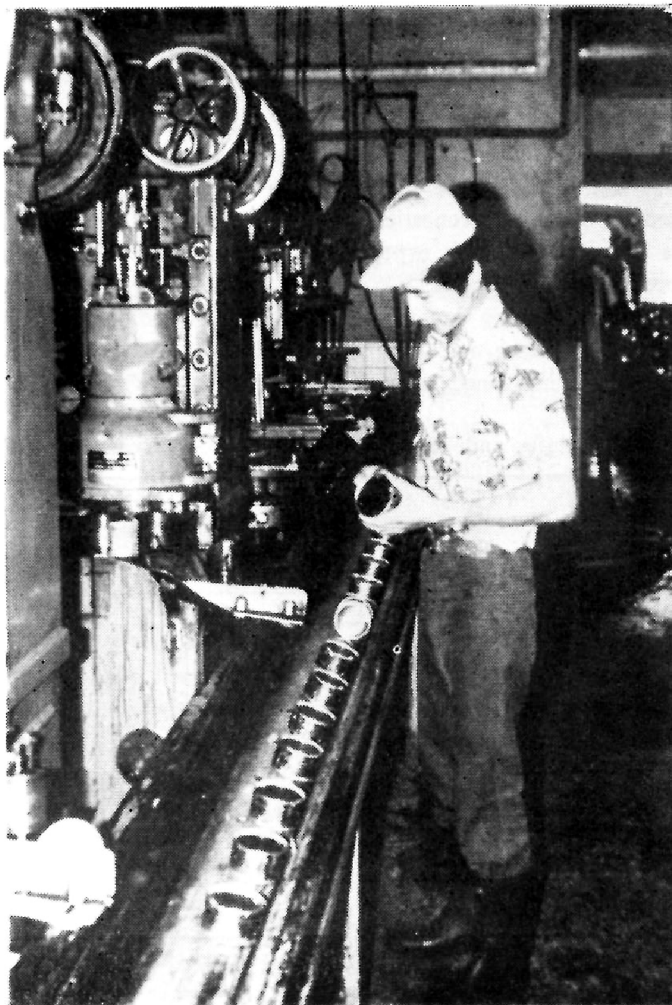


Fig. 4-1. 5M sanitary vacuum seamer.

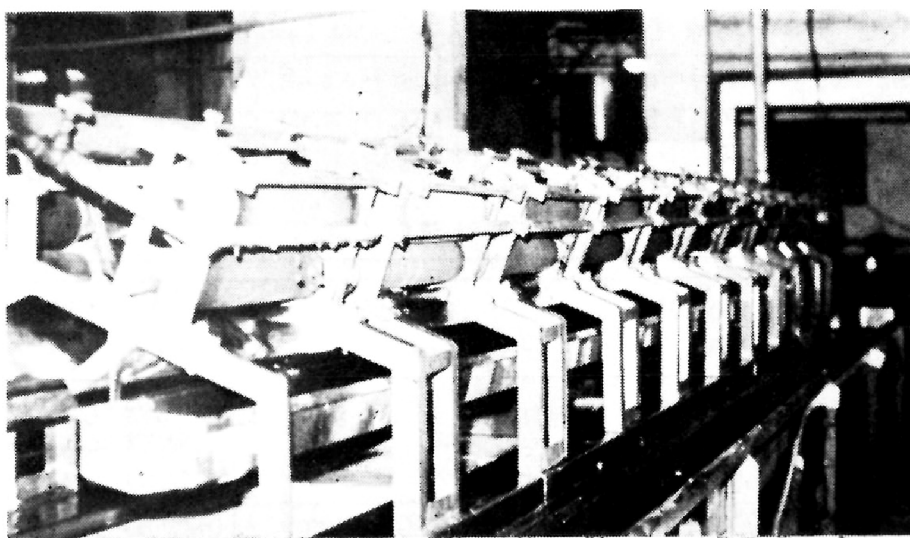


Fig. 4-2. Horizontal-type crab-meat separators.

Quantity and value of canned seafoods for export

The total export quantity of canned seafoods increased from 3 thousand standard cases in 1969 to 587 thousand standard cases in 1976. (Table 4-2)

Table 4-2 clearly shows that canned seafood export increased from 75,653 standard cases valued US\$3 million in 1972 to 330,127 standard cases valued US\$13.6 million in 1973, and to 586,518 standard cases valued about US\$20 million in 1976. In 1972, most of canned seafoods were exported to European countries. U.S. market was then explored. In 1975, both quantity and value of canned seafoods exported to U. S. A. reached 35% of the total quantity and value of exported canned seafoods.

The most important importing countries of Taiwan's canned seafoods are West Germany, U. S. A., Holland, Sweden, France, and Australia. (Table 4-3)

Besides the countries mentioned above, Denmark, Israel, Greece, Saudi Arabia, United

Table 4-2. Quantity and Value of Canned Seafood Exported, 1969-1976

Year	Quantity (Standard Cases)					Value (US\$ 1,000)				
	Total Std. Cases	To European Countries		To U. S. A.		Total US\$ 1,000	To European Countries		To U. S. A.	
		Std. Cases	%	Std. Cases	%		US\$ 1,000	%	US\$ 1,000	%
1969	3,174	—	—	—	—	—	—	—	—	—
1970	12,511	—	—	—	—	—	—	—	—	—
1971	27,367	—	—	—	—	—	—	—	—	—
1972	75,653	—	—	8,068	10.7	2,912	—	—	—	—
1973	330,127	247,291	74.9	39,300	11.9	13,600	9,149	67.3	1,563	11.5
1974	286,639	197,821	69.0	26,960	9.4	14,320	8,758	61.2	1,594	11.1
1975	352,777	209,167	59.3	126,062	35.7	11,488	6,797	59.2	4,034	35.1
1976	586,518	388,357	66.2	164,901	28.1	19,000-20,000*	—	—	—	—

* The total value (US\$19,000,000-20,000,000) of canned seafoods in 1976 is only estimated.

Table 4-3. Destination & Quantity of Canned Seafood Export 1972-1976

Year	Countries Quantity	U. S. A.		W. GERMANY		HOLLAND		SWEDEN	
		Std. Cases	%	Std. Cases	%	Std. Cases	%	Std. Cases	%
1972		8,068	10.7	41,250	54.5	6,658	8.8	2,950	3.9
1973		39,300	11.9	136,401	41.3	24,483	7.42	20,430	6.2
1974		26,960	9.4	136,600	47.7	15,115	5.3	20,066	7.0
1975		126,062	35.7	137,086	38.9	25,169	7.1	15,262	4.3
1976		164,901	28.1	286,739	48.8	42,481	7.2	22,773	3.9

Year	Countries Quantity	FRANCE		AUSTRALIA		OTHERS	
		Std. Cases	%	Std. Cases	%	Std. Cases	%
1972		5,750	7.6	0	0	10,970	14.5
1973		41,438	12.6	8,880	1.1	98,378	29.8
1974		14,045	4.9	27,999	4.1	72,520	25.3
1975		16,493	4.7	2,980	1.7	29,986	8.5
1976		12,335	2.1	9,765	1.7	48,215	8.2

Kingdom, Canada, Japan, South Africa also imported Taiwan's canned seafoods by thousands of cases each year.

Important Export Canned Seafood Items and Their Importing Countries

Among canned seafoods, canned tunas and bonitos have recently become the most important export items constituting 89.23% of the total canned seafood export in terms of quantity. (Table 4-4)

Table 4-4. Quantity of Important Canned Seafoods Exported 1973-1976

Unit: Std. Cases

Commodity Year	Total	Bonitos & Tunas	Shrimp	Crab Meat	Roast Pike Eel	Fish Paste	Snail
1973	330,127	193,344	8,377	124,904	1,445	923	—
1974	286,639	194,044	3,577	76,467	1,332	3,724	—
1975	352,777	301,680	1,006	46,167	1,164	260	1,636
1976	586,518	523,330	424	41,800	1,796	820	16,276

Although canned snail is not a seafood item, it is produced by seafood canneries in Taiwan; therefore, this item was classified as canned seafood by the Taiwan Cannery Association. The export of canned snail is very recent. Its quantity of 1976 increased to about 10 times that of 1975. This item was mainly exported to Canada, U. S. A., Denmark and Belgium.

Canned shrimp and crab are mostly exported to U. S. A., France and Australia. Canned crab was a major export item in 1973 when its export quantity was 125 thousand standard cases. This dropped to 42 thousand standard cases in 1976, mainly due to the shortage of crab catch.

Canned roasted pike eel and fish paste were mostly exported to U. S. A. Other canned seafoods exported includes king crab, mackerel, seabream, stone bream, flat fish, horse mackerel, oyster, cuttle fish, and caviar.

According to Chinese custom's statistics, the total value of export-canned tuna and bonito was about US\$14.4 million in 1976. More than 50% of Taiwan's canned tuna and bonito were exported to W. Germany in 1976. On the other hand, about 31.2% of W. Germany's imported canned tuna and bonito was from Taiwan in 1976. (Table 4-5)

Table 4-5. W. Germany's Imports of Canned Tuna & Bonito*

Year	1975		1976	
	Quantity (M. T.)	%	Quantity (M. T.)	%
Japan	6,558	47.9	3,346	23.8
Taiwan	2,046	14.9	4,377	31.2
Italy	2,420	17.7	2,842	20.2
Mauritius	895	6.5	263	1.9
Senegal	116	0.8	910	6.5
Others	1,655	12.1	2,308	16.4
Total	13,689	100.0	14,045	100.0

1 krt./ctn. = 9kg (netto/net) 1 ton = 111 krt./ctn. 48/185 g

* Statistics supplied by Hans Georg Moller, 2 Hamburg 18 Doormannsweg 43 Postfach 7711.

The quantity of canned bonito and tuna exported to W. Germany was 283 thousand standard cases in 1976. (Table 4-6)

Table 4-6. Quantity and Destination of Taiwan's Canned Tuna and Bonito Export in 1976

Unit: Std. Cases

Commodity	Countries				
	W. Germany	Holland	Sweden	U. S. A.	Others
Tuna & bonito in dressing sauce, and in oil	283,352	39,508	22,435	—	38,347
Tuna in brine	—	—	—	139,688	—
Subtotal	283,352	39,508	22,435	139,688	38,347

In 1973, most of the exported bonito was in the form of "in dressing sauce", while more and more bonitos are processed into the form of "in oil" recently. The canned bonito exported to European countries are mostly made from frigate mackerel. (figs. 4-3, 4-4, 4-5)

In 1976, the quantity of canned tuna (including yellowfin albacore, and skipjack) in brine exported to U. S. A. was 140 thousand standard cases of which 123 thousand standard cases were packed in cans of size "Tuna 2kg". (fig. 4-6)

Canned seafood for domestic consumption

Fig. 4-7 shows the canned seafood production for domestic consumption in Taiwan.

From 1953 to 1959, the production of canned seafood for domestic consumption was very small ranging from 130-900 metric tons. Due to the development of fisheries, the quantity of our fish catch greatly increased and consequently, the production of canned fish jumped to



32

The quantity
standard cases in

Fig. 4-3. Bonito being eviscerated on the butchering table (in the middle of which runs a slow-moving belt conveyor).



Fig. 4-4. Rectangular-shaped steel chamber for canning of tuna and bonito.

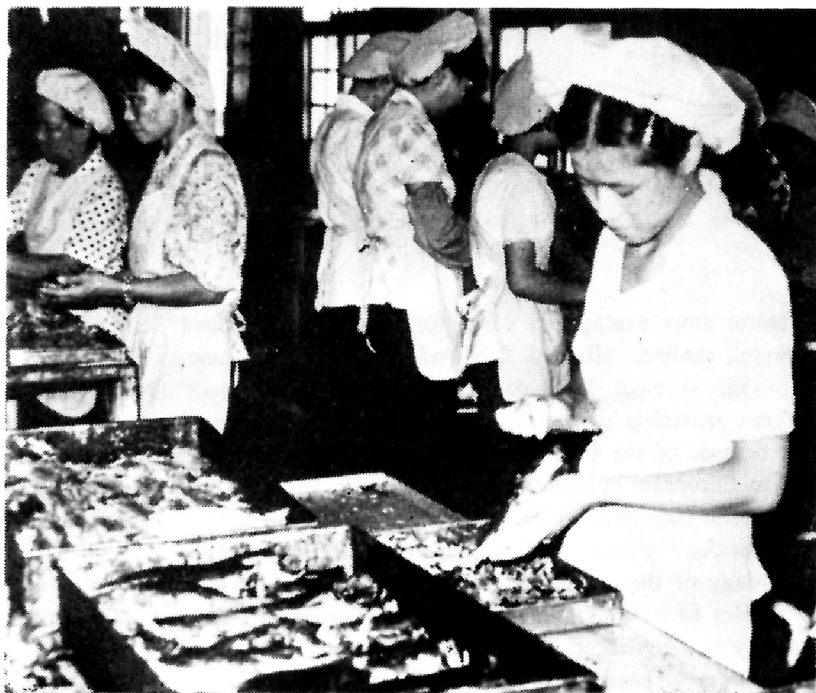


Fig. 4-5. Cleaning of bonito loin.

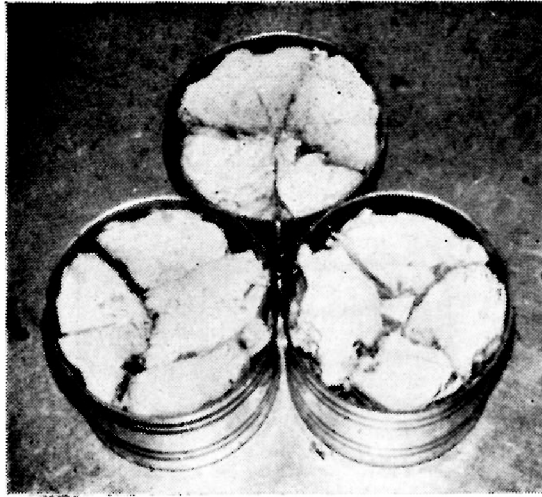


Fig. 4-6. 2-kg canned tuna in brine.

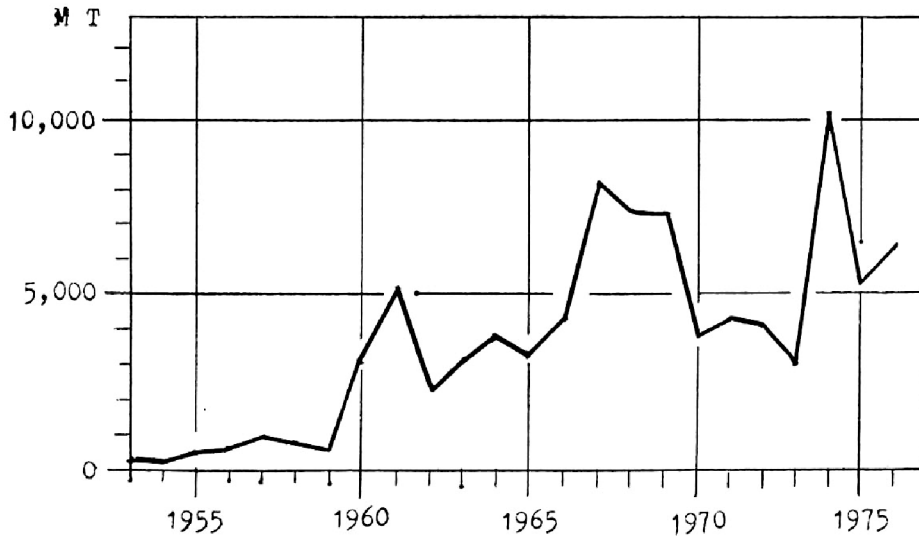


Fig. 4-7. Canned Seafood Production for Domestic Consumption in Taiwan, 1953 thru 1976.

some 3,000 metric tons average in 1960 through 1963. Canned bonito, frigate mackerel, skipjack, mackerel, sardine, pike eel, fish paste are the main items. The annual canned fish production of 1967 through 1969 doubled that of 1964 through 1966. This was due to availability of raw materials such as frigate mackerel which were formerly salted but now up as canned fish because of the poor market of salted fish since 1965. Because the export of canned bonito to European countries started in 1970 and 1971, the quantity of canned fish produced for domestic consumption decreased to around 3,500 tons in 1970 through 1973.

The canned seafood production for domestic trade reached another peak of 10,113 metric tons in 1974. Many of the canned seafoods which were originally for export ended up on the local market shelves because of the world-wide depression in that year. Though unanticipated, these good quality but higher priced canned tuna has enjoyed popularity in the local markets.

