UTILIZATION OF BYCATCHES AND LOW-VALUE FISH IN INDIA

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ABSTRACT

India has a coastline of 8 041 km with an annual marine fish landing of 2.97 million tonnes (1997). A total of 238 128 fishing craft are exploiting the marine resources of India and they land a large quantity of bycatch and low-value fishes. The percentage of bycatch varies from 70 to 80 depending upon the seasons. In recent times a sizable amount of low value fish and bycatch are brought ashore by traditional fishing crafts and medium sized fishing vessels due to the economics of fishing operations. In addition market for these fish is expanding. Bycatches are generally used for curing and manufacture of fish meal but those of better quality are also used for surimi production and export as frozen fish.

Bycatch is an excellent raw material for production of minced fish which can be exported and also converted into various value added products like hydrolysates, fish soup powder, fish flakes, moulded products etc. This paper describes in detail the methods of production of several value added products for the economic utilization of low-value fish, particularly the bycatches.

BACKGROUND

India has a coastline of 8041 km with an Exclusive Economic Zone of 2.02 million km^2. The estimated marine potential resource of the country is 3.9 million tonnes (m t). The current level of exploitation (1997) is 2.97 m t. The annual fish production of the country is 5.35 m t with 2.38 m t coming from the inland sector.

A total of 238 128 fishing craft are operational in the Indian waters. Of these 46 918 are mechanised boats, 31 726 motorized traditional craft and 191 207 traditional craft (Anon 1996). The country exported 378,199 mt of marine products earning foreign exchange of around US $ 1 billion (1997). In the field of aquafarming India ranks second in the world and in total fish production sixth in the world. Various figures concerning fisheries of India are given in Tables 1-7.

INTRODUCTION

Bycatches and low value fish that are discarded at sea are subjects of global concern. The bycatches from shrimp trawlers have been an issue of concern and investigation in many tropical countries like India for more than 40 years. This issue has been highlighted in several U.N. resolutions and conferences particularly the International Conference on Sustainable Contribution to Food Security 1995, Kyoto Declaration and notably the U.N. Resolution (AIC.2149.1 50. Rev. 1), which emphasized the vital role of providing sustainable food supplies and livelihoods for present and future generations. This resolution while underlying the significance of the role of bycatches and discards as human food states that this issue **"Warrants serious attention by the international community and a continued and effective response is necessary to ensure the long term and sustainable development of fisheries"**. But there are many imponderables on these bycatches or discards about their utilization as they are normally low-value fish. Some of them are listed below:

How economical is it for the vessel owners to preserve and bring their catch ashore?

The method to transport them to deeper interior markets to get better prices.

Improved methods of utilization to convert them to high value processed products.

Certainly discards are a threat to environments and habitats. Often this creates migration of some species. Although many attempts are made to reduce their quantities in fishing nets by exclusion devices they have met stiff resistance from fishers as these devices often reduce the amount of quality fish by around 10-15 percent. The problem is still open and needs global attention.

Table 1. Total fish production in India.

(in '000 tonnes)

Year	Marine	Inland	TOTAL
1950-51	53.4	21.8	75.2
1960-61	88.0	28.0	116.0
1970-71	108.6	67.0	175.6
1980-81	155.5	88.7	244.2
1990-91	230.0	153.6	383.6
1991-92	234.7	171.0	415.7
1992-93	257.6	178.9	436.5
1993-94	264.9	199.5	464.4
1994-95	269.2	209.7	478.9
1995-96	270.7	224.2	494.9
1996-97	296.7	238.1	534.8
1997-98 (Targeted)	292.5	243.8	536.3

Table 2. Investments in various Five Year Plans.

(Rs. in millions)

Plans	Total Plan Outlay	Outlay for Agri. & Allied Sectors	Outlay for Fisheries	% of Fisheries Outlay to	
				Total Outlay	Outlay for Agri. & Allied
I Plan	19 600	2 940	51.3	0.26	1.74
II Plan	46 000	5 290	122.6	0.27	2.32
III Plan	75 000	10 680	282.7	0.38	2.65
IV Plan	159 020	27 280	826.8	0.52	3.03
V Plan	393 220	43 020	1 512.4	0.38	3.52
VI Plan	975 000	66 090	3 711.4	0.38	5.62
VII Plan	1 800 000	105 240	5 465.4	0.30	5.19
VIII Plan	4 341 000	224 670	12 328.2	0.28	5.49
1997-98		15 350*	3 000.0*		

- Tentative allocation for central sector schemes only.

