

Seafood in Thailand

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1. Introduction

Fisheries is one of the most important industries in Thailand for decades. With the coastline of 2,696 km along the gulf of Thailand and Indian Ocean. The total fish production including coastal aquaculture reaches the amount of 3.3~3.6 million metric tons (mt) per year and ranks ninth among the largest fish producers in the world. Besides the wild caught fish, fish aquaculture particularly shrimp also play an important role in increasing countrys production and booting up Thailand to the world largest exporter recently. In the past five years, though capture fisheries have grown at a slow rate and have a tendency to be stagnant, aquaculture production has grown dramatically to serve the demand of the country.

2. Fish Production

Total fish production in 2001 was 3,648,400 mt which 72.1% was from marine capture fisheries, 5.5% from capture freshwater fisheries, 14.7% from coastal aquaculture and 7.7% from freshwater aquaculture (Table 1) (Department of Fisheries, 2003).

3. Marine Fisheries Production

In 2001, the total production of marine fisheries including coastal aquaculture was 3,166,200 mt. This quantity can be classified as fish 2,231,600 mt, shrimp 368,900 mt, cephalopods 165,400 mt, crabs 50,300 mt and molluscs 308,000 mt (Table 2). Among the fish, trash fish accounted for the 738,500 mt or 23.3% of the total marine fish landing. Pelagic fish accounted for 806,200 mt or 25.5% of the total landings. Pelagic species landings comprised Indo-Pacific mackerel

141,300 mt, Anchovies 145,000 mt, little tuna 45,700 mt and sardinella 145,000 mt. Demersal fish accounted for 440,000 mt. The catch mainly comprised 44,900 mt Lizard fish, 106,700 mt threadfin bream, 44,900 mt Crocker and 93,700 mt bigeye.

Shrimp, which are of the highest economic value per unit, accounted for 368,900 mt or 11.6 % of the total marine fish production. Among these, tiger shrimp and banana shrimp were major species landed at 278,100 mt and 21,300 mt respectively. Shrimp production is mainly delivered from coastal aquaculture. Black tiger shrimp (*Penaeus monodon*), which can grow well in warm water of tropical countries, is the dominant species. Having continuous expansion of shrimp farming over the past decade, the production reaches nearly 33% of the worlds shrimp aquaculture production and places Thailand on the world largest produce of aquaculture shrimp in recent.

Cephalopods accounted for 165,400 mt or 14.7% of the total production. Major species comprised 77,500 mt squid and 65,600 cuttle fish.

Molluscs accounted for 300,800 mt or 9.5 % of the total marine fish landings. The major economic crab species were swimming blue crab and mud crab. Other marine species included jelly fish and sea cucumber (49,200 mt) or 1.5% of the total marine fish production.

4. Freshwater Fisheries

Total production of fresh water fish in 2001 accounted for 482,200 mt or 15.2% of the total production, of which 58% was produced by aquaculture (Table 1). Fresh water fish comprises tilapia 127,600 mt or 26.4% of the total freshwater fish production. Catfish and local carp accounted for 107,700 mt and 85,600 mt respectively (Table 3).

5. Fish Utilization and Consumption

Table 1. Fisheries production in quantity by subsectors

(Unit : 1,000 mt)

Year	Total	Capture		Culture	
		Marine	Freshwater	Coastal	Freshwater
2001	3,648.4	2631.7	202.5	534.5	279.7
2000	3,713.2	2,773.7	205.1	467.0	271.0
1999	3,625.9	2,725.2	206.9	441.2	252.6
1998	3,505.9	2,709.0	202.3	367.7	226.9
1997	3,384.4	2,679.5	205.0	299.7	200.2

Source: Fisheries Statistic of Thailand, Department of Fisheries, 2003.