The local market of canned fish has always been very limited. The average annual consumption was about 4,400 metric tons (equivalent to 270,000 standard cases) in 1961 through

1973. Since the living standard of Taiwan's consumers has become much higher, the local market of canned seafoods is expected to expand gradually in the future.

Problems and prospects of Taiwan's canned seafood industry

The local seafood canneries have long experience with fish canning. Therefore, not too many technical problems are encountered by our seafood canning industry. However, Taiwan has to import tin plate from Japan, thus the local canneries have to pay an extra US\$2 per box of tin cans as compared with Japan's processors, who are our strong competitors for canned tuna in the American market. This is a drawback in our seafood canning industry.

In the past, Taiwan's fish canning industry was handicapped by the shortage of raw materials. Now as our refrigeration and cold-chain systems have been developed and are able to adjust the raw material supply and to enable a canned seafood plant to procure raw materials from distant sources, the plants' working days can be extended.

The present development of canned tuna industry has encouraged the deep-sea tuna fishing vessels to bring home their fish catch and sell it to the local canneries. There is a promising future for Taiwan's canned tuna industry.

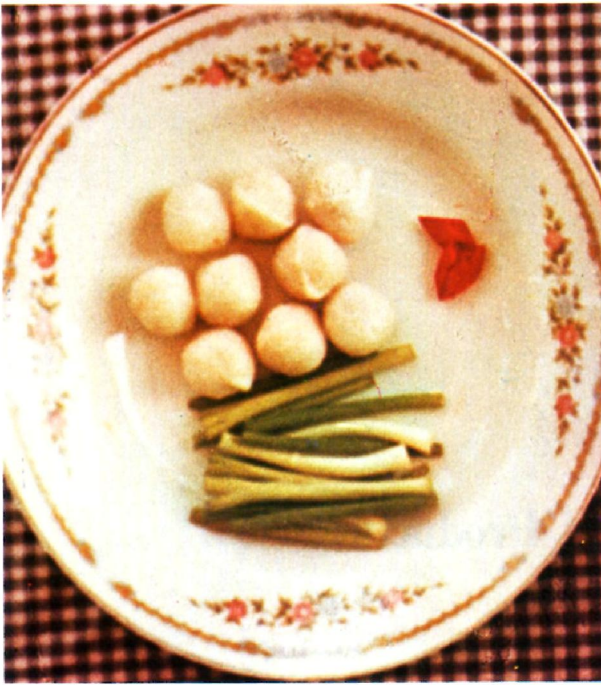
Large purse seining has recently begun operation in the East China Sea and Yellow Sea. It is anticipated that the quantity of raw materials such as mackerel for fish canning will greatly increase. This will further lend impetus to our canned fish industry.

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Part 3

Traditional Products



Fish balls



Fish bits (fried shredded fish)

These processed seafoods are also part of Taiwanese culture.



Dried mullet caviar (Dried mullet roe)



Dried shark fin

V. Minced Fish Products

SEN SHYONG JENG*

Introduction

Minced fish products, especially fish balls, have organoleptic properties that are well accepted by the local population. They represent a type of food widely used as a staple dietary ingredient. In Japan, the major minced fish products are kamaboko and chikuwa. However, in Taiwan over 90% of the minced fish products is consumed as fish balls. Usually fish balls are made into hot fish ball soup. Therefore, the consumption in winter time is two or three-fold larger than in summer time.

The production of minced fish products in Taiwan has increased year by year. In 1976, the production of this kind of food was 17,625 tons. This is the second largest processed fishery product consumed in the island, only next to dried fishery products. However, the production of dried fishery products has declined year by year due to the general economic well being of the people. It is expected that minced fish product may become the largest item of processed seafood consumed in Taiwan in future years.

Minced fish product processors

Fish balls in Taiwan are mainly supplied by house-hold processors. It is estimated there are over 600 processors in this island. In the corner of every large market of every city and town, there are one or two processors manufacturing fish balls. Besides fish balls these processors also produce fried minced fish products (tempura). Only in larger cities are there plants manufacturing minced fish product on a larger scale. They produce kamaboko, chikuwa and tempura, besides fish balls. Even these "plants" seldom have more than 20 employees. Therefore, it could be understood that although people in Taiwan consume a lot of fish ball, minced fish product is still not an industry like frozen and canned foods.

Market

Among all the minced fish products consumed in Taiwan, over 1/3 was consumed in Taipei city. This fact demonstrates that minced fish products are more accepted in the cities than in villages.

Raw Materials

In Taiwan, the principal species of fish used as raw material for manufacturing minced fish products are shark, lizard fish, pike eel and marlin. Shark (Fig. 5-1) is by far the most important species, accounts for over half of the total raw material. It is because that (1) shark has the character to make products having fine texture, (2) the fresh muscle of shark is not so liked by local people due to its ammonia flavor. Shark is caught along the coast of Taiwan and from overseas. The shark caught along the coast is iced, while that caught from overseas is frozen for 1-2 month. To ensure the best quality of the finished product, the fish for manufacturing minced fish products must be as fresh as possible. Hence, fish balls processed from frozen fish are not as good as those processed from fresh fish.

Besides shark, lizard fish and pike eel are also used to produce fish balls in some places.

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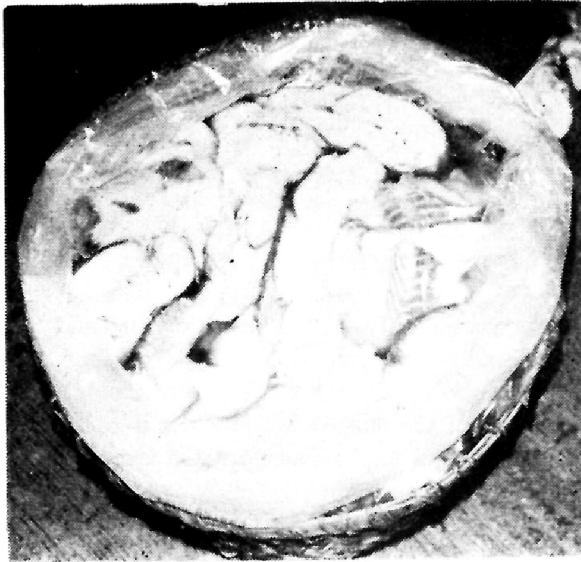


Fig. 5-1. Shark meat for further processing into fish ball.

Marlin is usually used for high quality fish balls. Some other low priced fish are used for producing fried minced product (tembura).

Processing Methods

(1) Home processing

The home processor usually buys fresh or frozen fish fillet from fish dealer who fillet the fish in fish market and store it in -20°C refrigerator. The fillet is then chopped with a chopper. The meat is kneading with starch, sugar, salt, and other additives in a meat mixer.



Fig. 5-2. Kneading machine for fish ball processing.



Fig. 5-3. Inside a minced fish product processing plant.

The minced meat is then shaped with hand to become fish balls. Sometimes a fish ball shaper is also used. The shaped fish balls are then boiled in boiling water. After removing from water, the fish balls are cooled and ready to sell. In the case of fried fish ball the minced meat is deep-fried. Usually, the low class minced meat is used for frying, since the fishy flavor could be diminished. These products are sold in the food market without any packaging. In this kind of processor, usually the shop owner and his relatives are the whole work force. The equipment is also very simple, consisting of only meat chopper, meat mincer (kneading machine, Fig. 5-2) and refrigerator.

(2) Processing plant (Fig. 5-3)

A plant that produce minced fish products usually buys frozen or fresh whole fish. The fish is deheaded, eviscerated, washed and deboned. Then the fillet is chopped with a chopper. To the chopped meat, cold water is added and the mixture is stirred. After the slurry has been left to settle, the supernatant is removed. This water extraction step is repeated several times. Dehydration of the watersoaked meat is carried out in a centrifuge, followed by pressing. After the press cake is minced, it is mixed with starch and chemical additives, such as sugar, salt, polyphosphate and others. The minced fish is then shaped to become fish balls, fish jelly (kamaboko), or fish stick. The shaped product is then boiled (fish ball), or fried (fried minced fish or tempura), or steamed (kamaboko). Usually these products are packaged and sold in the super-market.

This kind of plant is usually equipped with meat chopper, meat mixer, centrifuge, presser, fish ball shaper, heating and packaging apparatus, but the investment is very small.

Quality and future of Taiwan minced fish products

The qualities of Taiwan's minced fish products have been investigated recently. It was found that the quality of minced fish products made in plants is generally better than home-made products. The qualities of some home-made products are very fine, and some very poor. This is because there is no quality control in a small shop.

The chemical composition of some local minced fish products is summarized as Table 5-1. It shows that the protein content of these products is always higher than 15%, thus the minced fish product is a good source of animal protein.

Among all processed fishery products in Taiwan, minced fish product may be the most promising one, if its quality is improved. This is due to the fact that minced fish product is well

Table 5-1. Chemical Composition (%) of Some Taiwan Minced Fish Products

Sample	water	protein	lipid	sugar	ash	starch	salt
fish balls	66.80	17.06	3.34	3.09	2.44	4.42	1.60
	81.23	16.44	0.46	0.25	1.86	2.07	1.58
	81.00	15.81	0.39	0.33	1.61	0.69	0.75
	72.00	16.69	0.78	0.72	1.37	7.33	2.10
	79.54	12.54	0.24	0.29	2.74	2.63	2.64
kamaboko	69.81	16.25	0.21	1.78	3.42	5.04	2.64
	71.93	14.00	1.28	1.62	2.81	5.25	2.80
	71.43	13.19	0.20	3.43	2.58	8.29	2.44
fried fish jelly	57.69	18.00	6.11	2.70	3.79	6.39	1.95

accepted by the local people. There is no resistance to this food. It is also because the raw material of minced fish product is no longer recognizable; therefore, the disliked fresh fish or low-price-fish can be used as raw material. This makes the price of minced products more reasonable.

In order to have good quality and good future of minced fish products, the improvement of processing method and study of using new material are most important. For this purpose, the best conditions to use small shark as raw material to manufacture fish balls have just been studied by the author. A study of using other abundant fish to manufacture minced fish products is also underway.

VI. Low-Moisture Fishery Products

BONNIE SUN PAN*

Introduction

Since the last decade, utilization of fish protein from both established and potential fishery resources has been the center of interest for food scientists. Fish protein concentrate (FPC) for human consumption has been the main theme. The powdery FPC product is stable, dry, high in protein quality, free from fishery taste and odors, non-toxic, water soluble, and readily to be used in formulating other food products. However, the lack of functional properties has inhibited its development. Others are those consumed in their own forms, such as smoked, salted and/or dehydrated fishes, kamaboko, etc. The majority of those which fit in the latter category are traditional and native to the Orient.

Fish Bits (Fried Shredded Fish)

"Fish bits" is probably the most well-accepted fish product in China, Japan and Indochina. It is as popular to the Chinese children as potato chips to the American kids. In addition, it is a convenience food and contributes considerably to the necessary protein uptake in the Chinese youngsters' diet. It has also become an export item gaining increasing market in Japan and Okinawa.

A. Raw Material

The raw material used for production of fish bits consists of low-priced pelagic and shoaling fish species from the Pacific: lizard fish (*Saurida tumbil*), big-eye snapper (*Priacanthus tayenus*) ribbon fish (*Trichiurus lepturus*), amber fish (*Decapterus maruadsi*), horse mackerel (*Megalaspis cordyla*), and tilefish (*Branchiostegus japonicus*) are generally used. Among these species, lizard fish and big-eye snapper are favored, because they have longer muscle fibers than those of other species. Thus they contribute better texture and flavor to the end product than other species for production of fish bits. Despite the difference in muscle fiber, all these fishes are low in fat content^(2,3,4). Tuna flake as waste from canned tuna chunk processing has also been used for production of fish bits.

B. Processing

Since fish bit is a low-technology product, it is manufactured by well-established manufacturers as well as by kitchen-oriented producers. Therefore, pronounced variations have been observed in processing methods and product quality.

The general processing procedure includes handling and preparation, brining, steam stripping, deboning, dehydration, roasting and seasoning.

1. *Handling and preparation.* Fresh or frozen fish after thawing is washed, deheaded, and gutted. The waste is collected for production of fish meal or fish solubles.

2. *Salting.* Fish is either salted in brine of 18° Be or dry salted with 3-5% salt (weight of fish). The purpose of salting is to slightly denature the fish protein and thus retain the integrity of fish muscle fiber when undergoing frying-roasting. After salting, the fish is washed to reduce saltiness.

3. *Steam stripping.* Steaming of fish simplifies deboning, scaling and skinning. The salted fish is steamed at 100°C for 5 to 30 min until the backbone is readily separated.

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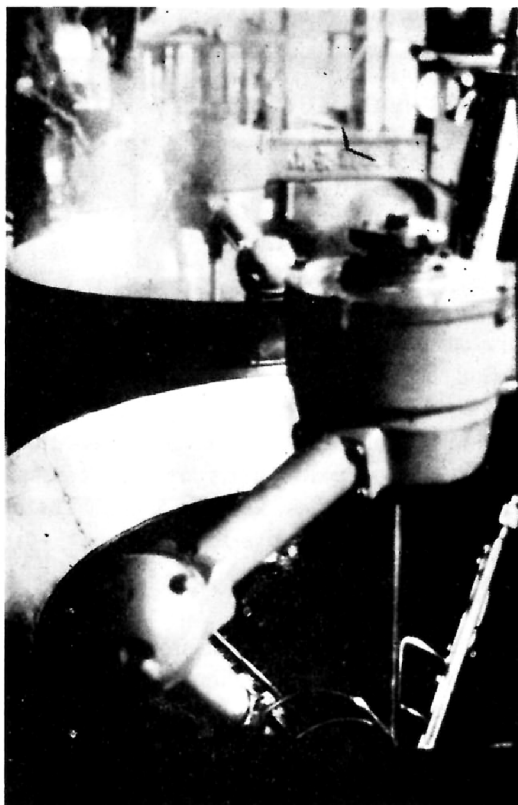


Fig. 6-1. The Open Pans with Stirring Facilities for Fish Bits Processing.

4. *Deboning and comminution.* Deboning is part of the regular process to obtain uniformity in texture and ash content of fish bits. It is done manually or mechanically. Equipment available for deboning is of two types. The first type consists of a continuous screw press, which forces the muscle tissue through a screen, while the bone and scale pass on around a pressure plate. The second type uses an adjustable moving belt to press fish against a rotating perforated horizontal cylinder. The fish is rolled against the drum and the muscle tissue is forced through the perforations while the scale, skin and bone remain outside the drum.

5. *Dehydration.* Centrifuge and hydraulic press are the two kinds of equipment used to reduce free water from fish. The time needed for the subsequent roasting-drying is thus shortened.

6. *Roasting and seasoning.* The semi-dehydrated fish is roasted in an open pan (Fig. 6-1) with frequent stirring until the moisture content of fish is reduced to 25 to 45%. It is then seasoned with sugar, vegetable oil, soysauce, shortening, salt, MSG, licorice, pepper, aniseed star, and fennel seed. The mixture is further heated and stirred. The temperature at the center of the batch is maintained at 80°C.

7. *Packaging.* Three types of packages have been used, glass jar, tin can and flexible package.

C. Chemical and nutritional characteristics

The composition of the fish bits is greatly affected by the source of raw material and the process used. The variation lies mainly on the extent of roasting-dehydration and amount of seasoning ingredients added. In general, fish bits consist of 60-80% fish and 20 to 40% other ingredients mainly fat and sugar.

The proximate composition varies a great deal with manufacturer's specifications, because the Standard of Identity of this product listed only the ingredients allowed and the adulterants prohibited⁽⁶⁾. The average of the proximate content from 20 manufacturers is listed as follows:

Table 6-1. Average Proximate Composition of Fish Bits (Fried Shredded Fish)

Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Carbohydrate (%)	Salt (%)
9.8	37.1	23.3	7.2	21.4	5.3

The lipid content of the fish used is comparatively insignificant, because it is only 1-2% in the raw material⁽⁹⁾. Therefore, the high lipid content is mainly due to the addition of oil and shortening.

The carbohydrate content is a result of the sugar added. Starch has been used as an adulterant to lower the manufacturing cost. However, it is prohibited.

Ash comes chiefly from salt addition and is less subject to the manufacturer variations.

Fish bits are a good source of protein as shown by its high protein content of 37%. The quality of fish protein is maintained through processing and is demonstrated by the high availability of lysine⁽⁷⁾ (Table 6-2).

Table 6-2. Availability of Lysine in Fish Bits (Fried Shredded Fish)

Product	Total lysine g/100 g protein	Available lysine g/100 g	Lysine Availability %
Fried shredded fish	6.39	5.09	79.6
Shortened Fried shredded fish	8.47	6.39	75.5

The loss of available lysine, as compared to the total lysine is presumably caused by the browning reaction.