Table 3. Indian fishery resources at glance.

1. Length of the coast Line (Kms.):	8041
2. Exclusive Economic Zone (million km2.):	2.02
3. Continental Shelf Area ('000 km2.):	506
4. Length of Rivers, Canals (km.):	171334
5. Brackishwater Area ('000 ha.):	1422
6. Reservoirs Area ('000 ha.):	2050
7. Tanks & Ponds ('000 ha.):	2855
8. Beels, Oxbow & Derelict Waters ('000 ha.):	788
9. Marine Fish Potential (million tonnes):	3.90
10. Inland Fish Potential (Million Tonnes):	4.50
11. Fish Production (Million Tonnes) 1996-97:	
MARINE:	2.97
INLAND:	2.38
TOTAL:	5.35

Table 4. Market/item wise fish export from India during 1996-1997.

Market Wise			Item Wise		
Japan	Q: V:	64 656 18 860.4	Frozen Shrimp	Q: V:	105 429 27 017.9
European Union	Q: V:	71 236 7 906.9	Frozen Fish	Q: V:	172 627 6 329.5
South East Asia	Q: V:	197 405 8 792.3	Frozen Squid	Q: V:	40 924 2 904.5
U.S.A.	Q: V:	29 792 4 360.5	Frozen Cuttlefish	Q: V:	31 778 2 723.7
Others	Q: V:	15 110 1 293.5	Others	Q: V:	27 441 2 238.0
TOTAL	Q (Quantity- MT): V (Value - Rs. Million) :	378 199 4 121.36			

Table 5. Potential Resources Available, Level of Exploitation and the Potential Available for Exploitation Depth-wise within the Indian EEZ.

(in million tonnes)

Depth Range (m)	**Total**	**0-50**	**50-200**	**200-500**	**Oceanic**
Demersal	1.28	0.625	0.028	-	1.933
Neretic Pelagic	1.00	0.742	-	-	1.742
Oceanic Pelagic	-	-	-	0.246	0.246
Total **(%)**	**2.28** **(58)**	**1.367** **(35)**	**0.028** **(0.7)**	**0.246** **(6.3)**	**3.921**
Present Level of Exploitation*	2.08	0.63	Negligible	Negligible	2.71
Available for exploitation	0.20	0.737	0.028	0.246	1.211

* *1995-96*

Table 6. Estimated group-wise fishery potential of the Indian EEZ

(in '000 tonnes)

GROUPS	Up to 50 m	Beyond 50 m	Total
Elasmobranchs	65	103	168
Eels	7	-	7
Catfish	60	63	123
Oil Sardine	191	-	191
Other sardines	96	-	96
White bait	91	-	91
Other clupeids	157	14	171
Bombay duck	104	-	104
Lizard fish	27	21	48
Perches	114	145	239
Sciaenids	120	22	142
Ribbon fish	95	216	311
Carangids	143	304	447
Silver bellies	82	4	86
Pomfrets	42	12	54
Mackerel	162	62	224
Seer fish	42	-	42
Tunnies	37	242	279
Flat fish	38	-	38
Penaeid prawns	178	-	178
Non-Penaeid prawns	54	-	54
Cephalopods	50	21	71
Priacanthus spp.	-	55	55
Black ruff	-	9	9
Indian drift fish	-	7	7
Deep sea prawns	-	3	3
Deep sea lobster	-	5	5
Oceanic tuna	-	209	209
Bill fishes	-	4	4
Others	254	189	443
Total	**2.210**	**1 690**	**3 900**

Table 7. Fishing crafts in Maritime States/UTs during 1994-95.

State/UTs	Traditional Craft	Motorized Traditional Craft	Mechanized Boats	Total
GUJARAT	8370	4283	8365	21018
MAHARASHTRA	9702	286	7930	17918
KARNATAKA	11952	1189	3655	16796
KERALA	27873	12913	4206	44992
TAMIL NADU	26737	5340	8230	40307
ANDHRA PRADESH	54000	3269	8911	66180
ORISSA	7796	2453	1665	11914
WEST BENGAL	4091	270	1880	6241
LAKSHADWEEP	780	298	443	1521
A & N ISLANDS	1180	160	230	1570
PONDICHERRY	5900	365	553	6818
GOA	1100	900	850	2850
TOTAL	**159481**	**31726**	**46918**	**238125**

THE INDIAN CONTEXT

From traditional and motorized traditional crafts there are no discards now because all catches are consumed fresh locally. In many states like Kerala demand for fresh fish has become great because of large scale export of all good species by processing factories. Fishery operations have become highly competitive in view of the large number of craft operating in inshore waters, which become non-remunerative except in peak seasons. Many vessel owners find it difficult to break-even in view of the high labour charge and cost of maintenance of vessels. An impact of these problems forced the vessel owners to bring fish that were formerly discarded to the land and sell at available rates.