Table 2. Marine fish landing major species

(Unit : 1,000 mt)

	2001	2000	1999	1998	1997
Total	3,166.2	3,240.7	3,166.4	3,076.6	2,979.2
Fish	2,231.6	2,225.5	2,250.8	2,241.4	2,237.5
Pelagic	806.2	841.5	868.8	880.5	871.5
Demersal	440.0	410.9	410.8	404.4	380.1
Other food	246.9	198.0	206.0	191.5	163.8
Trash fish	738.5	775.1	765.2	765.0	822.1
Shrimp	368.9	397.7	362.3	349.3	353.9
Banana	21.3	18.6	15.6	15.1	14.4
Tiger	278.1	309.5	276.1	251.7	229.5
School shrimp	11.1	11.9	10.3	11.2	13.0
Sergestid	4.0	3.8	7.7	15.4	17.5
Others	54.4	53.6	52.6	55.9	79.5
Crabs	50.3	58.1	55.4	58.0	51.1
Swimming	36.8	43.9	41.2	46.7	40.1
Mud	5.4	6.9	5.7	3.8	4.1
Others	8.1	7.3	8.5	7.5	6.9
Cephalopods	165.4	177.5	174.4	188.1	173.6
Squid	77.5	86.2	83.1	92.9	78.9
Cuttle fish	65.6	67.3	66.3	67.5	71.6
Octopus	22.3	24.0	25.0	27.7	23.1
Molluscs	300.8	242.1	238.9	175.0	120.7
Green mussel	148.5	129.9	73.9	56.9	61.0
Baby calm	52.5	49.1	70.0	49.7	35.8
Bloody cockle	77.2	47.8	63.4	44.6	8.3
Oyster	20.6	13.5	29.2	22.5	15.1
Others	2.0	1.8	2.4	1.3	0.5
Others	49.2	139.8	84.6	64.8	42.4

Source: Fisheries statistic of Thailand, Department of Fisheries, 2003.

Table 3. Fresh water species production

(Unit: 1,000 mt)

	2001	2000	1999	1998	1997
Tilapia	127.6	122.4	126.3	113.6	96.5
Catfish	107.7	110.1	96.8	73.2	62.9
Silver carp	85.6	87.3	86.8	83.3	58.8
Snakehead fish	25.1	24.9	22.0	22.0	28.1
<i>Seplat Siam</i>	23.0	22.3	22.5	18.7	13.3
Freshwater prawn	13.4	18.0	8.6	4.8	3.7
Others	99.8	95.5	95.9	113.0	141.9
Total	482.2	472.5	459.5	429.2	405.2

Source: Fishery statistic of Thailand, Department of Fisheries, 2003.

The pattern for fish utilization remains the same since the past. Fish are mainly consumed fresh and cured (salted, dried, steamed, smoked and so on). Canned products are consumed locally in smaller quantities compared with export volume and most of the frozen products are for export. Table 4 and 5 illustrate the utilization of marine and fresh water fish. In the past three years marine fish available for fresh marketing has slightly stable from 21% in 1999 to 20% in 2001, while the amount of fish used in freezing and canning increased to 24.8% and 25.4% or by 18.5% and 20.1%, respectively. On the other hand, fish used in curing decreased to 5.2% in 2001 or by 6.1% from 1999. The main reason for this change in the pattern of fish utilization could be the increasing cost of raw material resulting limited supply. Cured products produced from marine fish included dried salted fish, fish sauce, dried shrimp, dried squid, smoked fish, steamed fish, fish ball, dried mussel, fish crackers and budu sauce.

Most freshwater fish is utilization domestically, 76.6% of it, in fresh form for consumption. Curing absorbed 23.2% of raw material. Dried and salted took 11.7% of water freshwater production or 56,513 mt, followed by fermented fish which utilized some 29,558 mt. Table 6 shows the fish supply available for consumption in Thailand from 1997 to 2001. The total production including imported fisheries products minus trash fish landings, which are regarded as non-edible fish products; post-harvest loss which is always estimated at 15%; and total exports, gives the total domestic supply. When that figure is divided by the population, one arrives at annual per capita fish supply. To convert per capita fish supply to average consumption it is necessary to consider the weight of fish bones and viscera losses in processing and preparation, and plate waste at the time of consumption. The average conversion factor used is 60%, due to the edible portion of fish is approximately 60% of its whole, gutted weight. Consequently, in

Table 4. Utilization of marine fish

	2001		2000		1999	
	mt	%	mt	%	mt	%
Fresh consumption	639,572	20.2	609,251	18.8	664,944	21.0
Chilled/Frozen	804,214	25.4	771,286	23.8	785,267	24.8
Cured	164,642	5.2	262,496	8.1	193,150	6.1
Canned	636,406	20.1	638,417	19.7	585,784	18.5
Fermented	107,650	3.4	106,943	3.3	104,491	3.3
Fish ball	10,355	0.33	9,008	0.28	6,753	0.21
Fish meal	794,716	25.1	836,100	25.8	823,264	26.0
Fish/shrimp cracker	6,293	0.2	6,054	0.19	2,069	0.07
Other	2,349	0.07	1,145	0.03	678	0.02
Total	3,166,197	100	3,240,700	100	3,166,400	100

Source: Fishery Statistic of Thailand, department of Fisheries, 2003.