It has been suggested⁽⁸⁾ to add sesame seed to fish bits to improve flavor and nutritional quality, because sesame seed is a good source of methionine and vitamin A⁽⁹⁾. However, the sesame enriched fish bits are not available commercially yet.

D. Quality Parameter

Fish bits is a product that does not require refrigerated storage. It is very stable when vacuum packed. The major quality degradation is rancidity developed in improper storage. Both peroxide value (POV) and acid value were studied⁽⁷⁾ to establish a quality index for product stability: acid value was found in good correlation with sensory evaluation as shown in the following Table 6-3.

Table 6-3. Acid Value and Sensory Evaluation of Fish Bits⁽⁷⁾

Sensory evaluation of flavor	Acid Value
good	2.7
somewhat rancid	4.9
rancid	8.6

Acid value is thus suggested to serve as the objective quality parameter.

Dried Salted Fish

Dried salted fish has been used as a food product for thousands of years. Not only the

ancient Chinese, but also the Greeks and the Romans knew the magic of salt in food preservation long before civilization. However, the amount of dried fish consumption has decreased as technology in food preservation becomes more advanced. Nevertheless, the simplicity and low cost involved in salting preservation has enabled it to survive through the ages.

Round herring (*Etrumeus micropus*) is the major material used for dried salted fish manufactured in Taiwan. Between June and August, volumes of round herring are caught in the Penghu area. They are salted and dried under the tropical sun, which is the quickest way of handling such a large quantity of raw material.

A. Raw Material

Large seasonal variation is observed in the proximate composition of round herring as shown in Table 6-4⁽¹¹⁾.

Table 6-4. General Compositions of the Three Portions of Round Herrings⁽¹¹⁾

	Head-bone-fins		Viscera		Flesh-skin	
	Aug. (%)	Nov. (%)	Aug. (%)	Nov. (%)	Aug. (%)	Nov. (%)
Moisture	74.4	74.1	71.2	66.8	73.8	74.2
Protein	15.5	15.3	16.3	17.0	20.4	18.0
Fat	1.7	3.0	5.3	11.7	1.3	3.5
Ash	5.5	5.1	2.1	2.0	1.9	1.6
Total carbohydrates	2.9	2.5	5.1	2.5	2.6	2.7

Fat and protein in the flesh and skin are more subject to change than other constituents of round herring. The drying rate and the product quality are greatly affected by the fat content. The fractionation of lipid also showed seasonal variation as shown in Table 6-5.

Table 6-5. Fractionation of the Lipids of Round Herring Meat⁽¹¹⁾

	August (%)	November (%)
Total lipids*	1.3	3.5
Triglycerides**	46.5	47.5
Free fatty acids**	15.7	19.1
Phospholipids**	25.4	27.0
Hydrocarbons**	1.9	3.4
Cholesteryl esters**	10.2	2.5
Other**	0.3	0.5

* Per 100 fish, ** Per 100 g lipid.

Nevertheless, the percentage of triglyceride remains constant. Free fatty acid, phospholipid, hydrocarbon and cholesterol content varies with season of fish catch. Other data showed the unsaturated fatty acid fraction was more variable than the saturated fraction based on the comparison of fish caught in August and in November⁽¹¹⁾. Therefore precaution has to be taken to prevent rancidity and autoxidation during sun drying when the fish has high fat content, particularly high in free fatty acids and high degree of unsaturation.

B. Processing

The whole round herring is eviscerated and salted (salt: fish=50:300), then steamed and sun dried. The yield is 25 to 50%.

C. Quality characteristics and future improvement

The content of protein, fat and salt in the dried salted fish is shown in the following table 6-6.⁽¹²⁾

Table 6-6. The Chemical Composition of Dried Salted Round Herring

Composition	Content (%)
Moisture	41.0
Fat	7.4
Protein	36.7
Salt	13.7

Since round herring contains considerable amount of free fatty acid especially docosahexenoic acid (22:6)⁽¹¹⁾, the dried salted round herring is vulnerable to autoxidation resulting in discoloration. Combination of antioxidants are being tested in the author's laboratory to eliminate the discoloration developed in drying.

Mold growth has been found in the storage of dried round herring. *Aspergillus glaucus* and *Penicillin* are the major species of mold associated with the spoilage of salted round herring⁽¹³⁾. Combinations of either sorbate, methyl naphthoquinone, or butyl *p*-hydroxy benzoate and dehydroacetic acid have proved effective preventatives of mold growth in dried salted herring.

Commercial products that demonstrate microbial stability without the addition of antimycotics are usually too dry to be palatable. However, it is possible to increase the residual moisture content and maintain the microbial stability by lowering water activity. Different solutes have been tested in the author's laboratory to reduce effectively the water activity of salted round herring. Hopefully, the present low-moisture salted fish can be converted into an intermediate moisture food.

Dried Shrimp

Shrimp consumption has increased in recent years. U.S. consumes about one third of the global shrimp harvest. Japan's consumption of shrimp is about half of that of U.S. These two countries hold the largest shrimp export market of Taiwan. It is mainly the fresh frozen shrimp that is exported. Because of the increasing foreign market, the shrimp harvest in Taiwan has also increased accordingly as shown in the following Table 6-7.

Table 6-7. Harvest of Shrimp Between 1970 and 1975⁽¹⁴⁾

	Year					
	1970	1971	1972	1973	1974	1975
Harvest, mt	30,897	37,047	47,101	49,081	49,841	63,226

Forty percent of the shrimp harvest is from the Keelung area.

A. Production

There are two types of processed shrimps in Taiwan. One is individual quick frozen (IQF) shrimps. The other is the dried product of medium and small-size shrimps. The former is chiefly for export while the latter is largely for domestic consumption.

There are four kinds of dried shrimps: (1) salted and precooked small whole shrimp; (2) uncooked small whole shrimp; (3) salted, precooked and deshelled medium shrimp; (4) uncooked soft-shell shrimp.

B. Quality parameters of dried shrimp

The microbial growth associated with the spoilage of dried shrimps are mainly mold and halophiles. The quality factor that determines the growth is moisture content. The extent of dehydration leading to different storage stability was demonstrated by Gore *et al.*⁽¹⁵⁾.

Table 6-8. Extent of Dehydration Leading to Different Storage Stabilities.

Moisture Content (%)	Storage before Spoilage (days)		Spoilage
	10-12°C	25-30°C	
80 (fresh)	3		putrid, high bacteria count
50 (cooked)		4- 5	NH ³ off-odor, high bacteria count, mainly mold
40 (cooked)		4- 5	Ditto
30 (cooked)		7-10	NH ³ off odor, high mold count
20 (cooked)		30-35	NH ³ off odor, mold growth

Therefore, the moisture content of dried shrimp is kept below 20% to enhance the storage stability at room temperature. Sorbic acid and sorbohydroxamic acid have been used as antimycotics. The latter is more favorable due to its effectiveness, wide pH range and low LD₅₀ (0.7 mg/kg)⁽²³⁾.

The texture of dried shrimp is greatly affected by the cooking time. Prolonged cooking results in excessive dehydration and thus toughness. Lowering pH also leads to loss of tenderness⁽¹⁶⁾. Addition of polyphosphate in cooking increases the tenderness in texture⁽¹⁷⁾ and prevents the lowering of pH in storage⁽¹⁸⁾.

The color of dried shrimp is a function of the presence of three pigments: haemocyanin, carotenoids mainly astaxanthine, and melanin the result of tyrosinase activity. Blanching and cooking eliminates the formation of melanin. The carotenoid compounds, especially astaxanthine, are responsible for the characteristic red color of fresh and dried/or cooked shrimps. However it is readily oxidized causing the color to fade. Ascorbic acid, BHA and liquid smoke flavoring have found to be effective antioxidants⁽¹⁹⁾. In addition, they have synergistic effects⁽¹⁹⁾.

The bad odor developed in storage is a result of degradation of free amino acids and nucleotides. Irradiation in UV light accelerates the undesirable reactions. Therefore packaging that prevents the transmission of UV energy is put in some commercial practices to preserve the flavor of dried shrimps.

Dried skipjack stick (Katsuobushi)

This product is produced by a combination of smoking, drying and mold-fermentation of skipjack flesh (Its processing procedure is briefly described in "Fish as Food"⁽¹⁰⁾).

In 1890, the Japanese first introduced the katsuobushi processing techniques to Taiwan. However, it was not manufactured in large quantity until 1910 when skipjack fishing became more advanced.

The dried skipjack stick (Fig. 6-2) is mainly for export to Japan. The average annual export is about 900-1000 tons. The quantity of local consumption is about 300 tons a year.

Due to the fast development in tuna and bonito canning industry, the raw material supply for katsuobushi processing has been limited in quantity. Materials such as frigate mackerel (Fig. 6-3) and round herring have been processed in place of skipjack to produce shavings, a substitute of katsuobushi.

Dried oyster and oyster sauce

Dried oyster, a cooked-and-dried product, is one of the important ingredients in traditional

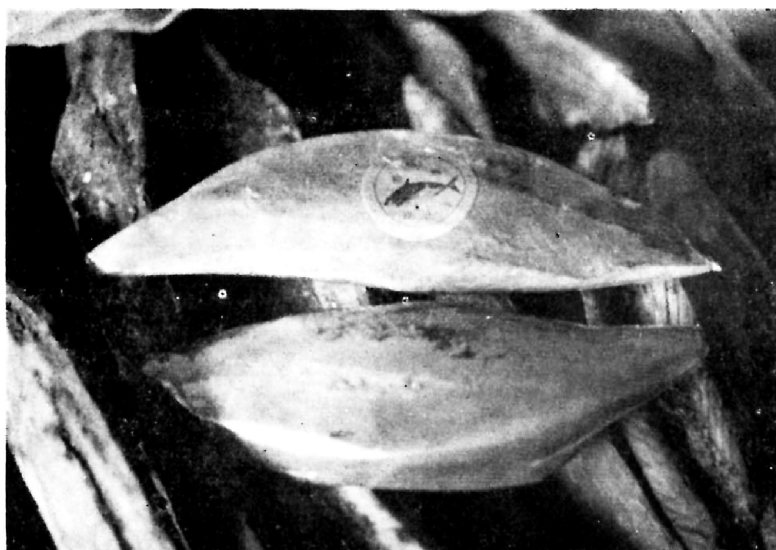


Fig. 6-2. The Finished Product of Dried Skipjack Stick (Katsuobushi).

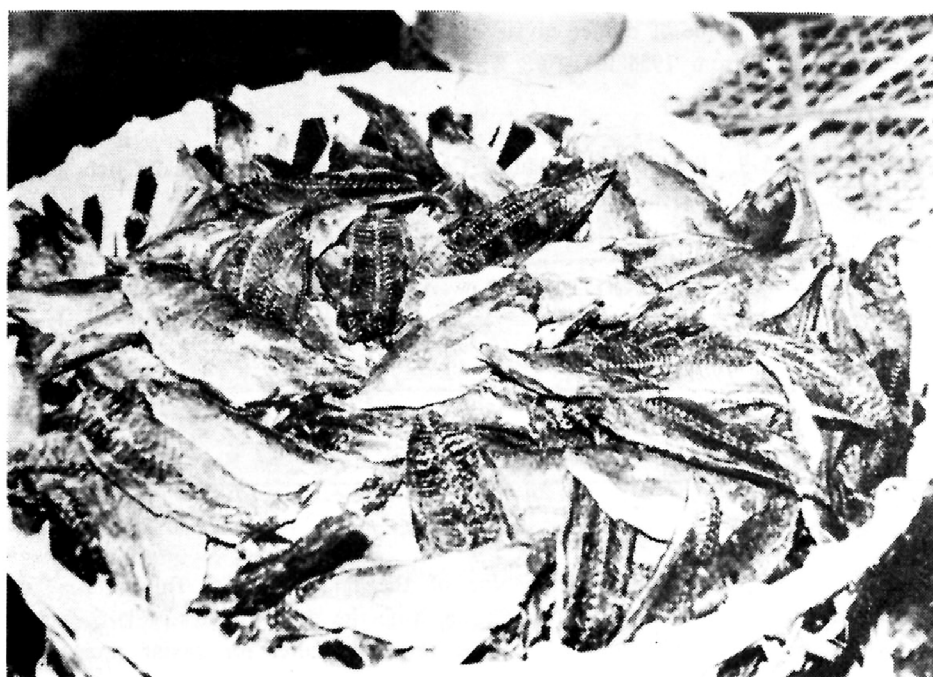


Fig. 6-3. The Smoked Dried Frigate Mackerel Which will be Further Processed into Shavings.

chinese gourmet cooking. Oyster sauce is made from oyster nectar undergoing concentration and fermentation. These two products in Taiwan are processed concurrently.

Oyster sauce is mainly consumed by Chinese and Vietnamese. The product from Taiwan is exported to Hong-Kong, Macao, and Singapore as well as consumed by the local Chinese especially the Cantonese. Because the price of the raw material is expensive, the amount of production is limited.

Processing

1. *Shucking*. Shucking is accomplished manually using a knife or through short-time

cooking. Using microwave for shucking has been reported. However it is not used in commercial practice yet. In common practice, shucking is done manually, since short-time cooking results in flavor loss and textural change.

2. *Washing.* The oyster is dipped in brine of 2-3 Be' for 20 min and washed to remove the remaining broken pieces of shell, and filth.

3. *Cooking.* Oysters are cooked with 4% salt (weight to weight of oyster) for an hour. The cooked oysters are sun dried after filtrations. The nectar, containing 11-12% salt, is collected for manufacturing oyster sauce.

4. *Concentration.* Concentration of oyster nectar is achieved under vacuum. The finished concentrate contains 25% salt. Sugar, 5%, and preservative, 0.05% *p*-hydroxybenzoic acid generally, are added to increase the storage stability. Water is added to adjust the concentrate to a proper strength.

5. *Yield.* The yield of oyster sauce is 30%, that of dried oyster is 7-9%.

Mullet Caviar (Dried Mullet Roe)

Mullet caviar is one of the most popular and expensive traditional delicacies to the Chinese and Japanese. To be served at the table, it is first roasted over a small fire. Simultaneously, small amount of rice wine may be smeared on the surface of the caviar to enhance the flavor. When slight scorches are formed on the surface, the caviar is sliced into 0.2 mm thickness.

The quantity and value of mullet caviar production is shown in Table 6-9. The price has increased 7 times from 1958 to 1976. The total value also increased 6 times during that period.

Table 6-9. Production of Mullet Caviar Processed from Local Catch in Taiwan from 1958 to 1976

(Data source: Statistics of Fisheries of Taiwan Area)⁽⁹⁾

YEAR	QUANTITY (M. T.)*	VALUE (NT\$ 1,000)**	PRICE (NT\$/Kg)
1958	40	5,048	126
1964	112	22,814	204
1970	109	63,205	580
1976	35	32,650	935

* MT: metric ton.

** NTS: 38=US\$ 1.00.

Recently, because of the economic value of the mullet caviar, Taiwan has imported considerable amounts of mullet, mainly for its roe, from the eastern states of U. S. A. In 1976, for instance, Taiwan imported about 640 metric tons of mullet for caviar processing. The caviar so produced is partly for domestic consumption, and partly for export to Japan.

A. Processing

Because of the limitation of raw material, the processing of mullet caviar in Taiwan remains a small family business. The processing procedure is as follows:

1. *Raw material.* Female mullets are separated from the catch. Roes are then taken out and shipped for processing.

2. *Cleaning of roe.* The blood vessels attached to the surface of ovarian membrane are thoroughly removed to prevent blackening reaction caused by blood during processing and storage.

3. *Salting.* Fifteen percent of salt (weight to weight) is evenly applied on the roes. The latter are then piled up to about five layers, with weight on top for 5 to 6 hours.

4. *Desalting.* The over-salted roes are desalted in water for 5 to 6 hours at room temperature. Special caution is taken to keep the ovarian membrane intact.

5. *Pressing.* The desalted roes are placed in rows for examinations. Occasionally, the membrane of the roe is broken in handling. Cellophane has been used to mend the broken membrane to improve the appearance of the roe. The roes are then covered with dry cloth, on top of which is a piece of board carrying some weights. The roes are pressed for 24 hours.

6. *Drying.* The salted and pressed roes are sun dried, then cooled indoors and turned over until next day. It is sun dried again for 3 hours. The roes are again pressed with heavier weight, and sun drying is repeated for 2 to 3 days. At the end of drying, a small amount of saturated fat is applied to coat the caviar to give it a rich shining appearance.

7. *Packaging.* The final product is vacuum packed in transparent flexible packages, and stored with refrigeration at 5°C. Rancidity and mold growth in storage are thus prevented.