Another factor which contributed to the reduction of the discards is the recent export potential of these low priced fish. Fishes like ribbon fish, cat fish, sciaenids, jelly fish and threadfin bream, which were once considered discards, are now processed and exported to South-East Asian countries. The export of frozen fish from India showed a steady increase from 12.6 percent (1985-86) to 45.64 percent (1996-97). In 1996-97 India exported 173 005 m t of frozen fin fish valued at 6 369.2 million Indian Rupees. The south east Asian Countries offered the market for these low value fish like ribbon fish, threadfin bream, croakers etc. with a unit value realization around 0.8 US S (MPEDA 1998). South East Asian countries shared the major portion of fresh export from India (70.48 percent) underlying the significance of the vast export potential of these low-value fish.

Table 8. Growth of export of miscellaneous bycatches from trawls *(1996-97)*.

	Quantity (m. tons)	**Value (Million Rupees)**
Dried Products		
Jelly Fish	88	8.2
Octopus	32	0.7
Snail meat	532	40.4
Sea dragon/horse	9	1.9
Dried Fish	5918	156
Frozen Octopus	2952	133.5 (+402% growth)
Frozen Fish	173005	6392.2

QUALITY OF BYCATCHES AND DISCARDS

In a multispecies fishery, the concept of bycatch is often a misnomer. Even though shrimp trawlers target their operations on shrimp, substantial quantity of fin fish do occur in the catches. As per price realized at landing centres, these species are categorized into four groups:

Table 9. Quantity of bycatch -fish landed by shrimp trawlers in India*.

Category	Price range (per kg in Rs.)	Quantity (mt)	In relation to total production by trawlers. (%)
(i)	07 – 10	176 000	16
(ii)	10 – 20	561 000	50
(iii)	20 – 50	21 800	19
(iv)	> 50	169 000	15
TOTAL	-	**1 124 000**	**100**

* *Data : Courtesy, Director, Central Marine Fisheries Research Institute, Cochin, Figures average annual production for period 1992-96.*

Bycatch is handled well and processed quickly by local communities. In states like Kerala, Karnataka and Gujarat markets are available and much is used now by surimi plants. In states like Kerala about 70 percent is consumed as fresh fish. Gujarat is another good example where bycatch utilization is virtually 100 percent (Bostock, 1987).

In the Bay of Bengal, the situation is different. There is large variation in fleet size ranging from few days to 30 days of endurance at sea. Bycatch losses have been assessed by the Bay of Bengal Programme and according to their report (Bostock and Ryder 1995) bycatch losses are a function of the time spent at sea and type of vessel, the larger is the vessel, the greater is the discards. The estimated quantity of the discards are 100-300,000 m t from the east coast fleet (Visakapatanam and north to the Sandheads bank), and it was shown that great majority of this figure is derived from large multiday vessels of over 16 m, especially freezer trawlers over 20 m.

Table 10. Bycatch discards from India's East Coast Trawlers (Visakapatham).

Category	Type of Vessel	Gross tonnage of the vessel	Number of vessels	Voyage time(approximate days)	Annual discards (tonnes)
1.	Double rig trawler of 20 m Length (freezer)	150	150	30 – 50	40-60,000
2.	Double rig trawler of 16-19 meters (mainly ice)	40 – 50	70	21	21-32,000
3.	"Sona" stern trawlers	20-25	70	15	14,000
4.	Mechanized fishing boats (10-11 m)	7-16	320	1-7	18,000
5.	Mechanized boats (Andhra Pradesh)	OAL 10-15	8911 *	1-7	NIL (Total utilization)

Data : Source 1-4: Gordon (1990) 5 (Ministry of Agriculture, Govt. of India).*

SPECIES AND SIZE RANGE

Category I. Shark, lizard fish, jelly fish, octopus, anchovies, threadfin bream, skates etc.

Category II. Sciaenids, catfishes, carangid, chirocentrus, barracuda, ribbon fishes, solefish, scombroids, clupeids, polynemids, tunas etc.

Category III. Flat fishes, perches, tunas, eels, pomfrets (small size), cods, etc.

Category IV. Pomfrets (big size), perches, seers.

Table 11. Protein content of some low-value species.