Table 5. Utilization of freshwater fish

	2001		2000		1999	
	mt	%	mt	%	mt	%
Fresh consumption	369,509	76.63	375,448	79.46	359,696	78.28
Chill/Frozen	-	-	-	-	-	-
Cured						
Dried/salted	56,513	11.72	46,683	9.88	49,718	10.82
Steamed/smoked	23,338	4.84	25,704	5.44	19,115	4.16
Fermented	29,558	6.13	21,640	4.58	29,270	6.37
Fermented paste	289	0.06	661	0.14	138	0.03
Fish sauce	2,603	0.54	2,126	0.45	1,517	0.33
Others	385	0.08	238	0.05	46.0	0.01
Total	482,200	100	472,500	100	459,500	100

Source : Fishery statistic of Thailand, department of Fisheries, 2003.

Table 6. Supply available for consumption in Thailand

(Unit : 1,000 mt)

	2001	2000	1999	1998	1997
Total domestic production	3648.4	3713.2	3625.9	3505.8	3384.4
Non-edible fish products	738.5	775.1	765.2	765.0	822.1
15% post-harvest loss	547.2	556.9	543.8	525.8	507.6
Total exports	1398.9	1356.7	1394.1	1312.2	1181.2
Total imports	991.4	842.6	930.8	728.9	710.1
Total domestic supply	1955.1	1867.0	1853.6	1631.6	1583.5
Population (million)	62.3	61.87	61.66	61.46	60.81
Annual per capita supply (kg)	31.38	30.17	30.06	26.54	26.04
Estimated av.consumption (kg)	18.82	18.10	18.03	15.92	15.62

Source : Fishery Statistic of Thailand, Department of Fisheries, 2003.

1997~2001, per capita fish supply was approximately 26~31 kg and average consumption was 15~18 kg. However, consumption varied from region to region and fish produced through fish ponds and small scale fisheries have not been taken into account in the fisheries statistic.

6. Fish Processing Industry

Out of the total landing in 2001 of 3648.4 million tons, about 794,716 mt (21.7%) was converted to fish meal, while 804,214 mt (22.04%) was frozen and 636,404 mt (17.44%) were canned. Approximately 384,593 mt (10.5%) were processed into traditional products and 1,009,081 tons (27.65%) used for fresh consumption (Table 4 and 5). The number of fish

processing factories in each segment of the industry is indicated in Table 7. It is observed that since 1999 the number of processing factory has slightly increased. Apart from the fish canning factories and prawn/fish freezing factories, most fish processors are small to medium scale especially for traditional products. Most traditional establishments are located in coastal area close to fish landings sites. The traditional products are mainly for domestic market and have tendency to export. Fish processing activity could be identified to three levels as follows:

1) Processing stage

This activity involves the preparation of raw material for local market and for processing factories which include cleaning, dressing, filleting, picking and shucking. Initial processing is carried out mainly at peeling sheds.

2) Traditional product processing

Traditional products are mainly processed by the small and medium enterprises in the form of salting, drying, steaming, smoking and fermenting. Products includes fish and shrimp cracker as well as fish ball (Table 7). Processors still rely on traditional practices, experience and manual processing. To date, even though they do not use much modern technology, they have made progress in upgrading quality standards and are packing more and more in response to their customers requirement for quality. Curing is a simple method but it involves some challenging problems mainly hygienic practices and process productivity. Smoked fish is also a common product in some area. The storage life is long because the product is dry (15% moisture content). This products is used to provided protein in curry. Fermented product, fish sauce was originated from cottage industry and at present the product is produced commercially which requires about 104,493 mt of fish to produce fish sauce annually. This product consume locally and some are for export. Fish sauce factories are mostly medium scale. The fish (anchovy) mix with salt in concrete tanks where it is kept for eight to twelve months. The fish sauce is filtered before bottled. Shrimp paste is another type of fermented product. Local shrimp paste is purple brown in color and most of it is traditionally produced by small scale processors. The raw material is acetes spp to which salt is added at ten percent by weight. The mixture is drained for five to eight hours then dried to reduce the water content before pounding. It is kept in wooden boxes or jars for at least three months before consumption.