B. Chemical Composition

As the roes are dried, the chemical compositions are changed accordingly. The composition at various stage of caviar processing is shown in Table 6-10.

Table 6-10. The Chemical Composition of Mullet Caviar* at Various Processing Stages

Processing stage	Moisture (%)	Total solid (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	Water soluble solid (%)
Raw material	50.0	50.0	26.8	20.5	0.9	0.1	2.7
Salting	39.5	60.5	29.6	22.2	5.9	5.2	9.5
Desalting	57.8	41.2	21.1	18.4	—	—	4.8
Dripped drying	53.2	46.8	23.2	19.9	1.1	0.7	4.9
Sun drying, 1st day	48.0	52.0	25.5	21.7	2.0	—	6.1
Sun drying, 2nd day	40.5	59.5	—	26.4	—	—	—
End product	34.1	65.6	32.1	27.4	2.6	1.0	7.6

* Processed in Keelung.

Variations in chemical composition of mullet caviar have been observed. The moisture content of mullet caviar processed in Keelung was found as high as 34%, while that of those processed in Kaohsiung was 28%. Therefore, chemical composition is subject to changes in raw material and process method.

Dried Fin (Shark Fins) and Dried Fin Ray

A. Material

Dorsal, pectoral, pelvic and tail fins of sharks are the raw material of dried fins. The main species for processing of dried-fins in Taiwan are:

Japanese gray shark	<i>Galeorhinus japonicus</i> (Muller & Henle)
Dog shark	<i>Mustelus manazo</i> Bleeker
Hammer head	<i>Sphyrna lewini</i> Griffith
Spotted guitarfish	<i>Rhynchobatus djiddensis</i> Forskal

Spotted guitarfish is an excellent material because it has long dorsal fins.

B. Processing

a. Dried Fin

1. *Preparation.* Fins are washed and immersed in hot water (80-90°C) till the placoid scales can be rubbed off easily. The temperature of hot water has to be under 100°C, or the

fin rays will melt, thus reducing the quality of the product. Remove flesh and cartilage from the fins.

2. *Bleaching.* Fins are immersed in 2-3% hydrogen peroxide to be bleached for 30-40 min.

3. *Drying.* Fins are sun dried on a bamboo mat and are turned twice a day to accelerate drying. Drying is completed in two or three days. The yield is about 9-15%.

b. Dried Fin Ray

1. *Preparation of fin ray.* Dried fin, preferably with long ray and of good quality, is soaked in water for 8-12 hrs, until it becomes soft.

2. *Bleaching.* The residual flesh, skin and scale attached to the fin, are removed to prevent discoloration in order to assure stability in storage. The fin is soaked in boiling water for 5 min followed by soaking in 2-3% hydrogen peroxide solution for 30-40 min for bleaching. It is then washed thoroughly to remove the residual peroxide. Rolling machine is used to separate fin rays from skin. The length and entirety of the ray are the chief quality parameters of dried fin ray.

3. *Conglomeration of fin ray.* The skin-free fin rays are arranged in fan shape. Each conglomerate weighs 100 gram. Fish collagen dissolved during preparation of dried fins serves as the cohesive agent.

4. *Bleaching.* If discoloration occurs or the former H_2O_2 bleaching has not been successful, the fin ray conglomerate is either fumed with SO_2 or dipped in 2-3% H_2O_2 for further bleaching.

5. *Drying.* The fin ray conglomerate is sun dried (Fig. 6-4). The yield is 85-90% on basis of dried fin. The product is packed in P.E. bags for storage.



Fig. 6-4. The Dried Fin Ray Conglomerate as Finished Product.

C. Utilization

The dried-fin is used in soup and is usually served in feast only. When it is boiled, it has a delicate gelatinous appearance. It is an expensive delicacy. Nevertheless, it is high in protein and mineral, thus it is quite nutritious, as shown in the following table.

Table 6-11. The Nutrient Content of Dried Fins (Shark's fins)

Nutrient	Content (%)	Nutrient	Content (%)
Moisture	13.76	Calcium	0.146
Protein	83.53	Phosphorus	0.194
Fat	0.28	Iron	0.0152
Carbohydrate	0.20	Potassium	0.177
Energy/100 g	345 cal		

Quantity and value of dried-fins in Taiwan near the last ten years are listed as follows:

Table 6-12. The Quantity and Value of Dried Fins in Taiwan (1965-1974)

Year	Quantity (M. T.*)	Value (Thousand NT** \$)
1965	129	18,112
66	151	14,281
67	160	10,057
68	179	18,686
69	787	24,249
70	258	38,379
71	116	28,007
72	109	26,465
73	89	24,031
75	95.5	28,459

* Metric ton ** NTS 38=US\$ 1.00

It is apparent from the table that the quantity of dried fins manufactured in the last decade has been reduced. However, the value per unit weight has been doubled.

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Part 4

Algae Utilization

VII. Agar-Agar Manufacturing

GIN-CHEN CHEN*

Introduction

The manufacture of agar-agar in Taiwan is little known in the world. There is very little trade of agar-agar with foreign countries, and it is scarcely reported by the technologists and the agar producers. The agar industry in Taiwan began in 1944, when the supply of agar from Japan was very limited during the period of World War II. In the recent three decades, except for a small quantity of special products used for medical and bacteriological studies, almost all the agar consumed is produced in Taiwan, which comes up to 150 tons annually.

Before 1960, Taiwan's agar industry depended on several species of *Gelidium* naturally grown on the rough rocks along the northern coast of Taiwan. But the *Gelidium* seaweeds are now no longer the principal raw materials for manufacture of agar in this island. The industry is now chiefly supported by the *Gracilaria* seaweeds cultivated in brackish water ponds in southern part of Taiwan with total area of about 400 hectares.

Our agar-agar products are classified in three items according to the different final shape, namely (1) agar sheets, (2) agar strips and (3) agar powder. The latest wholesale price at local market is NT\$250 (US\$6.58) per kg for agar sheets, NT\$358 (US\$9.42) per kg for agar strips and NT\$300 (US\$7.90) per kg for agar powder with jelly strength of 600 g/cm². Due to its warm weather, Taiwan has no place suitable for manufacture of agar outdoors, and there has been no bar-shaped agar product which is still commonly produced in Japan in the winter season.

Harvesting of *Gelidium*

Seven species of *Gelidium* and two species of *Pterocladia* are recognized as important agar-bearing seaweeds in Taiwan, which can be used directly for manufacture of agar without alkali treatment before extraction. *G. amansii*, *G. japonicum*, *G. latiusculum* and *G. planiusculum* are mostly grown along the northern coast of Ilan County and the eastern coast of Taipei County. *G. kintaroi* and *G. yamadae* are usually harvested from the northern coast of Taipei County. *G. pusillum* and *P. nana* are grown only along the coast of Keelung City, but *P. tenuis* ranges from the northern coast of Taipei County through the coast of Keelung City, the eastern coast of Taipei County to the northern coast of Ilan County.

These seaweeds grown in the natural conditions are traditionally collected in the spring season by women and children, who live in the coastal fishing villages, by wading at low tide. Only when the price of the seaweeds comes up to an attractive level, will some fishermen join the harvesting of *Gelidium* using rowboats and simple diving apparatus. After being brought ashore, the seaweeds are roughly divided into three assortments: (1) the lot of seaweeds containing about 70% of *P. tenuis*, (2) the lot consisting of a mix of *G. amansii*, *G. japonicum* and *G. latiusculum*, and (3) the lot containing mostly *G. kintaroi* and *G. yamadae*. Then they are sun-dried and sold to persons who deal in dried seaweeds and have some warehouse and facilities in the coastal villages.

According to the Taiwan Fisheries Yearbook, the annual production of *Gelidium* gradually decreased since 1970 from 464 mt to about 100 mt due to the development of both the technique of agar making and the *Gracilaria* culture industry in Taiwan (Table 7-1). The diminished demand and price of *Gelidium* greatly discourage the coastal fishermen from harvesting seaweeds today.

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Table 7-1. Annual Production of Sun-dried *Gelidium* and *Gracilaria* Seaweeds in Taiwan

Quantity: M. T. Value: Thousand NTS

Year	Gelidium		Gracilaria	
	Quantity	Value	Quantity	Value
1962	381	5,358	326	155
1963	336	4,366	175	133
1964	497	6,415	143	179
1965	398	4,459	155	125
1966	279	3,437	695	705
1967	249	3,473	1,148	1,390
1968	343	5,054	2,519	3,477
1969	415	6,903	1,735	2,424
1970	464	7,912	1,560	1,727
1971	242	4,115	1,948	2,881
1972	213	3,260	3,255	5,428
1973	148	2,825	5,060	10,557
1974	147	6,288	5,985	21,965
1975	106	5,450	5,643	54,943
1976	104	5,447	6,836	91,082

Note: US\$1.00=NT\$38.00

Culture of *Gracilaria*

Gracilaria is now the most important raw materials for the manufacture of agar in Taiwan. Culture of *Gracilaria* started in 1962, when demonstration in the Hsinta Lagoon was started by the Chilou Fishermen's Association. Later in that year, an experiment on the culture of *Gracilaria* by attaching them to ropes was carried out in Taiwan with the assistance of the Joint Commission on Rural Reconstruction. Since then the culture of *Gracilaria* in ponds formerly used for milkfish has gradually gained popularity. The total culture area is now estimated as 400 ha. Pingtung County alone accounted for 135 ha. with a production of 2,000 mt of dried seaweed annually.

The pond:

In nature, *Gracilaria* grow best in water of comparatively low salinity and low wave action. Inlets and shallow sea with a salinity of 8 to 25‰ (specific gravity 1.005-1.020) are suitable for their growth. The best growth is obtained at temperatures of 20° to 25°C. In the pond, they begin to die when the salinity exceeds 35‰ (specific gravity 1.024).

Most of the *Gracilaria* ponds in Taiwan are located in southern part of the island where high temperature prevails. In the selection of pond site, the following should be taken into consideration:

- The area should not be exposed to strong wind, which will pile up the *Gracilaria* on one side or one corner of the pond.
- Freshwater should be available to dilute the water when salinity becomes too high due to evaporation.
- There should be sufficient tide difference to facilitate change of water.
- The bottom should be of sandy loam.
- The water should have a pH value of 6 to 9, preferably 8.2-8.7.

Most of the ponds now in use are small in size (about one hectare) and rectangular in shape,

with the long axis perpendicular to the direction of the wind. Preferably a windbreak should be erected on the windward side.

Planting stock:

Although four species of *Gracilaria* of economic importance are recognized in Taiwan, due to its adaptability to a wide range of environmental conditions, its high cropping rate and high jelly strength of the dried seaweed, the *G. confervoides* is most extensively cultured.

The cuttings or torn sections of the *Gracilaria* are usually used as planting stock. Each plant is either torn apart at the base by hand or cut into pieces, which are planted uniformly on the bottom of the pond. It is important to plant only healthy stock. The healthy plants are those which (1) feel elastic on touch, (2) possess many shoots or stems with tips of reddish brown colour, (3) have heavy or thick stems, (4) feel brittle on being bitten, (5) have straight ends, and (6) are free from adhesion of detritus and other foreign materials.

When it is necessary to buy the planting stocks from other farmers, trucks are used to transport the planting stocks early in the day or in the cool of the evening. They are frequently sprinkled with sea water on the way and covered with wet straw or gauze to minimize evaporation. Perforated pipes of plastic or bamboo are inserted into the bottom portion for aeration to prevent over-heating. Upon arrival at the destination, the planting stocks are immediately put into the pond.

Pond management:

About 5,000 kg of the fragmented plants are planted in a pond of one hectare in size. Too low a stocking rate will result in profuse growth of phytoplankton. Planting time is usually in April. They are usually fixed on bamboo sticks planted on the bottom or covered with old fish nets to prevent them from drifting to one side or one corner of the pond.

The depth of pond water is generally 20 to 30 cm in the months from April to June. With the increase of temperature after June, it is increased to 60 to 80 cm. Frequent change of water is necessary to maintain the proper salinity as well as to provide the nutrients for the growth of the *Gracilaria*. During the dry season, some water should be introduced every day to avoid undue increase of salinity due to evaporation. During rainy days, the pond water should not be changed, sometimes for as long as a week, but if the salinity of the pond water drops too low, introduction of water of high salinity is necessary.

Since *Gracilaria* do not tolerate temperature below 8°C, the depth of the pond water should be increased when winter sets in, or they may be moved into wintering ponds, which are deeper and protected with windbreaks.

About 500 to 1,000 Milkfish per hectare (size of 150 g or more) may be introduced at the early stage to control the green algae (*Enteromorpha* and *Chaetomorpha*). They will consume the *Gracilaria* after the green algae are gone. When this happens, efforts should be made to remove them by netting them at the water inlet where they congregate.

Many *Gracilaria* farms stock their ponds with grass shrimps, *Penaeus monodon*, or crabs, *Scylla serrata*, to obtain additional income.

Harvesting, drying and packaging:

The *Gracilaria* are harvested once every ten days from June to December. Harvesting is by hand or by the use of scoop nets. They are uprooted and washed in the pond water to remove the mud, detritus, sand and snails that adhere to them.

After being thus cleaned, the *Gracilaria* are spread uniformly on bamboo screens or plastic sheets (usually placed on the sides of the ponds) to be dried under the sun. Sometimes they are spread on a concrete surface to dry. The drying ratio is about 1:7, generally 10,000 to 20,000 kg of dried *Gracilaria* are produced from one hectare of pond annually.

The dried *Gracilaria* are packed in gunny sacks in quantity of 100 kg each, either for export to Japan or sold to local agar plants.

Inspection of raw materials

The quantity and quality (solubility and jelly strength) of agar extracted either from *Gelidium* or *Gracilaria* varies according to the species, the growth stage and the environmental conditions (the place where the seaweed grow). In order to judge the value of raw materials, the following method was found to be adoptable for inspection of dried seaweeds as raw materials for agar-making upon completion of several experiments carried out by the Taiwan Fisheries Research Institute with the support of JCRR in 1969.

Step 1. Alkaline treatment:

- a) *Gelidium* do not need this alkaline treatment.
- b) Put 100 g of the dried *Gracilaria* into a 2 l-beaker and pour 1,500 ml of 5% NaOH water solution to cover the sample of the seaweed, then, use a waterbath to keep the seaweed immersed in alkaline solution at a temperature $92 \pm 2^\circ\text{C}$ for 60 minutes.

Step 2. Washing:

- a) Put 50 g of the dried *Gelidium* in cool water to be washed thoroughly for removal of such palpable matter as adhered mud, calcareous incrustations, shells and sea salts.
- b) Take the treated *Gracilaria* out of the heated alkaline solution after completion of Step 1, then immerse it in running water with continual agitation for 30 minutes.

Step 3. Acid treatment:

- a) Immerse the washed *Gelidium* into 750 ml 0.1 N $\text{CH}_3\text{COOH}-\text{CH}_3\text{COONa}$ buffer solution (pH 4.78-4.8) for 30 minutes, then drain off the solution thoroughly.
- b) Immerse the washed *Gracilaria* into 1,500 ml 0.1 N sodium acetate buffer solution (same as above a) for 30 minutes and drain off the adhered solution thoroughly.

Step 4. Extraction:

Put the acid treated sample of seaweed, either a) *Gelidium* or b) *Gracilaria*, into 2 l-beaker with 1,500 ml water on an electric heater to keep a temperature of about 100°C for extraction of agar. It is necessary to adjust the heater carefully to avoid violent boiling and to stir the seaweed frequently during this process.

It takes 30 to 60 minutes to complete the extraction of agar at the point when the seaweed becomes pasty.

Step 5. Filtering and congelation:

Right after the completion of extraction, pour the liquor (the solution of agar in water and the soluble impurities) into 2 l-beaker through four-fold gauze filter. The remaining sediment has to be tied up in the same gauze used for filtering and pressed slightly for collection of additional filtrate.

After completion of filtering, the pressed sediment in gauze should look like a dumpling of bean paste. Imperfect extraction is indicated when the sediment appears to be fibrous.

Then place the 2 l-beaker (covered with a plate glass, containing filtered agar solution of about one liter) in room temperature until next morning to congeal the liquor thoroughly into agar gel.

In case it is necessary to make a rough quick evaluation, it is common to measure the volume and the jelly strength of the agar gel after the filtered agar solution congeals thoroughly. But for making a strict inspection, it is better to follow the steps described below.

Step 6. Dehydration and drying:

Place the agar gel in an electric refrigerator keeping a temperature of -5°C to -10°C , until the gel is completely frozen. Take the frozen gel out of the freezer together with the 2 l-beaker, and pour some cool water (change the water several times) to quicken the thawing and wash out the impurities. Then dry the agar in room temperature after separation of

water in the wet agar by means of centrifugal force or static pressure.