Common name	Scientific name	Moisture	Protein	Fat	Ash
Anchovy #	*Stolephorus spp.*	79.40	15.10	1.30	2.60
Barracuda	*Sphyraena barracuda*	76.50	21.28	0.64	1.51
Bombay duck *	*Harpodon nehereus*	88.50	7.50	2.00	1.50
Caranx	*Caranx sp.*	76.40	17.60	1.17	2.83
Catfish *	*Arius dussumieri*	75.00	18.00	1.4	1.50
Eel *	*Muraenesox spp.*	83.00	13.50	0.75	1.50
Japanese threadfin bream#	*Nemipterus japonicus*	74.90	18.10	0.76	3.12
Jew fish *	*Sciaena miles*	78.60	17.80	1.36	1.73
Mackerel	*Rastrelliger kanagurta*	71.19	21.21	7.51	1.33
Malabar sole	*Cynoglossus semifasciatus*	77.00	17.50	2.70	3.10
Perch *	*Epinephelus chlorostigma*	75.00	17.00	2.50	1.75
Reef filament threadfin bream	*Nemipterus mesoprion*	76.70	19.80	0.44	0.37
Ribbon fish	*Trichiurus savala*	74.46	22.66	0.42	1.96
Rock cod (juvenile)	*Epinephelus sp.*	67.40	24.30	0.30	2.60
Silver belly	*Leiognathus bindus*	74.70	18.70	0.88	1.97
Snappers #	*Lutjanus spp.*	73.00	20.80	1.40	1.87
Sole *	*Psettodes erumei*	76.50	15.50	1.25	1.75
Spotted butter-fish	*Scatophagus argus*	75.98	18.85	3.77	1.40
Carangids	*Caranx sp.*	77.09	20.97	0.38	1.56
White bait	*Anchoviella sp.*	77.98	18.50	0.46	2.06
Whiting	*Sillago sp.*	76.32	21.90	0.25	1.53

From east cost *(Lat. 17^0 40' E, Long. 83^0 20' N)*
* *From Saurashtra Coast* *(Lat. 20^0 55' E, Long. 70^0 20' N)*
Other fishes from South west coast *(Lat. 9^0 57' E, Long 76^0 15' N)*

LANDING, PREPROCESS HANDLING AND TRANSPORT

Currently, both the traditional and mechanized sectors do not preserve these bycatches. Normally in vessels of above 18 m OAL, having longer endurance at sea, quality fish are sorted out and stored in the chilled stores and the rest discarded. During the last phases of fishing, depending upon storage capacity, the rest of the miscellaneous fish are also kept. Smaller vessels of OAL 15 m and below usually go for one to three days of fishing. Only shrimps are kept in ice and trash fish is not preserved. In fact, they are brought as such. Most of these species are used for either drying or manufacture of fish meal. Spoilage rates can be around 30 percent or above. This is one reason that fish meal produced in India is not of the quality suitable for shrimp feed. This type of fish meal is chiefly used as poultry feed.

Some of the problems associated with bycatch handling on board and on shore are the following :

1. Limited ice storage capacity in fishing vessel.
2. Labour associated with sorting these species. The fishing crew seldom get time to do this work on board the vessel.
3. Low market price at landing places where the fish is usually auctioned. As middlemen involved work in groups during auction, price realisation is very poor.
4. Contamination of shrimp by low-quality fish is not now appreciated by shrimp processors due to implementation of HACCP.

PROCESSING AND UTILIZATION OF BYCATCHES

Traditional

Salting and curing

This is still the most popular method of processing bycatches. In fact about 60 percent of bycatches are utilized by this method. The fish is heavily salted in the ratio fish to ice 1:1, 1:0.5 etc. depending on the quantity of fish and salt available. In peak seasons, when fish landings are heavy, less salt is used as salt becomes expensive. Big fish are gutted and split open and salted. Fish like sardines, shark etc. are normally kept immersed in saturated brine solution and then sun-dried. Nowadays consumers generally prefer low-salted fish. Price of fish used for drying varies from Rs.1 to 5/kg. and the market price of dried fish varies from Rs.10 to 20 per kg.

Fish meal

In places like Bombay, Veraval, Visakapatnam and Mangalore, modern fish meal plants are operational and convert bycatches by wet-reduction into quality fish meal.

But there is a traditional fish meal industry which is run very profitably. The marginally spoiled as well as lean fresh fish are dried in the open beach and then pulverized in a mill without further processing. Usually sardines, anchovies and other trash fish are used in this process. Quality of this type of fish meal is poor and sand content can be very high, sometimes up to 7 percent.