3) Industrial processing

The industrial scale processing has grown rapidly. Products are mostly for export market. In 2001, there were 44 canning industries. Half of these produced mainly canned tuna. They all followed good practice and food safety under HACCP implementation in order to meet

international standards and regulations. The number of canneries has not increased because the existing factories have not reached their full capacity. Major species utilized by the cannery were tuna, sardine, shrimp, crab, shellfish, squid and cuttle fish. There were 146 freezing and cold storage factories. Major species utilized by industries were fish, shrimp and cephalopods. Most of the processors produced block frozen products and a major development in this area has been shift to the production of valued added products. To date, 50% of exported seafood products are either processed and packed into consumer packs or made into prepared seafood products for direct institutional retail sale in major world markets. This is done through upgrading quality, using new technology. Diversifications are mainly based on shrimp, cephalopods and fish. Currently shrimp is value-added into cooked and peeled shrimp, cooked whole shrimp, peeled butterfly, tail-on, peeled tempura, battered and breaded shrimp and processed products. The processed products include shrimp shaomai, hargao, shrimp spring roll, shrimp on sugar cane, shrimp dumping, shrimp patties and tom yam kung (Thai-style shrimp soup). Today, most cephalopod products have undergone at least primary processing. Many are also processed to convenience products and delicacies such as cooked squid ring, squid/cuttle fish skewer, stuffed squid and breaded squid ring. Surimi industry has started in Thailand since 1980. Most of surimi factories produce secondary products such as imitation crab stick, fish ball, fish cake, breaded minced fish and cuttlefish ball. Eight imitation crab stick factories have been separately established from surimi factories. In 2001, there were 93 factories producing fishme.

Table 7. Number of fish processing establishments

Type of plant	2001	2000	1999	Raw material processed
Freezing/Cold storage	146	142	134	Shrimp, fish, cephalopod
Cannery	44	45	42	Tuna, sardine, shrimp, crab, shellfish, squid
Fish sauce	83	86	89	Anchovy, sardinella
Fish meal	93	96	98	Fish
Salted fish	739	665	619	King mackerel, anchovy, crocker
Dried shrimp	128	124	140	<i>Panaeidae</i> sp. and <i>Palaemunidar</i> sp.
Dried squid	341	381	418	Cuttle fish, octopus
Dried mussel	154	160	207	Green mussel
Steamed fish	68	86	78	Indo-pacific mackerel
Smoked fish	20	17	19	Lizard fish, crocker
Cracker	184	148	144	Sardine, shrimp, crocker
Fish ball	81	82	86	Threadfin bream, Big eye
Budu sauce	149	123	105	Sardine
Total	2,230	2,155	2,179	

Source : Statistics of Fisheries Factories, Department of Fisheries, 2003.

Table 8. Thailand's international trade in fisheries commodities

(Quantity : mt)

(Value : million bahts)

Year	Import		Export		Balance value
	Quantity	Value	Quantity	Value	
2001	991,425	47,038	1,398,997	190,900	+143,862
2000	842,676	33,995	1,356,734	185,750	+151,755
1999	930,885	33,289	1,394,104	165,718	+132,429
1998	728,960	36,492	1,312,250	176,311	+139,814

Source: Fisheries Record of Thailand, Department of Fisheries, 2003.

4) Trade of fishery products

The fish processing industry, especially factories of export scale, has been one of the top world exporters despite trade barriers and competition, and Thai exporter recognized as quality products. Comparing the year 1998 and 2001, the country's exports grew by 6.2% in quantity and 7.6% in value (Table 8).