Step 7. Calculation on ratio of agar yield:

Weigh the agar obtained after Step 6, then take one to two grams from it for analysis of moisture content. The calculation will be as follows:

$$X = \frac{w(1-m)}{W(1-M)} \times 100$$

X = percentage of agar yield against the quantity of dried seaweed used.

W = weight of raw material used as sample in grams.

w = total weight of agar yield from sample in grams.

M = ratio of moisture content in raw material.

m = ratio of moisture content in agar yield.

Step 8. Measurement of jelly strength:

Weigh 4.5 g of agar-agar after the drying process of Step 6 is completed. Place the agar into a 500 ml-flask and pour in 300 ml distilled water, then heat the water to keep it boiling until the agar is completely dissolved. The vapor from the boiling water must be condensed and returned to the flask so that the solution will contain exactly 1.5% of agar.

Make a record of the time used from the time the water starts boiling until the heating stops soon after the agar is completely dissolved. It is indicative of the agar solubility.

When the agar solution in the flask becomes somewhat cool (about 45°C), pour it into a rectangular vessel (L 15 cm × W 5 cm × H 5 cm) and place it in room temperature till the next morning for complete congelation. In case of necessity, remove the heat of the agar gel by placing cold water around the outside surface of the vessel, and keep the temperature of agar gel as near 20°C as possible before measuring its jelly strength.

In the end of this Step 8, the apparatus for measuring jelly strength of agar gel, which was introduced by the Japan Agar-Agar Producer's Association, is commonly used in Taiwan. The jelly strength of agar gel is usually indicated by the maximum perpendicular weight on a square centimeter of plane surface which does not break the agar gel in 20 seconds.

Manufacture in commercial plants

Six plants listed in Table 7-2 and several family producers not in list are engaged in manufacture of agar with total daily output capacity estimated as 700 kg. The equipment, facilities and the processing methods adopted by those plants are different from one another, due to the different form of the main product of the plant and the varied experience in technology or business.

For instance, the seaweeds washing facilities are different from one plant to another. For obtaining clean agar solution after the extraction, some are adopting pressure filters, or using high-speed centrifugal machines, and others only depend on sedimentation. In order to produce agar strips, some use air freezing rooms in their plants, others make use of the brine tank in small ice-making plants to freeze the agar gel strips piled up inside the 300 lbs-ice cans.

The processing of agar sheets is simpler than that of other products. It can be made in a fairly big plant and also in a household. It is not easy to give detailed explanations on the various processes for manufacturing each form of agar product in different production scale respectively, but as an example, the processing method mentioned below is now in practice for making agar powder in a commercial plant in Taiwan.

Step 1. Alkaline treatment:

An agar plant in Kaohsiung prefecture uses only dried *Gracilaria* as raw material for manufacture of the powder product.

Table 7-2. List of Agar Plants in Taiwan

Name of plant	Form of Agar products	Capacity of Daily Output (Kg)	Annual Production (MT)	Address
1. Taiwan Agar-Agar Manufacturing Co.	Sheets & Powder	200	25	145, Yungho Li, Putzu, Chiayi County
2. Ocean Agar-Agar Manufacturing Co.	Strips	35	10	10-1, Wunfua Rd. Putzu, Chiayi County
3. Tun-Mao Agar Manufacturing Co.	Strips & Powder	120	35	100, Chungsan Rd. Shilo, Yunlin County
4. Fei-Kwang Agar Manufacturing Co.	Strips & Powder	150	40	62-6, Ichia Li, Ninte, Tainan County
5. Ho-Fong Agar Manufacturing Co.	Sheets & Powder	35	10	1-11, Sangming Rd. Sanfua, Tainan County
6. Cheng-Yi Agar Manufacturing Co.	Powder	60	10	5, Neikang Li, Taliao, Kaohsiung County
Other family producers	Sheets	100	20	
Total		700	150	

The dried seaweed is usually removed from the warehouse to the workshop (Fig. 7-1) early in the morning for alkaline treatment and washing. First, the dried *Gracilaria* is immersed into 5% NaOH solution at $92 \pm 2^\circ\text{C}$ for 60 minutes using the big iron basket shown in Fig. 7-2. Then, the drained seaweed is washed thoroughly in a big washing tank by the powered agitator (Fig. 7-3).

Step 2. Acid treatment:

In order to remove the impurities in the raw material, which are soluble in weak hydrochloric acid, the seaweed is transported to the next tank (Fig. 7-4) after completion of the washing mentioned above, and immersed in the circulating acid water with automatically controlled pH value of 5.5 until the next morning.

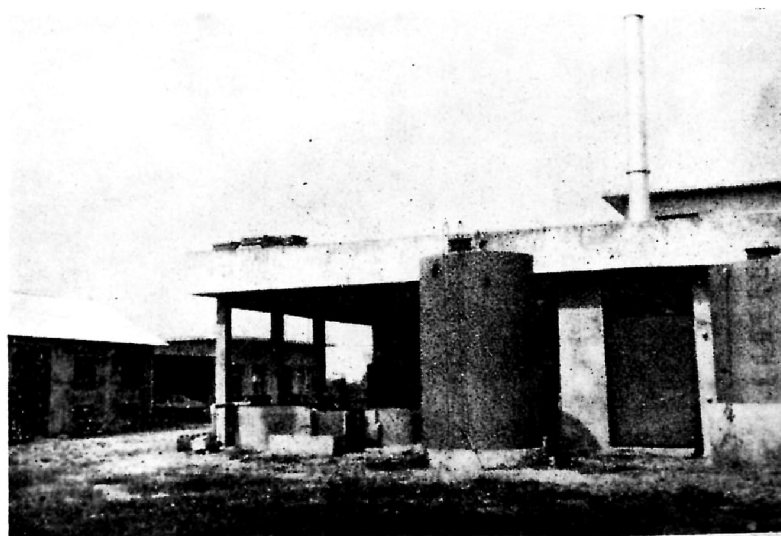


Fig. 7-1. Warehouse (left) and Washing Workshop for Dried Seaweeds in Premise of the Plant.

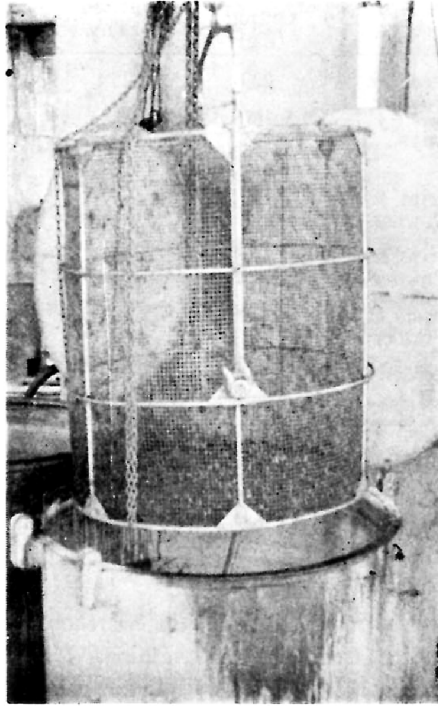


Fig. 7-2. The Facilities for Alkaline Treatment of Dried *Gracilaria* Seaweeds.

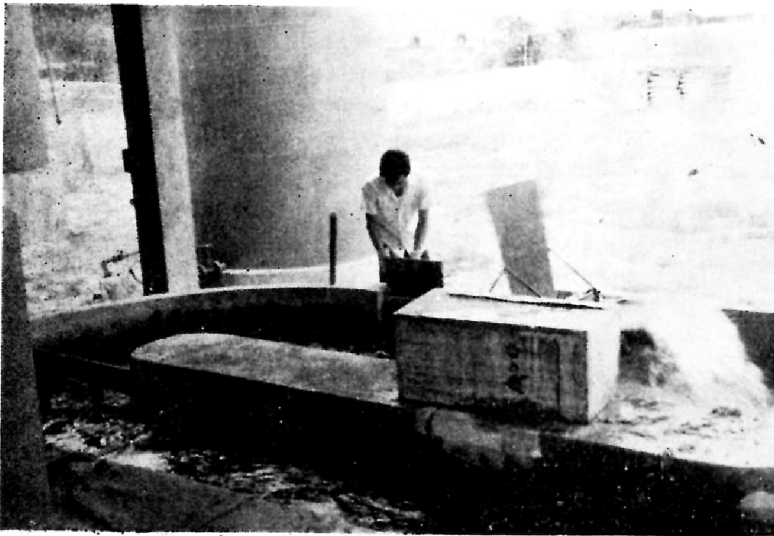


Fig. 7-3. The Washing Tank with Powered Agitater.



Fig. 7-4. The Immersion Tanks and the Automatic pH Control Equipment for Acid Treatment.



Fig. 7-5. Cookers for Extraction of Agar Containing Matter from Seaweeds.



Fig. 7-6. Filtering Facilities.

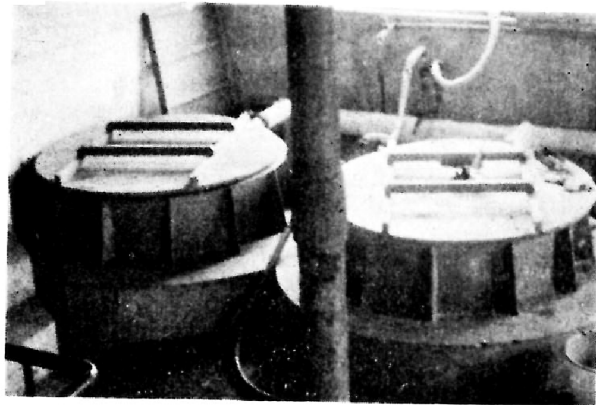


Fig. 7-7. Sedimentation Tanks for Filtered Liquor.



Fig. 7-8 Frozen Agar Block are Crushed into Pieces by an Ice-crusher.

Step 3. Buffer solution treatment:

The buffer solution treatment is carried out before the extraction process. In order to decrease the cost for this process, 0.03 N CH_3COONa solution is used for this purpose. Put CH_3COONa (3.7-4 kg) into 1,500 liter water, and add 0.1 N solution of HCl slowly until the pH value comes down to about 4.5 before the treatment.

The seaweed through Step 2 of about 300 kg in drained weight is immersed at once into the above buffered solution for two hours. After each treatment, add some water into the tank to keep the solution in suitable volume, then add 0.5 kg CH_3COONa and necessary amount of HCl to readjust the pH value so that the buffered solution can be used repeatedly.

Step 4. Extraction:

The buffer solution-treated raw material is placed in a 3 ton stainless steel cooker (Fig. 7-5), which is heated by pressure steam, and cooked with water until the agar containing matter is separated completely from the fiber of the seaweed. Usually the extraction can be completed in no longer than two hours.

It is helpful to add 0.06% of sodium phosphates (mixture of sodium metaphosphate 70%, —polyphosphate 15%, —pyrophosphate 15%) into the water for the extraction, to decrease the color of the extracted agar solution which may be caused by undesirable iron ion in the water.

Step 5. Filtering:

When the extraction is completed, the hot liquor (the solution of agar in water and the soluble impurities) with the pasty sediment is discharged from the bottom of the cooker and filtered through washed gunny sacks shown in Fig. 7-6. The filtrate is then pumped into the sedimentation tanks (Fig. 7-7).

Then, the comparatively clean liquor in the sedimentation tanks is pulled off from the top by high-speed (15,000 rpm) centrifugal machines, for further separation of solid impurities.

Step 6. Congelation and freezing:

The liquor from the centrifugal machines is put into shallow congelation tanks until the next morning, and then placed into 300 lbs-ice cans to be immersed in cold brine (-10°C) for about two days to be frozen completely.

Step 7. Dehydration and drying:

The frozen blocks of agar gel are crushed by ice crusher (Fig. 7-8). The crushed pieces are discharged into a water tank for washing the impurities away from the pieces of agar by running water.

After the crushed pieces are completely melted, the relatively pure agar is bleached and washed again before dehydration by the lowspeed (2,000 rpm) centrifugal machine (Fig. 7-9) and drying to a residual moisture content of 20%.

Step 8. Grinding and packaging:

The pieces of dried agar are again crushed mechanically into powder (Figure 7-10), and



Fig. 7-9. Washing the Melted Pieces of Agar After Bleaching.



Fig. 7-10. The Dried Pieces of Agar are Mechanically Crushed into Powder.

packed in PE-sacks in quantity of 100 g, 500 g, 1 kg and 10 kg separately according to the request of the customers.

Export of alkaline treated seaweeds to Japan

The export of alkaline-treated *Gracilaria* to Japan has gradually increased in recent years due to the increased production of *Gracilaria* in Taiwan and the improved technique on quality control of the treated seaweeds.

The dried *Gracilaria* and *Gelidium* exported in 1976 was 581 MT, valued at NT\$13 million, and the dried alkaline treated *Gracilaria* exported to Japan reached 232 MT, valued at NT\$16.6 million in the same year.

The wholesale prices of the dried *Gelidium* in June 1977 were: NT\$47 per kg for that of the best quality and NT\$32 per kg for the medium quality. The dried *Gracilaria* is still cheaper than *Gelidium* in the local market. The local price of dried *Gracilaria* was NT\$16.5 per kg in June 1977.

The alkaline treated and dried *Gracilaria*, which contains over 30% of agar with jelly strength of over 500 g/cm², is now exported to Japan continually at a price of US\$1.70 to 2.00 per kg., FOB.

VIII. *Chlorella* Industry in Taiwan

C. S. CHEN*

Introduction

Increasing overseas trade and large profit of *Chlorella* products account for the rapid growth of the *Chlorella* industry in Taiwan in the past three years. During the period of 1973-1977 the number of *Chlorella* plants in this island increased from three to twenty eight. The *Chlorella* boom made it one of the most rapidly growing industries in Taiwan's industrial history. *Chlorella* was originally developed as a protein source for human consumption. However the situation has changed since its versatile biological activities were discovered. Nowadays people are more interested in its new utilization such as health food, diet food, food additive and so on.

Historical

Professor Lindner in German for the first time attempted to use *Chlorella* as food and animal feed during world war I. The research was followed by Hader, a German professor, during world II. After the war, *Chlorella* research was extensively conducted in German, U. S. A. and U. S. S. R. Owing to shortage of food, Japanese scientists began *Chlorella* research as early as 1949. Dr. Tamiya developed an open circular system for mass production of *Chlorella*. The project was extended to commercial production in 1957, sponsored by the Japanese Government and Rockefeller Foundation.

Chlorella research in Taiwan was first conducted by the Academia Sinica and Taiwan Sugar Research Institute in 1957. Commercial production of *Chlorella* was started by Taiwan *Chlorella* Company in 1964. However, *Chlorella* products were not generally accepted by the public because of high price and digestion problem.

Since 1957, an increasing number of scientific reports have suggested that *Chlorella* contains a wide variety of biologically active constituents, and that these constituents are good for human health improvement. As a result of these reports, *Chlorella* buyers increased very rapidly, especially in Japan. Later it was found that *Chlorella* could be cultivated at lower cost in Taiwan. Therefore, *Chlorella* production in Taiwan has prospered since 1973.

Culture and Production of *Chlorella*

Chlorella live in freshwater and is a single-cell green algae. It is autotrophic and spherical or slightly flattened in shape, very much the same as human erythrocytes.

Three species are usually used for industrial production, namely, *Chlorella vulgaris*, *Chlorella pyrenoidasa* and *Chlorella ellipsoidea*.

Culture methods of *Chlorella* are either open-type or tank-type. The former has been mostly used in practice. This method needs a concrete pool and stirring system as shown in Fig. 8-1.

Chlorella is grown in a pool containing culture solution under solar illumination. The culture solution may vary from plant to plant. In general it contains per liter: urea 0.6 g, potassium phosphate 0.3 g, magnesium sulfate 0.3 g and ferrous sulfate 0.05 g; neutralized to pH 7.0 with acetic acid.