Improved methods of utilization:

Although bycatches are rated as low value fish, they are high value fish in terms of nutritional quality. They contain a high amount of valuable proteins ranging from 13 to 21 g/100 g wet fish (Gopakumar, 1997). Fish plays a major role in human protein nutrition by supplying over one third of the total animal protein intake, Thailand (41.1 percent of total animal proteins); Bangladesh (46.7 percent); Japan (47.0 percent); Philippines (51.5 percent); Sri Lanka (51.5 percent); Indonesia (53.5 percent) and Korea DPR (65.2 percent) (Laureti, 1996). Most of these fresh fish are also a rich source of n_3 polyunsaturated fatty acids (Gopakumar 1997). Because of the ready availability, low-cost and nutritional quality it is very important that better utilization of these valuable bycatches be given global attention. Some of the products which can be manufactured commercially and also on a small-scale are described below:

Minced fish

Most species of bycatches can be converted to minced fish by the use of deboning machine of the type Bader 694. Yield of deboned meat varies from 35 to 50% based on type of fish used (Table 12). It is used for the preparation of several value added products like surimi, kamaboko, sausages etc. The separation process is based on physical squeezing of the split fish between a perforated drum and rubber belt. One of the disadvantages of the minced fish is that it often contains small bones, scales and skin as contaminants. Minced fish is unstable and cannot be kept unprocessed for long and can also be contaminated during production if handling practices are not sound. Minced meat is also highly susceptible to microbial, enzymatic and oxidative reactions. Despite many inherent limitations, minced fish has become the most accepted way of utilizing bycatches of low-value fish and pelagics.

Product from minced fish

Block-frozen fish mince.

Fish mince can be pressed into 500g and one kg. blocks and then quick frozen at –40°C. The blocks are very susceptible to freeze dehydration. Hence, it is imperative that they have be glazed with water by dipping in ice-cold water after freezing. When ideally packed in cartons it is an excellent consumer product since a house-wife can prepare a variety of products out of these block-frozen mince. In India block frozen fish mince is a well accepted consumer product and the integrated Fisheries Project at Cochin has established a good market for this product.

Texturized or Moulded products :

Fish mince is an excellent raw material for several reformed products like fish balls, fish burgers, fish fingers, etc. The mince is washed two to three times with water and mixed with polyphosphate (sodium salt) 0.1 percent by weight, sodium chloride (0.1 percent w/w) and starch (0.1 to 0.2 percent w/w). The whole meat is tumbled or macerated. The dough is then shaped to blocks or desired shapes. The blocks are then frozen at –40°C and kept stored at –30°C. They can be cut to different shapes in the form of fingers, cakes etc, battered and breaded and fried in vegetable oil. Seasoning and spices can be added to impart desired flavour and taste. Fish fingers made out of mince may not have the properties of fingers prepared from whole fish fillet, but fingers prepared from minced meat are comparable for most sensory properties like taste and flavour. However, being much cheaper, they offer better market prospects. This is also one of the best-ways to use bycatches as fish fingers are a high value item in western markets. By improving the processing and texturization the product quality can be considerably improved. In fact this is an area of research in food science which needs prioritization.

Table 12. Yield of mince and waste from different species of fish.

Fish	Average	Average length cm	Head + Viscera %	Mince %	Waste after mincing %	Total waste * %
Barracuda *(Sphyraena sp.)*	90.9	22.5	25.4	43.0	30.1	55.5
Thirian *(Decapterus russeli)*	35.5	15.0	37.7	43.3	23.1	53.8
Cat fish *(Tachysurus sp.)*	91.8	20.4	48.0	30.1	21.6	69.6
Goat fish *(Upeneus taeniopterus)*	56.2	15.7	33.3	44.4	20.0	53.3
Caranx compressus	181	25.4	36.0	40.2	23.0	59.0
Caranx malabaricus	105	19.2	47.6	24.3	28.2	75.8
Horse mackerel *(Megalapsis cordyla)*	110	23.2	32.9	29.5	37.5	70.4
Jew fish *(Johnius dissumeiri)*	65.5	17.4	37.3	30.8	32.7	70.0
Pallikkora *(Ottolithes argenteus)*	75.2	18.7	29.0	39.1	27.4	56.4
Ribbon fish *(Trichiurus savala)*	365	61.3	26.4	48.9	25.2	51.6
Pentaprion longimanus	25.5	13.2	32.4	56.8	10.7	43.1
Vala *(Chirocentrus sp.)*	243	43	19.2	54.8	26.0	45.2
Leatherskin *(Scomberoides lyssan)*	340	36.3	20.6	39.7	38.2	58.8
Scad *(Alepes mate)*	57.6	17.4	33.3	29.6	35.8	69.1
Threadfin bream *(Nemipterus japonicus)*	73.6	19.3	30.1	32.9	36.8	66.9
Lizard fish *(Saurida tumbil)*	211.6	30	14.9	58.2	26.7	41.6