7. Export and Import of Fishery Product

Export of fisheries products increased from 1,394,104 mt valued of 165,718 million bahts in 1999 to 1,398,997 mt valued of 190,900 million bahts in 2001. Export commodities consist primarily of high market value products, such as shrimp and tuna (Table 9 and 10). Type of products exported have been diversified from shrimp, fish and cephalopods. There are more than 20 major fish and fisheries products which earn foreign currency income. There include frozen shrimp, canned tuna, canned seafood, frozen cephalopods, frozen tuna loins, frozen fillet and surimi and others.

1) Frozen shrimp

With regards to export, shrimp products have ranked as the top leading exported fisheries commodity contributing 20% volume and 52% value of the total export of Thailand. In 2001, export of frozen shrimp accounted for 145,187 mt, valued 55,037 million bahts. Shrimp exports were slightly increased from 1999 to 2001 but declined dramatically in 2002, down 28% in term of volume and 39% in term of value when compared with 2001. This is due to the issue of nitrofurans residue in aquaculture black tiger shrimp. Especially the EU market, the total export dropped sharply 70% from 2001. The largest importer of Thai frozen shrimp still remains with the US accounted for 46% of the total exports in 2001. Japan is the second large amounted to 17% and followed by Singapore 7%.

Regarding the import of chilled and frozen shrimp, the total import in 2001 accounted for 24,539 mt, valued at 5616.7 million bahts increasing 27% in quantity from the previous year. The imported shrimp is mainly comprised with red shrimp (*Pleoticus muellei*, *Pandalus borealis* and *Solenocera crassicornis*) and black tiger shrimp. Red shrimp is from Greenland and Iceland for Japanese raw consumption product (Sashimi) processing. Black tiger shrimp is from India, Indonesia, China, Bangladesh and Vietnam. Most of the imported raw material is further used for processing of value added products for export.

2) Canned tuna

Thai processors use both domestic and imported tuna for canning, and the domestic catch consists of tonggol and little tuna. The majority of tuna that Thailand imports are skipjack, yellowfin and some albacore. Imports now account for over 80% of the tuna used in their processing. Canned tuna exports were quite stable in volume from 1999 to 2001 but increasing in value. The largest market for canned tuna is USA, Canada, Australia, EU and Japan.

3) Traditional products

Compared with shrimp and tuna, the traditional products (salted, dried, smoked and fish sauce) volume of trade is much smaller. In 1999, exports accounted for 92,929 mt and were valued at 4,817 million bahts. However, in 2001 the exports increased to 191,736 mt, valued at 13,913 million bahts. The market for their products is Japan and Asia.

8. Ensuring Quality of Fish and Fishery Products

The Department of Fisheries through Fish Inspection and Quality Control Division is responsible for controlling and ensuring that fish and fisheries products exported from Thailand are safe, wholesome and meeting standards and requirements of the importing countries. Major responsibilities include:

- Ensure the implementation of basic food hygiene, good manufacturing practices and preventative control quality system by fish processing establishments.
- Verify that approved fish processing establishments are effectively implementing a quality management program based on Hazard analysis and Critical Control Point (HACCP).
- Provide analytical services and health certificates to accompany shipments for export.
- Provide responsible assurance that raw materials are free of chemical residues, environmental contaminants, biotoxins as well as pathogens through monitoring programmes.
- Conduct research work to improve quality of raw material, processing techniques and quality management system as well as develop new effective and validated analytical techniques.

Table 9. Export volume of fishery products

(Unit, mt)

Commodity	2001	2000	1999
Fresh and frozen	572,145	559,627	593,845
Fish	340,891	330,885	366,564
Shrimp	145,187	142,320	138,105
Crab	4,041	3,457	3,867
Squid	82,026	82,965	85,309
Canning	543,589	499,823	522,200
Sardine	32,944	36,523	46,967
Tuna	298,416	265,743	282,840
Shrimp	110,051	87,697	82,840
Crabs	8,497	5,106	7,615
Squids	9,826	9,403	7,999
Baby calm	6,573	8,191	11,398
Others	77,282	87,160	82,541
Salted dried and Smoke	31,017	26,628	20,807
Fish	29,429	25,130	19,203
Shrimp	986	1,018	1,113
Crab	93	52	24
Squid	509	428	467
Fish sauce	30,948	28,758	38,224
Oyster sauce	1,947	2,116	1,944
Fish oil / Sea weed	745	1,499	503
Fish meal	7,065	8,970	4,639
Preserved	103,757	27,070	8,173
Fish	96,419	-	-
Shrimp	-	3,774	-
Awabi	66	15,341	19
Other	7,272	7,955	8,154
Fresh / frozen and salted	24,067	21,943	23,781
Mollusces	17,890	8,649	7,700
Other	6,177	13,294	16,081
Aquatic animal live	17,356	15,923	20,273
Fish	9,114	7,654	9,503
Other	8,242	8,269	10,770
Others	66,361	164,377	141,177
Total	1,398,997	1,356,734	1,394,104