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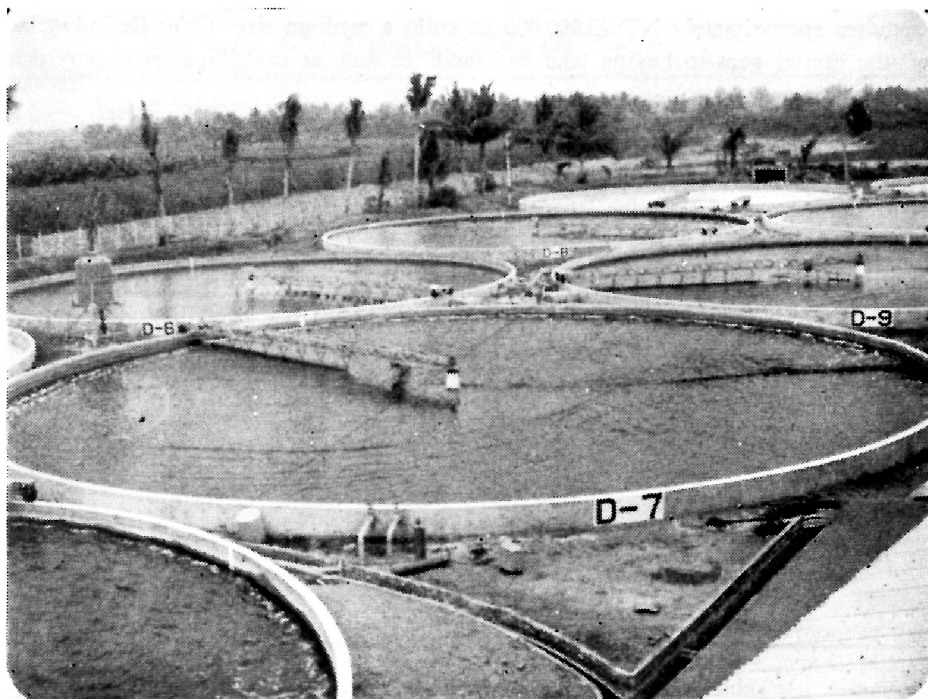


Fig. 8-1. Open Type Culture of *Chlorella*.

Before growing the *Chlorella* in a concrete pool, *Chlorella* cells are first cultured in a small flask under aseptic condition. The *Chlorella* culture is scaled up to two liters through several transfers. The 2-liter culture then is used to inoculate an outdoor inoculum pool, this is transferred to a medium size pool, and later transferred to a large pool. *Chlorella* can be harvested when the color of the culture turns into dark-green.

Concentration of *Chlorella* can also be measured by "packed cell volume" (PCV), which may be defined as the volume (in ml) occupied by packed *Chlorella* cells obtained by centrifugating one liter of *Chlorella* culture. A packed cell volume of 12-16 is an indicator of time for harvesting. *Chlorella* is pumped from the culture pool into a storage tank (Fig. 8-2) and harvested by means of centrifugation (Fig. 8-3). The *Chlorella* cake then is subject to a spray drier to obtain *Chlorella* powder, which is ready to sell. Another important commercial product of *Chlorella* is *Chlorella* growth factor (CGF). It is made by treatment of *Chlorella* in boiling water for 30-60 minutes and the insoluble residue removed by centrifugation. The insoluble residue may be spray dried and sold.

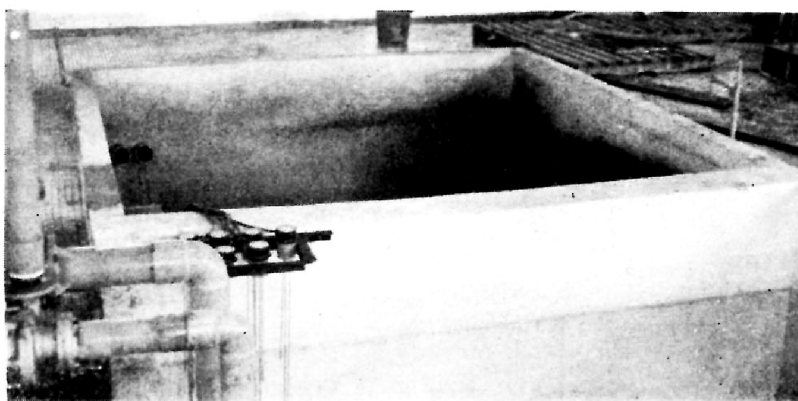


Fig. 8-2. *Chlorella* Storage Tank.

It requires approximately NTS40,000,000 to build a medium size *Chlorella* industrial plant. Most of the capital goes to buying land and facilities such as centrifuges and spray driers.

Market

Up to 90% of the *Chlorella* products in Taiwan are exported to Japan. Some of these are sold to Europe and U. S. A. by Japanese Companies. Only 10% of the *Chlorella* products

Table 8-1. *Chlorella* Export from Taiwan

Year	Amount (ton)
1971	17
1972	22
1973	40
1974	116
1975	200
1976	540
1977	720

Table 8-2. Production of *Chlorella* in Some Countries

Country	Number of <i>Chlorella</i> plants	Production (ton/year)
R. O. C.	28	1500~1884
Japan	6	400
Malaysia	1	84

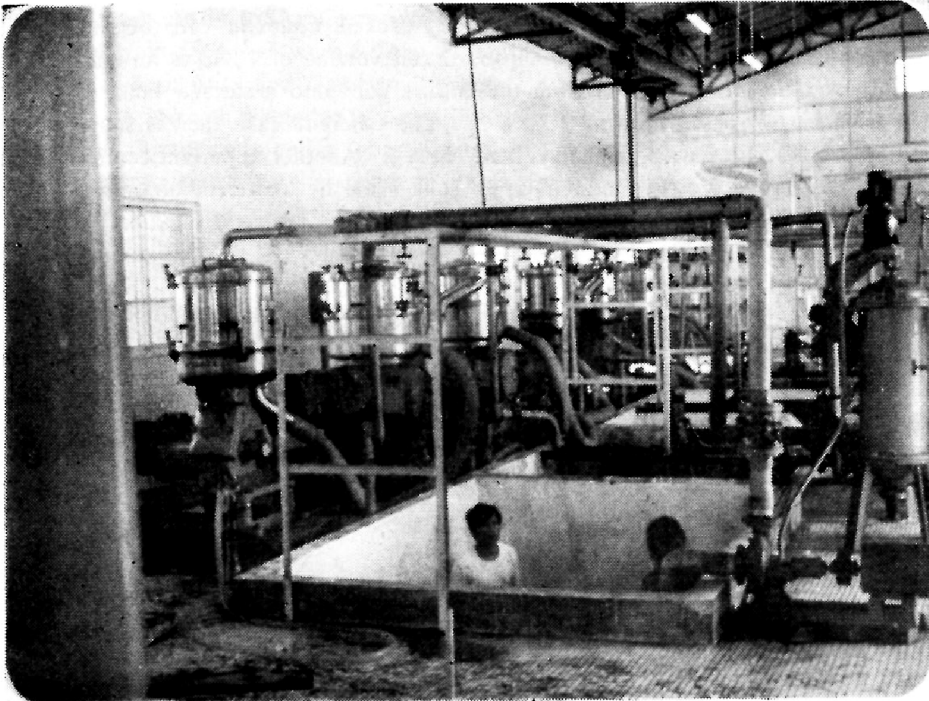


Fig. 8-3. Centrifuges for *Chlorella* harvesting.

Table 8-3. Standard of *Chlorella* Powder

Viable bacteria	<10 ⁴ per gram
<i>E. coli</i>	Negative
As	<10 ppm
Heavy metals	< 3 ppm
<i>Chlorella</i> growth factor	3-5%
Crude proteins	50-60%
Crude lipids	6-10%
Carbohydrates	22-35%
Ash	7-10%
Moisture	<5%
Chlorophyll	3-4%
Crude fiber	3-5%

are sold domestically. Table 8-1 shows amounts of *Chlorella* exports each year. Table 8-2 shows *Chlorella* production of some countries. There seems to be danger of over production of *Chlorella* in Taiwan from Tables 8-1 and 8-2. Table 8-3 shows the general standard of *Chlorella* powder that meets the requirement of Japanese companies.

Utilization

Chlorella is rich in protein and vitamins. The chemical composition and vitamin content of *Chlorella* are shown in Table 8-4 and 8-5 respectively. In Table 8-6, the chemical composition of some popular crops and *Chlorella* are compared. The protein content of *Chlorella* is even higher than soybean. Table 8-7 shows the composition of essential amino acid of *Chlorella* and wheat proteins. Content of all essential amino acids except sulfur containing amino acids is similar to or higher than the standard composition.

Table 8-4. Chemical Composition of *Chlorella*¹

Crude proteins	53.6%
Crude lipids	6.31%
Fiber	10.33%
Starch and others	19.28%
Ash	10.14%

Table 8-5. Vitamin Content of *Chlorella* (per gram)¹

Vitamin B ₁	1.0-3.5 mg
Vitamin B ₂	3.6-5.3 mg
Niacin	11.9-24.3 mg
Vitamin B ₆	2.3 mg
Pantothenic acid	0.8-2.0 mg
Folic acid	3.8-9.9 mg
Vitamin C	40.0-46.4 mg
Vitamin B ₁₂	2.2-9.9 (μg)
Provitamin A	80,000-104,000 (I. U.)

Table 8-6. Chemical Composition of Some Crops and *Chlorella* (%)

	Protein	Lipid	Carbohydrate	Ash	Moisture
<i>Chlorella</i>	55.0	18.0	18.0	6.0	3.0
Rice	6.2	0.8	76.9	0.6	15.5
Wheat	10.5	2.0	72.4	1.6	13.5
Barley	10.0	1.9	71.7	2.4	14.0
Soybean	34.1	17.9	31.0	5.0	12.0

Table 8-7. Composition of Essential Amino Acids in *Chlorella*¹

	Amino acid standard solution (mg)	Wheat proteins (mg/100 g)	<i>Chlorella</i> proteins (mg/100 g)
Isoleucine	270	262	305
Leucine	306	442	473
Lysine	276	126	387
Phenylalanine	180	322	304
Methionine	144	78	80
Threonine	180	174	258
Tryptophan	90	69	91
Valine	270	262	336
Cystine	270	192	127

Chlorella also contains 4-6% *Chlorella* growth factor (CGF). This special factor accounts for the versatile utilization of *Chlorella*.

The function of CGF may be summarized:

1. Effective in stimulating the growth of animals, bacteria and young plants.
2. Stimulating the division, reproduction and metabolism of cells. It also can activate cells.
3. Enhancing the utilization of proteins as well as in vivo synthesis of proteins.
4. Promoting growth of lactic acid bacteria, consequently inhibiting growth of other pathogenic bacteria.
5. Therapeutically effective in ulcer, especially gastric and duodenal ulcer.

It is expected that more new functions of *Chlorella* may be found in the future.

Owing to the composition of *Chlorella* and the unique growth factor it contains, the following utilization has been developed.

1. health food.
2. diet food
3. improving the flavor of foods. (see Chapter IX. p. 78)
4. used for culture of microorganisms.
5. animal feeds.

Prospect

Digestibility and high cost have been the bottle neck of industrial production of *Chlorella*. It had been thought that the low digestibility of *Chlorella* was due to its tough cell wall. However it was found recently that the digestibility of *Chlorella* tremendously depends upon drying condition. Proper drying could bring the digestibility of *Chlorella* powder from 10% to 85%. Two of the most promising methods of drying *Chlorella* are freeze drying and spray drying with cool air. The latter is more suitable for industrial production.

Chlorella powder either freeze dried or spray dried with cool air disperses readily to single cells when put into water. *Chlorella* in a single cell state can be easily attacked by the digestion enzymes and effectively absorbed. If *Chlorella* is improperly dried the *Chlorella* cells tend to aggregate firmly. The aggregated *Chlorella* cells no longer separate readily in water.

The high price of *Chlorella* products limits its use as a popular protein food. New techniques for *Chlorella* production at lower cost are eagerly sought. Some species of *Chlorella* and *Scenedesmus* were found to be able to grow under dark condition in a fermentation tank in the presence of suitable organic carbon source, usually glucose. Their growth rates were more than ten-fold faster than when they were grown under sunlight, namely autotrophically. This method obviously could cut down the cost. A number of new *Chlorella* manufacturing companies and some fermentation companies in Taiwan have attempted to use this so called tank culture.²

The composition of *Chlorella vulgaris* cultured in tank, namely heterotrophically, was found to be different from that grown autotrophically. Of course, it is expected that the chlorophyll differs prominently. Table 8-8 shows such differences.²

The environmental conditions of Taiwan favor the growth of *Chlorella* because of its excellent geographical location. However, the *Chlorella* industry in this island runs into difficulty resulting from high competition, limited domestic market, and too much reliance on the Japanese market. The following efforts should be made in order to maintain a steady growth of Taiwan's *Chlorella* industry:

1. Proper control of the number of new *Chlorella* manufacturing plant.
2. Establishing a national standard of *Chlorella* product as soon as possible.
3. The quality of *Chlorella* should be under the control of a government institution.
4. Developing new overseas trade outlets other than Japan.

Table 8-8. Comparison between the Chemical Compositions of *Chlorella vulgaris* Grown Autotrophically and Heterotrophically (per 100 g)²

		Autotrophically grown cell	Heterotrophically grown cell
Crude protein	(g)	58.2	54.2
Pure protein	(g)	41.2	39.5
Crude lipid	(g)	16.1	13.0
Nitrogen free extract	(g)	14.6	22.6
Crude fiber	(g)	4.4	4.2
Ash	(g)	6.7	5.9
Chlorophyll	(g)	3.8	1.8
Carotenoids	(g)	0.5	0.3
RNA	(g)	6.3	5.5
Thiamin	(mg)	0.70	0.99
Riboflavin	(mg)	3.4	6.32
Vitamin B ₆	(mg)	0.52	2.30
Niacin	(mg)	18.6	21.70
Pantothenic acid	(mg)	1.6	10.0
Folic acid	(mg)	4.5	0.025
Biotin	(μ g)	15.1	42.6
Cyanocobalamin	(μ g)	trace	trace
Ascorbic acid	(mg)	18.5	52.6
Provitamin A	(IU)	91,200	82,500
α -Tocopherol	(mg)	33.1	26.4

5. A *Chlorella* trade association should be established. The quantity and price of *Chlorella* products should be regulated by the association in order to avoid high competition.
6. Breaking through the limitation of *Chlorella* growth in order to reduce the cost.
7. Developing new *Chlorella* products. One of the possibilities is accumulating *Chlorella* lipids by growing *Chlorella* in nitrogen deficient medium.

Acknowledgements

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Part 5

Research & Extension

IX. Fishery Technology Research & Extension Work in Taiwan

J. L. CHUANG

Since the Taiwanese people have been relying largely on the rich marine resource as a source of animal protein, fishery technology research work started quite early in Taiwan. The poor transportation system forced the fishery technologists, fishermen and fishery product distributors to drain their brains to improve the processing and preservation methods for the surplus fish catch.

After World War II, fishery technology research and the fish processing industry remained stagnant for a very long time until recent years. The recent high development of the fisheries industry in Taiwan is responsible for activating the fishery technology research and extension work.

Fishery technology researches in the last few years and their achievements

Fishery technology research in Taiwan is aimed mostly at practical application. The research projects carried out in the last few years can be classified into three categories:

I. Survey

1. Survey on the processed fishery products of Taiwan ^{1,2}
2. Study on the market potential of processed fishery products in Taiwan ³
3. Zinc and other heavy metal contents in canned crab in Taiwan ⁴
4. Chemical toxins (heavy metals, pesticide residues, PCB, radioactive substances) in the fishes of Taiwan ^{5,6,7,8,9,10}
5. The survey on *Vibrio parahaemolyticus* and *Salmonellae* in Taiwan's fishery products ^{11,12}
6. Free and esterified cholesterol contents of some seafoods in Taiwan, ¹³

Achievement: "The surveys on the processed fishery products of Taiwan" which were made by a field survey team of about 20 members gave the most up-to-date detailed information on fishery technology improvement in relation to the development of our fisheries. The technical and other problems of the fish processing industry were also brought up for the related institutes and agencies for solutions. On the other hand, the project, "Study on the market potential of processed fishery products in Taiwan", is conducted from the consumers' approaches to study the local people's buying behavior, consumption pattern, etc. All these informations are essential to the further development of the fish processing industry.

From 1971 through 1975, Taiwan's fishery research had been involved in investigating the chemical toxins suspected to occur in the food fishes of Taiwan. It was found that the average mercury contents of medium size fish were far below the 0.5 ppm guideline of USFDA and only some of the large size fish (such as swordfish and sharks) were contaminated by mercury in excess of 0.5 ppm. Taiwan's cultured fishes were also investigated. Generally speaking, their heavy metal concentrations (such as Hg, Pb, Cu, Ni, Zn) did not appear to constitute a health hazard to the consumers. The use of pesticides in the last 20 years did not result in significant accumulations of organochlorine pesticides in the fish as to render them unsuitable for human consumption.

Though the cultured fishes of Taiwan showed low concentrations of chemical toxins, some fishes and shellfishes from coastal waters and rivers near industrial plants contained high level of heavy metals, organochlorine pesticides, and PCBs. This may become a food safety problem. However, measures are being taken by the Government to prevent these kinds of pollution from

becoming widespread.

Microbial contamination in Taiwan's fishery products was also investigated in the last few years. 1,469 random samples of fish and mollusks have been examined. A total of 581 isolates of *Vibrio parahaemolyticus* and *Vibrio alginolyticus* were obtained.

The ratio between these two species of vibrio was 1:4. 72% of the *Vibrio parahaemolyticus* isolates were typable by means of the agglutination test with K antisera, and were able to be classified into 24 K serotypes. Two of 290 isolates were found to lyse both rabbit and human O type blood cells within 24 hours. All the 21 selected strains from each represented K serotype were pathogenic for mice, causing death within 24 hours after intraperitoneal injection. Of the eight antibiotics utilized to determine drug sensitivity of *V. parahaemolyticus*, chloramphenicol appeared the most effective. Sulfa drugs were relatively ineffective.

313 specimens of animal meals, including the imported and home-produced fish meals, bone meals, and meat bone meals, were collected for examination of *Salmonellae* contamination. 52 strains of *Salmonella* organisms, classified into 12 serotypes, were isolated from these specimens. *S. derby* (16 strains) was isolated in the highest rate, and followed by *S. senftenberg* (9), *S. typhimurium* (6), *S. newport* (5), *S. weltevreden* (4). These serotypes were considered as common *Salmonella* serotypes in Taiwan. The *Salmonella* contamination rate of the imported fish meals was generally lower than that of home-produced, except the fish meals from Peru which were found to have a higher rate of *Salmonella* contamination (14.3%) than that of home-produced meals (9.8%).

Eight fish samples obtained from different fish markets in Taiwan were studied. Their range of free cholesterol is 40 mg%—167 mg%. The mean values of the percentage of cholesterol ester in total cholesterol were 32% in hair-tail, 25% in striped marlin, 26% in black pomfret, 51% in tilapia, 20% in carp, 23% in silver carp, 20% in shrimp and 43% in oyster respectively. The mean values of free cholesterol in the eight samples were 17% higher than those of five kinds of meat (including meat products). As to the cholesterol ester, the former was 8% more than the latter.

II. Improvement of fishery products and demonstration

1. Improvement of frozen roasted eel processing (See Chap. III.)
2. Studies on the production of fried shredded fish (fish bits) ^{14,15}
3. Demonstration of preservation of freshness of fish and shrimp on board small fishing boats
4. Studies and demonstration of canning of crab, clam and shrimp ^{16,17,18}
5. A study on addition of *Chlorella* growth factor (C. G. F.) to improve flavor of canned fishery products ³¹

Achievement: Export of frozen roasted eel to Japan is a thriving business in recent years. Since the Japanese government in 1974 regarded this product as cooked food and ruled that its total plate count should not exceed 1×10^5 organisms per gram and its coliform test should be negative, rejections by the Japanese side often occurred. The prompt execution of the project, "Improvement of frozen roasted eel processing", has helped the industry to solve this problem by supplying the best sanitary processing conditions. Export quantity of this product in 1976 to Japan thus doubled that in 1974.

Fried shredded fish (fish bits), a seasoned and dried but fatty fish product, is very popular in the local markets. In the project, "Studies on the production of fried shredded fish", the shelf-life stability of this traditional product was thoroughly investigated and remedial processing and packaging methods were suggested and brought to the attention of the industry.

Canning of crab and shrimp gradually became important in recent years. The Food Industry Research and Development Institute, under JCRR'S financial support, has helped the industry to improve the quality (texture and flavor) and prevent blackening commonly found in commercial canned crab and shrimp.

The addition of 1% of C. G. F., which is the water-soluble extract of *Chlorella*, to the

canned mackerel and bonito (both in brine³¹ and in oil) can effectively improve the quality of the final products after 6-month storage. The trimethylamine (TMA) and volatile basic nitrogen (VBN) value of canned fish will be comparably reduced if C. G. F. is added. The color of the canned fish will also be improved if C. G. F. is added.

III. Utilization study and basic research

1. Experiment or processing and utilization of low-grade fish landed by deep-sea trawlers
2. Studies on chemical composition and the flavoring components of Taiwan's oyster and clam ¹⁹
3. Studies on utilization of Taiwan's seaweeds (brown algae, monostroma, and red algae) ^{20,29,30}
4. Treatment of marine products with microwave energy ²¹
5. Simplified and quick methods to determine the concentration of Zinc, TMAO in aquatic animals ^{22,23,24} and tylosin in meats ²⁵
6. Experiments on fresh preservation of shrimp ^{26,27,28}

Achievement: Upgrading and utilization of fishery products of lower market value have world-wide interest. Taiwan Fisheries Research Institute (TFRI), under JCRR's financial and technical assistance, has conducted a series of experiments on processing and utilization of low-grade fish landed by deep-sea trawlers. Many new processed products, such as seasoned jerked fish, fish burgers, fish ham, fish noodles, etc. were prepared and demonstrated to the local processors.

Monostrama, a green algae, is exported to Japan in raw or semi-processed forms as well as processed into seasoned paste for domestic consumption. A series of experiments conducted by TFRI were carried out to develop various processed forms for domestic consumption.

The Institute of Oceanography of National Taiwan University has investigated the polysaccharide content naturally occurring in Taiwan's algae and found that the algae, *Sargassum*, has high content of alginic acid. It was also found the quantity of *Sargassum* along the coast of Taiwan is very large. These facts led to the initiation of another project, "Feasibility Study of Alginate Production in Taiwan".

Microwave treatment (4 kw, 3 min) could prevent the discoloration (blackening) of shrimps. However, experimental canning of the microwave treated shrimps showed that the canned product had the defects of fading and darkening of the red pigment. Fish ball and shelf fried kamaboko after being treated with microwave (4 kw, 2 min) were found to have a longer life. However fried shredded fish (fish bits), due to its low Aw showed little difference between these with and without microwave treatment.

A series of experiments were carried out on the use of sodium bisulfite for prevention of shrimp blackening aboard fishing vessel and on the methods to reduce sulfur dioxide residue in the raw or cooked shrimp. The methods so developed by TFRI were demonstrated to the fishermen and processors.

Research and extension projects underway and their objectives

The research and extension projects underway are classified into three categories:

Subjects	Executing Agency
I. Improvement of fishery products	
1. Improvement of Minced Fish Products	Taiwan Provincial
a) To survey the quality of the fish balls sold at local markets.	College of Marine
b) To study the quality of fish balls by using chemical and bacterial methods, organoleptic test and also by "plunger test".	Science & Techno-
c) To study the effects of freezing on the quality of fish	logy (TPCMST).

- balls made of small sharks.
- d) To improve fish ball processing and packaging.
 - e) To investigate the relationship between fish ball quality and chemical properties of fish protein.
2. Improvement of Dried Shrimp and Dried Round-herring Processing and Packaging TPCMST
 - a) To survey the quality of the dried products sold at local markets.
 - b) To identify the major flavoring components of the products and then to find proper processing method and packaging material for retaining the favorable flavoring components.
 - c) To maintain the microbial stability by decreasing water activity and using new antimicrobial food additives.
 - d) To find suitable packaging method to ensure quality and long shelf-life.
 3. Studies on green discoloration of frozen dolphin-fish fillet Taiwan Provincial
Kaohsiung Junior
College of Marine
Technology
(TPKJCMT)
 - a) To investigate the cause of green discoloration of frozen dolphin-fish fillet by the following approaches:
 - (i) microbiological test: to isolate and identify the microbes from green fish meat.
 - (ii) chemical tests: to analyze the chemical substances (such as SH group of cysteine) which is suspected to be responsible for green discoloration.
 - (iii) biochemical tests: to test the enzymes existing in the green flesh.
 - b) To find the methods for preventing green discoloration.
 4. Quality improvement of fish sticks Food Industry Re-
search & Develop-
ment Institute
(FIRDI)
 - a) To test the effects of additives on elimination of objectionable fishy odor.
 - b) To control water activity to improve the texture property and storage conditions.
- II. Basic research and utilization study
1. Feasibility study of alginate production in Taiwan (using *Sargassum* as raw material) (1976-1977) Institute of Oceano-
graphy, NTU
 - a) Approach from biological point of view
 - (i) To estimate the production of *Sargassum* in Taiwan and to determine the optimum harvesting quantity for conserving *Sargassum* resources.
 - (ii) To examine the relationship between growing conditions of the seaweed and the quantity and quality of alginate.
 - b) Approach from chemical and mechanical point of view: Taiwan Fisheries Re-
search Institute
(TFRI) & FIRDI
 - (i) To examine the effect of different extraction conditions on quantity and the quality of alginate.
 - (ii) To find the best filtration method
 - (iii) To choose the suitable bleaching agents.
 - (iv) To study the concentration and recovery rate of alcohol, when it is used for alginate precipitation.
 - (v) To study the proper drying methods.
 - c) Semi-industrial production study TFRI, Kaohsiung

2. Study on the Utilization of Deep Sea Shark Liver Oil
 - a) To study the liver oil yield of different species of deep-sea sharks caught in the water adjacent to Taiwan. TPCMST
 - b) To isolate squalene from deep-sea shark liver oil by using molecular distillation and column chromatography and to determine the effectiveness of the isolation methods by using thin-layer chromatography, gas-liquid chromatography and IR spectroscopy.
 - c) To determine the characteristics of the isolated squalene.
 - d) To study the chemical and physical changes of isolated squalene during storage and to find a suitable anti-oxidation method.
 - e) To study the conditions for preparing decahydro-squalene (partially hydrogenated squalene) which can be used as material for cosmetics manufacturing.
 - f) To study the preparation of polymerized squalene products which can be used as high-grade machine oils.
3. Studies on the utilization of shrimp and crab processing waste FIRDI
 - a) To prepare native chitin into treated chitin and chitosan which are recently used as solid supports to immobilized enzymes and as coagulating agent for suspended solids in processing waste from vegetable, poultry, cheese and egg breaking plants.
 - b) To test the quality of the treated chitin and chitosan.
 - c) To estimate the production cost of the treated chitin and chitosan.
4. Utilization of shark skin treated with proteolytic enzymes as a food-binder in fishery products. TPCMST
 - a) To find the suitable conditions for preparing the shark skin into a food-binder.
 - b) To test the quality of the binder.
 - c) To test its possible usage as a binder in fishery products.
5. Development of new fish ball analogous products: TPCMST
 - a) To utilize soy protein, a by-product of soybean oil industry, to substitute part of the fish protein in the fish ball.
 - b) To utilize squid for preparation of fish-ball-analogous products.
 - c) To conduct the flavor, color and texture tests and sensory evaluation of the above-mentioned products.
6. Utilization and processing of Antarctic krill TFRI, Fu-jen Univ., National Chunghsing Univ., Academia Sinica
 - a) To process krill into edible products such as shrimp cracker, minced products etc. for human consumption.
 - b) To improve the biological value of krill's products, to determine the influences of krill's fat to rats' body fat and cholesterol, and to determine the iron availability of krill and its remedial effect on anemia.

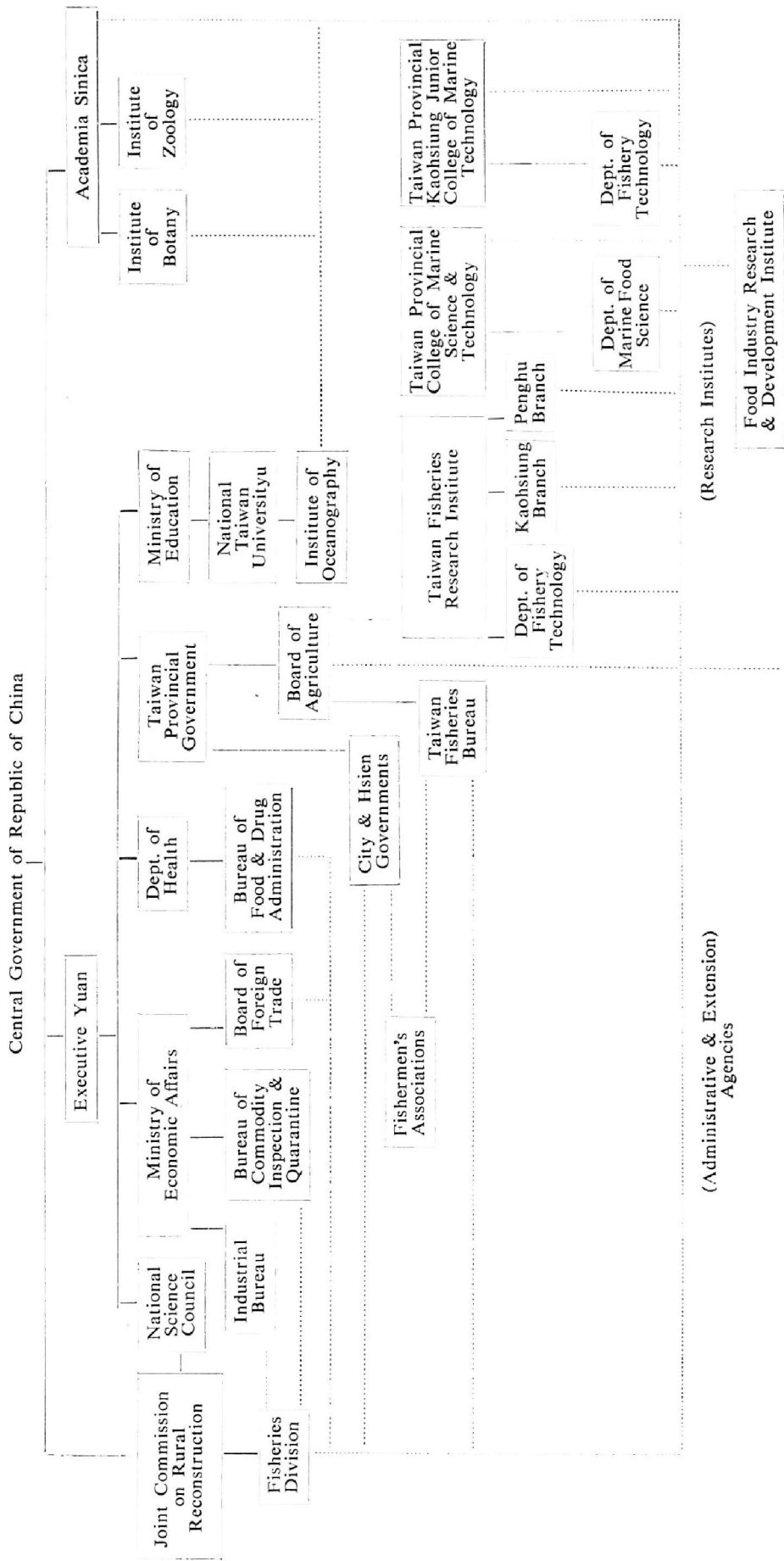
- c) To isolate, purify and identify proteases existing in krill and to compare the enzymes with other proteolytic enzymes for medical uses.
 - d) To study the consumer's preference of krill in the local market
7. Microbial Investigation of fishhold of fishing vessels in Taiwan TPKJCMT
- a) To isolate, identify the organisms in the fishhold (or in the fishhold slime)
 - b) To use the above-data to give remedial recommendations and to improve sanitary conditions of Taiwan's fishing boats.
8. Identification of estrogen-like substance in shrimp's head Academia Sinica
- a) To extract the estrogen-like substances from the shrimps head and then test its activity with bioassay and biochemical methods
 - b) To identify the substance.
9. Production of carrageenins by using imported red algae TFRI
- a) To estimate its production cost in Taiwan.
 - b) To help the local processors to establish a plant to process carrageenin and algins.
10. Studies on using fish solubles and brown fish meal to substitute white fish meal in eel feed. TFRI, TPKJCMT
- a) To study the possible toxic effect of fish solubles and brown fish meal to cultured eel.
 - b) To formulate eel feed by using the substitutes, fish solubles or brown fish meal.

III. Extension

Under the Chinese Government's "Accelerated Rural Development Program" started in 1973, many big-scale extension projects were initiated.