Source: Fisheries Static of Thailand, Department of Fisheries, 2003.

9. Application of HACCP in Fish Processing Industries in Thailand

HACCP, which stands for Hazard Analysis and Critical Control Point, clearly expresses its

Table 10. Export value of fisheries products

(Value : 1,000 Bahts)

Commodity	2001	2000	1999
Fresh and frozen	84,550,429	85,802,354	74,697,334
Fish	16,041,346	14,454,957	14,517,182
Shrimp	55,037,819	59,840,298	48,348,244
Crab	1,528,433	858,193	493,230
Squid	11,942,831	11,448,906	11,338,678
Canning	86,089,889	75,105,677	69,221,637
Sardine	1,565,556	1,584,982	1,477,879
Tuna	29,148,639	20,572,727	24,163,955
Shrimp	43,572,362	41,959,191	38,902,838
Crabs	3,776,896	1,941,299	2,460,327
Squids	2,022,485	1,791,056	99,012
Baby calm	675,607	708,198	1,312,622
Others	5,328,344	6,548,225	796,004
Salted dried and Smoke	2,220,469	1,895,529	1,342,040
Fish	1,582,332	1,332,836	801,857
Shrimp	380,957	362,702	347,913
Crab	52,859	24,718	3,231
Squid	204,321	175,273	189,039
Fish sauce	835,894	702,507	637,780
Oyster sauce	106,558	79,187	63,613
Fish oil / Sea weed	31,085	106,505	63,011
Fish meal	170,743	130,831	66,074
Preserved	8,615,050	6,577,444	994,671
Fish	7,462,244	-	-
Shrimp	21,386	1,113,538	-
Awabi	-	5,335,501	9,010
Other	1,131,420	1,284,605	985,661
Fresh / frozen and salted	2,135,322	1,847,713	1,779,759
Molluscs	1,586,999	429,137	455,618
Other	548,323	1,418,576	1,324,139
Aquatic animal live	1,709,652	1,619,552	2,149,082
Fish	989,703	803,006	1,037,462
Other	719,949	888,516	1,111,620
Others	4,435,532	9,854,099	8,480,697
Total	190,900,623	185,750,368	165,718,093

Source: Fisheries Static of Thailand, Department of Fisheries, 2003.

approach to food safety, which is to identify the pertinent hazards and establish control measures to prevent them. HACCP was first introduced to the Thai seafood industry in 1991 and became mandatory for all fish processing establishments approved for export since 1996. Approved

establishments must have HACCP programme implemented, documented and verified. Guidelines for development of documented programme have been provided and updated to meet international standards. Currently, 222 of the 266 (83%) approved export establishments have successfully implemented HACCP and the rest are being verified. Traditional product processors producing fermented fish, fish sauce, shrimp paste, for example, are the latest group in the industry to implement HACCP. Currently, there are 40 traditional product processors registered for export of which 31 (78%) have fully implemented HACCP in their establishments. The rest are in the process of improving their controls and having re-assessment from the Department of Fisheries.

10. Research on seafood

There are both university and research institute dealing with research activities on sea food. Most of the research works are in the area of fish handling, fish processing, product development, packaging of fisheries products and utilization of fisheries waste. When each article was analysis, it was found that the product development article was emphasized in minced fish and products from minced fish, the rest were fermentation, cured, smoked product. For fish handling article, the research was divided into 2 parts namely fish handling on board and fish handling on land. Most of the work in these areas were emphasized on fresh/frozen fish, shrimp handling and fish transportation. The other articles of the handling area were found on squid and fresh water fish. The articles on packaging was more on canned fish product development and the work development of fish product packaging especially polyethylene bag. Almost all of the utilization of fisheries waste studies was on chitin and chitosan from shrimp head and shell. Biotxin studies pay attention on occurrence of poison from marine horseshoe crab, puffer fish and freshwater puffer fish. For the research work on contaminant of heavy metal such as cadmium, mercury and lead are the major study in marine fish both fresh and canned products. HACCP study was emphasized on exported products such as frozen, canned seafood and traditional products in some products such as fish sauce and dried shrimp. The work on the development of machine used in processing work have been designed and invented such as fish scaling removal machine, fish cleaner machine, solar machine and dried shredded fish machine.