1. Strengthening basic fisheries personnel and fisheries extension work. (started from 1975 till now) Taiwan Fisheries Bureau (TFB), Taiwan Provincial Fishermen's Association, TFRI
 - a) To select and train some forty prospective fisheries college graduates and then to dispatch them to the different fishermen's associations, Hsien/City governments so as to upgrade the quality of the personnel of the said agencies.
 - b) To help organize fisheries technical groups islandwide; the fisheries extension workers will then periodically discuss the local fisheries technical problems and difficulties and find solutions for them.
 - c) To give on-the-job-training to the extension workers every year, so that they can be well-equipped with the knowledge and techniques needed for the extension work.
2. Demonstration on improved processing technique of fishery products in Penghu hsien. TFRI
 - a) To help improve the rather primitive processing techniques of Penghu's fishery processing industry which is the most important economic activity in the prefecture (hsien)

Chart 1. Institutes Involved in Fishery Technology Research & Fishery Product Administrative Agencies in Taiwan



- b) To introduce modern processing techniques, machinery and packaging materials to Penghu's fish processing industry.
 - c) To process the locally landed round herring, squid and shrimp etc. into higher quality ready-to-cook or ready-to-eat products and to closely study the market acceptability of the said products in Taiwan.
3. Installation of low-temperature fish driers TFB
- a) To demonstrate the use of low-temperature fish driers to the local processors and help them install the driers.
 - b) To extend government loans in the first year to some 15 processors who intend to install the new equipment.
 - c) To help promote the production of higher quality fishery products by using the low-temperature fish drier both for local market and for export.
4. Use of freezing equipment on inshore fishing boats* TFB
(started from 1973 till present)
- a) To help the inshore fishing boats install freezing equipment in order to keep the freshness of their fish catch.
 - b) To partially subsidize and to extend government loans to the inshore fishing boat owners who want to have their boats installed with freezing equipment.

* Under this project, so far one hundred and fifty seven fishing boats were installed with freezing equipment.

Fishery Technology Research, Extension and Administrative Agencies

Institutes involved in fishery technology research and fishery product administrative agencies in Taiwan are shown in Chart I.

The Joint Commission on Rural Reconstruction (JCRR)—was created in 1948 as a non-permanent bilateral agency for the rural reconstruction of China in the immediate postwar years.

There are nine technical divisions in charge of plant industry, agricultural resources & forestry, irrigation & engineering, fisheries, animal industry, agricultural credit, rural economics, farmers service, and rural health.

This organization has been operating with funds made available to it on an annual basis from a Sino-American Fund for Economic and Social Development in the Republic of China. Its program emphasis is placed on innovative types of projects. Since 1973, an "Accelerated Rural Development Program" fund, a government grant, has been all or partly allocated through JCRR and used under the guidance of National Planning Committee for the purpose of accelerating agricultural and rural development.

National Science Council (NSC)—was first established in August 1967 under the Executive Yuan. Its functions are: (1) to coordinate national science research and development work, (2) to handle national science and technology development funds to support research and development programs, and (3) to supervise and evaluate science and research and development programs.

Academia Sinica—was founded at Nanking in 1928. During the evacuation to Taiwan in 1949, two institutes, mathematics and history & philology, were moved to Taiwan intact.

Despite the adverse conditions it underwent in the early 50's, Academia Sinica has since

gradually built up itself at Nankang and reactivated or inaugurated eight more institutes. The present ten institutes are Mathematics, Physics, Chemistry, Botany, Zoology, History and Philosophy, Entomology Modern History, Economics, and American Culture.

Academia Sinica is primarily financed by the Central Government. Its basic missions are:

- (1) Conducting scientific research in its own institutes, and
- (2) Aiding and coordinating the efforts of other research institutes and universities in their scientific pursuits.

Taiwan Provincial College of Marine Science & Technology (TPCMST)—TPCMST, which was founded in 1953, is a college devoted exclusively to the studies of the ocean and its related fields, such as Fishing Technology, Fishery Technology, Aquaculture, Oceanography, Marine Engineering, Naval Architecture, River and Harbor Engineering, Electronic Engineering, Navigation and Shipping & Transportation Management.

The Dept. of Fishery Technology, which offers B. S. degree, emphasizes training of fishery food technologists for the local fishery processing industry, while the graduate school of marine food science, which offers M. S. degree, emphasizes the research and development of fishery products and its processing.

Taiwan Provincial Kaohsiung Junior Colleg of Marine Technology (TPKJCMT)—is a five year junior college which admits only graduates of junior high school. The main purpose of this school is to train technical personnel in the fishery industry and marine transportation.

The Dept. of Fishery Technology of this junior college has been actively involved in fishery technology research in recent years.

Institute of Oceanography, National Taiwan University—The Institute of Oceanography was established on August 1, 1968 at the National Taiwan University (NTU). The objectives of the Institute are as follows:

- (1) To carry out basic studies in all disciplines of oceanography.
- (2) To study problems concerning exploitation of marine resources.
- (3) To participate in international cooperative oceanographic research.
- (4) To educate and train young scientists for oceanographic research.

The Institute is a unit in the graduate school of NTU. Graduate students with a bachelor's degree in physics, chemistry, geology, biology, meteorology or engineering are admitted.

The Institute is now organized into three divisions: Division of Physical Oceanography, Division of Marine Geology and Geophysics and Division of Marine Biology and Fishery Biology.

Taiwan Fisheries Research Institute (TFRI)—was founded in 1929 as "Taiwan Experiment Station". After World war II, this organization was given its present name, "Taiwan Fisheries Research Institute".

There are four technical departments and seven branch stations in the Institute, of which only the Department of Fishery Technology (in Keelung), Kaohsiung branch station and Penghu branch station are actively involved in fishery food technology research and extension works.

Food Industry Research & Development Institute—is a non-profit legal entity established in 1965 with financial support from CIECD (Council for International Economic Cooperation and Development), JCRR and the Cannery Association of Taiwan. The function of this institute is to (1) carry out applied research to help the industry develop new products, to introduce new processing methods and to improve the quality of the existing processed food, (2) organize demonstration and training programs to disseminate the improved technology of food processing, and (3) carry out feasibility studies to advise on product development and new processing procedures.

Administration and regulation of fisheries in Taiwan are carried out by the *Taiwan Fisheries Bureau of the Taiwan Provincial Government*. In each hsien (prefecture) or city government, a fisheries section is established and has charge of the work in fisheries administration and improvement.

There are 41 self-supporting *fishermen's associations* in Taiwan. The purpose of the as-

sociations is to serve the fishermen in the following ways:

1. Render service in cooperative marketing and cold storage.
2. Provide public facilities, and carry out maintenance of harbor and facilities.
3. Carry out welfare work such as medical clinics, children's nurseries, insurance, etc.
4. Assist the government in carrying out fisheries improvement projects and collection of statistical data.

Several agencies under the Ministry of Economic Affairs are also partly involved in fishery processing and fishery product administration and regulation. *The Bureau of Commodity Inspection and Quarantine* is responsible for inspection of import and export fishery products.

The Industrial Bureau is responsible for regulation concerning seafood plant and their enforcement, while the *Board of Foreign Trade* is to foster the international trade of fishery products.

The Bureau of Food & Drug Administration under the Department of Health is to be established in the near future to be partially responsible for inspection of fishery products for domestic consumption.

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Appendix I. Fish and Fishery Products Inspection in Taiwan

W. H. CHEN*

Commodities subject to inspection shall not be exported or imported until they have passed the inspection with a passing certificate.

Domestic commodities subject to inspection shall be inspected in the following manner:

1. Periodic inspection,
2. Spot inspection.

In case domestic commodities subject to inspection fail to pass the inspection, the Authority-in-charge may order the suspension of production, manufacture, display or sale of such commodities.

I. The fish and fishery products subject to inspection and their applicable national standards:

1. Export fresh, chilled or frozen fish shall be inspected according to the China National Standards (CNS) 3732 and 1451.

2. Export fresh, chilled or frozen shrimps and prawns shall be inspected according to the CNS 2300 and 2301.

3. Export fresh, chilled or frozen cuttle fish and octopus (squid) shall be inspected according to the CNS 3733 and 1451.

4. Export, import and domestic canned fish, crustacea and molluscs shall be inspected according to the CNS 1229 and 3526.

5. Other marine products

(1) Export Gelidium and Gracilaria shall be inspected according to CNS 2378 and 2416.

(2) Export liver oils of fish and marine animal shall be inspected according to the CNS 296 and 1223.

(3) Export dried or smoked (but not further prepared) skipjack and Frigate mackerel, horse-mackerel, mullet, sardine shall be inspected according to CNS 2379, 2417, 2169 and 2170 respectively.

(4) Import fish meal for fodder shall be inspected according to the CNS 2243 and 2245.

II. Inspection procedures

1. Commodity inspection shall be carried out at the place where the inspection agency is located or at the port of shipment or port of discharge. The inspection may also be carried out upon request in the factory or plant or at entrepot.

2. Application for inspection of commodities subject to inspection shall be made to the inspection agency by a responsible person of the factory, exporter, importer, or agent thereof. The same lot of commodities covered by one application form for inspection should be of the same kind, grade and type.

If commodities to be exported have been inspected at the place of production, application for checking shall be made to the inspection agency located at the port prior to the shipment. Unless the said commodities are in conformity with the inspection documents, they shall not be exported.

* First Division, Bureau of Commodity Inspection & Quarantine

3. Samples required for the purpose of inspection of commodities subject to inspection shall be taken from the factories or plants, dealers, exporters, importers, or agents thereof.

4. Commodities which require packing to maintain quality shall be packed in the manner set forth below, and the packing shall be duly inspected:

(1) If there are National Standards applicable, the packing shall be done in conformity with such standards. If there are no National Standards applicable, the packing must be able to maintain the quality of commodities and must be durable for storage and transportation.

(2) The same lot of commodities shall be packed identically in form, size and weight, provided that this shall not apply to the fractional parts.

5. A passing certificate for commodities subject to inspection shall be granted if the commodities have passed the inspection. In case of a certificate requiring a stipulated period of validity, the Authority-in-charge shall fix such period respectively for varied kinds of commodities.

6. Where commodities fail to pass the inspection, the inspection agency shall give the applicant a notice to this effect, attached to the inspection record. The applicant may apply for re-inspection, free of charge, within fifteen days after receipt of such notice.

7. After the commodities have passed the inspection and a passing certificate has been granted accordingly, if the certificate is lost or the commodities are exported or imported in lots, application for re-issuing or renewing the certificate may be made, the period of validity for both case being the remainder of that of the original certificate.

8. If the commodities that have already passed the inspection fall under any of the following conditions, application for inspection shall be made:

(1) If the period of validity of the certificate has expired;

(2) If the packing has been changed or the packing been corroded thereby affecting the quality of the commodities;

(3) If the commodities have been damaged by water or fire, or bear other noticeable marks of damage;

(4) If the indications have been found incommensurate or confusing;

(5) If any item subject to inspection has been changed.

9. Upon receiving application for inspection, reinspection or for renewal of inspection, the inspection office shall complete the inspection within a prescribed period of time.

The prescribed period of time referred to in the preceding paragraph shall be fixed by the Authority-in-charge respectively in consideration of various kinds of commodities.

10. Besides the inspection agency which shall perform the inspection of commodities, the Authority-in-charge may authorize the relevant government agency or a body corporate to undertake the technicalities of inspection on behalf of the inspection agency.

The authorized inspection referred to in the preceding paragraph shall be directed and supervised by the inspection agency. Persons authorized to perform inspection and persons authorized to sign or issue an inspection report shall, so far as such work is concerned, be deemed as public officers and shall respectively assume corresponding responsibilities.

11. The inspection agency may assist domestic factories or plants manufacturing commodities to improve their equipment and facilities, inspection system or quality control. When the equipment and facilities, inspection system and quality control of a factory or plant are conformable to the standards established by the Authority-in-charge, the inspection procedures may be exempted or simplified after approval therefor has been obtained.

Factories or plants entitled by law to the CNS stamp on their products may be treated according to the preceding paragraph, if the quality of their products has been controlled effectively.

Factories or plants which have been granted approval for exemption from or simplification of the inspection procedures referred to in the preceding two paragraphs shall be directed and supervised by the inspection agency. Persons engaging in inspection shall, so far as their inspection work is concerned, be deemed as public officers and shall respectively assume corresponding responsibilities.

The regulations governing exemption or simplification of inspection referred to in Paragraph 1 shall be stipulated by the Authority-in-charge.

Appendix II. Complete Utilization of Shark in Taiwan

Introduction

Chinese cuisine is an art, while Chinese food is often a masterpiece. Among all the foods, "delicacies from the sea" (seafoods) are highly appreciated by the Chinese and have become an essential part of Chinese dinner. For years, Chinese have made use of every single part of the fish. The shark, for example, is completely utilized in Taiwan.

The production of sharks from 1965 to 1976 is shown in table AII-1.

Table AII-1 Shark Production in Taiwan 1965-1976

Year	Quantity (M. T.)	Value (NT\$1,000)*
1965	17,539	118,494
1966	20,335	131,524
1967	23,327	145,662
1968	30,167	191,288
1969	30,333	215,056
1970	33,735	255,874
1971	36,822	282,697
1972	36,840	309,059
1973	34,789	364,861
1974	41,912	430,458
1975	58,136	626,397
1976	53,892	799,571

* US\$1=NT\$38

In 1975 and 1976 shark production reached more than 7% of Taiwan's total fisheries production. These sharks vary greatly in size and species.

Raw Material

The species sharks widely utilized in Taiwan are as follows:

1. *Stegostoma fasciatum* (大尾虎鯊)
 - I*. Zebra shark
2. *Chiloscyllium colax* (印度狗鯊)
 - I. Cat shark, Lip shark, Ridge-back cat shark
3. *Sphyrna zygaena* (雙髻鯊)
 - I. Hammer-head, Round-headed hammer head shark
4. *Sphyrna mokarran* (鱸雙髻鯊)
 - I. Hammer-head
5. *Sphyrna lewini* (紅肉雙髻鯊)
 - I. Hammer-head
6. *Isurus glaucus* (灰鯖鯊)
 - I. Blue pointer, Mako shark, Snapper shark, Blue porpoise shark, Bonito shark
7. *Alopias pelagicus* (淺海狐鯊)
 - I. Threshar shark, Fox shark, Common threshar

8. *Alopias profundus* (深海狐鮫)
 - I. Threshar shark
9. *Carcharias taurus* (白鰐鮫)
 - I. Sand shark, Sand tiger, Ground shark, Slender-toothed shark
10. *Mustelus manazo* (星貂鮫)
 - I. Dog shark, Gunmmy shark
11. *Mustelus kanekonis* (白沙貂鮫)
 - I. Dog shark, Gray shark
12. *Galeorninus Japonicus* (日本灰鮫)
 - I.-II**. Eiraku-buka
13. *Negogaleus macrostoma* (大口沙條鮫)
 - I.-II. Hoso-ibarazame
14. *Galeocerdo cuvier* (鼬鮫)
 - I. Tiger shark, Leopard shark
15. *Galeocerdo rayneri* (烏鼬鮫)
 - I. Tiger shark
16. *Scoliodon walbeehmi* (瓦氏扁頭鮫)
 - I. Sharp-nosed shark, Milk shark
17. *Carcharhinus longimanus* (汚斑白眼鮫)
 - I. white-tipped shark
18. *Carcharhinus menisorrhah* (黑印白眼鮫)
 - I.-II. Marei-zame or Sumitsuki-zame
19. *Carcharhinus gangeotcus* (恒河白眼鮫)
 - I.-II. Mejiro-zame
20. *Prionase glauca* (鋸峯齒鮫)
 - I. Great blue shark, Blue shark
21. *Squalus megalops* (短吻棘鮫)
 - I.-II. Tsumari-tsuno-zame
22. *Centropholous lusitanicus* (尖鰭鮫)
 - I.-II. Aka-aizame
23. *Centropholous niaukan* Teng (猫公沙)
 - I.-II. Niaukan-zame
24. *Dalaoias licha* (黑鮫)
 - I. Black shark, Black jack
25. *Galeus glaucus* Linne (蜥鮫)

Utilization of Shark

1. The meat of most of the above-mentioned species can be processed into fish balls (see chapter V). In case the shark contains higher concentration of urea, it should be washed with diluted acetic acid at least twice.
2. The fins can be processed into dried shark fins or dried shark-fin rays (see Chapter VI)
3. The skin can be dried (sun-dried) and served as imitation shark fin at dinner table, or it may processed into leather
4. Liver
 - a. For squalene extraction
Centrophorus lusitanicus Bocage & Capello
Centrophorus niaukan Teng are used

* I=Common name;

** II=Japanese name.

- b. Liver oil for medical use (vitamin A & D supplement) may be obtained from
 - Galeus glaucus* Linne
 - Isurus glaucus*
 - Mustelus manazo*
 - Hammer-head (*Sphyrna zygaena*, *mokarran*, *Sphyrna lewini* etc.)
5. Bones
 - a. The cartilages (from head bones, jaw bones, etc.) can be dried and served at table as dried fish fin
 - b. The spinal bone can be manufactured into ornaments or processed into bone meal
6. The viscera and head can be either directly used as feed (for duck feeding) or further processed into fish meal or fish solubles.
7. The teeth have been extensively used as ornaments in recent years.

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