Following are some articles of research conducted:

1) Handling

- Quality changes of fresh and frozen squid (*Loligo chinensi*) during storage
- Freshness measurement of catfish by sensory and chemical methods (K-value)
- Trials on dry packing of live Black tiger shrimp (*Penaeus monodon*)
- Handling and transportation of live green mussel

- Improving catfish quality for value-added products
- Improving by-catch on board for human consumption
- Extending shelf life of sardine (*Sardinella* sp.) by chilled sea water.
- Effect of Handling on yield and quality of canned sardines
- Removal of off-odor in Nile Tilapia flesh
- Development of depuration process in live cockles (*Anadara granosa* Linn)

2) Processing and packaging

- The effect of trehalose on the quality of dried fish fillet and minced
- Effect of type and quantity of flour used on the quality of frozen fish ball
- Improving fish sauce technology from *Stolephorus* sp.
- Factors affecting the gel forming ability of surimi and quality of crab analog
- Process development of dried salted *Sepat-Siam*
- Improving and extending shelf life of lactic acid fermentation fish (Som-fug)
- Effects of preservation methods on geosmin content and off-flavor in Nile-tilapia (*Oreochromis niloticus*)
- Quality of anchovy kept on board and quality of fish sauce during fermentation
- Factor affecting odor and histamine formation in Pla-ra
- Drying of fermented fish using superheated steam and hot air
- Effect of storage time and temperature abuse on post mortem chemical and microbiological changes in shrimp (*Trachypenaeus* spp.)
- Quality of fish sauce in various types of packaging
- Frying process improvement and shelf life of fried salted *Sepat Siam*

3) Product development

- Surimi production from *Tilapia nilotica*
- Product development of canned mussel
- Development of minced fish product (Pla-yor) and shelf study
- Development of surimi noodle processing and packaging
- Production of snack foods supplemented with protein from dried tiger prawn head by extruder
- Surimi and surimi based product from dark meat fish
- Ready to eat fermented fish (Pla-ra)

4) Food safety and quality control

- cadmium content in Cephalopods

- Toxic puffer fish in thailand
- Chemical changes in tuna
- Levels of mercury and cadmium in canned seafood for export
- Toxins of *Arothron mapp* and *Lagocephalus inermis*
- Tetrodotoxin in Thai horseshoe crab
- Chemical and microbiological changes in irradiated fish balls
- Analysis of mercury in marine fishes and canned tuna
- Geosmin and off-flavor in Nile Tilapia (*Oreochromis nilotica*)
- Salmonella contamination in Thai shrimp
- Contamination of *Escherichia coli* 0157:H7 and *Campylobacter* in exported frozen shrimp product
- Lead, mercury and cadmium levels of economic marine fish at markets in Bangkok and landing places
- Survey on toxic freshwater puffer fish in Udonthani province
- Diversity of insect pests of dried seafood in the eastern region of Thailand
- Hazard control in aquaculture
- Determination of benzoic acid and sorbic acid in fish balls by HPLC
- Monitoring of toxic freshwater puffers
- Monitoring on the pesticide residue of salted and dried fish
- Factor affecting decomposition in canned shrimp
- Quality changes during processing, fermentation and storage of low-salt carbohydrate fermented Thai fish product (Som-fug)
- Incidence of Salmonella in fishery products
- Nematode parasites in marine fish
- Quality of fish sauce in various types of packaging

5) Biotechnology

- Application of biotechnology in fermented product (Pla-ra)
- Chitosan from fish industrial offal
- Chitin deacetylase from *Mucor rouxii*
- Preservative effect of chitosan on food

6) Engineering

- Design and development of a solar fish drier
- Equipment design for small scale fish meal processing

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