* *Includes head + viscera and waste after mincing.*

Fish protein hydrolysates

Protein hydrolysates have an important role in protein fortified foods and beverages, due to their high solubility and digestibility. The technology of production of protein hydrolysates has become cheap and all machinery is available commercially. One great advantage of this product is that all species bycatches and low-value fish can be utilized for the production of hydrolysates compared to many other products which can only be produced from selected fish species. A variety of methods of production techniques are available. The most common among them are listed below :

Acid hydrolysis

The whole fish is cleaned well to be free of slime and adhering dirt. They are then comminuted in a mechanical meat mincer. The minced fish meal is then cooked well with 2 to 6 N acid containing water and maintained at about 90-100°C for 12-24 hours to get a completely soluble finished product. The major disadvantage of this process is that the final finished product, protein hydrolysate, will be acidic and has to be neutralized by alkalies to bring the pH to 7. This step invariably introduces large quantities of salt in the hydrolysates. Apart from this, another major disadvantage is the loss of some acid labile amino acids. This results in the loss of nutritive value.

Enzymatic hydrolysis

In the industrial processes of production of protein hydrolysis a number of enzymes are used. The enzymatic production of protein hydrolysates is perhaps the most convenient and cheapest technique. The process is fast and gives hydrolysates without much loss of essential amino acids. However, a suitable enzyme has to be selected for this process. The choice enzyme depends on factors like stability, cost etc. The important commercially available proteolytic enzymes are papain, pepsin, bromolein, ficin and trypsin. Most protein hydrolysates are highly bitter in taste. Hence, flavouring agents like cocoa are usually used during their fortification in food preparations to mask the bitter taste.

Among the important proteolytic enzymes listed above, the widely used ones are bromolein and papain. The industrial methods of production of protein hydrolysates using bromolein and papain are given below:

Hydrolysis with bromolein

1. *Preparation of enzyme*

Commercially available enzyme is dissolved in 100 parts of citrate buffer of pH 6. It is then centrifuged and the supernatant is taken. This is the stock enzyme solution for hydrolysis. This is stable, if kept at 3 to 5°C, for a week.

2. *Preparation of water fat emulsion :*

Ten parts of hydrogenated fat, antioxidant (BHA or BHT, 0.0%) and 0.15 part of sorbitan monostearate (emulsifier) are mixed together and heated to 65°C for about 10 to 15 minutes. To this, water containing 0.35 part sorbitan monostearate is added (90 parts) and the whole mixture is homogenised in a Waring blender and then kept overnight. Next day the soluble oil – water emulsion is separated from the excess fat and taken separately.

3. *Hydrolysis*

Take 100 parts minced fish meat, 20 parts water and 80 parts oil water emulsion and homogenized in a blender for 5 minutes. To the resulting pasty mass add the enzyme stock solution (six parts by weight) and transfer the whole mass into a reaction vessel maintained at 57°C. The hydrolysis is continued for 15 minutes with continuous stirring. After the reaction is over the mixture is heated to 80°C for 12 minutes to deactivate the enzyme. The whole mass is again homogenised in a blender and then rapidly cooked to 5°C. The resulting fish hydrolysate is dried in a spray drier to get a fine powder.

Hydrolysis with papain

Enzyme stock solution

About 25 g of the enzyme is taken in 100 ml distilled water and centrifuged. The clear filtrate is taken.

Hydrolysis

Comminuted fish meat is cooked with water (1:1 w/v) and this process results in the sterilisation of the mixture also. The pH of the mixture is adjusted with acids to 6.5. The mixture is transferred to a reaction vessel maintained at 55°C and the enzyme is added to this mixture (1:30, enzyme nitrogen to protein nitrogen). The whole mixture is stirred vigorously and the hydrolysis is continued for half an hour until it is completed. The hydrolysate is filtered, concentrated and dried under vacuum to get a fine highly hygroscopic powder.

This hydrolysate can be incorporated in a variety of food preparations like soups, beverages etc. to enhance their protein content and thereby enhance nutritive value.

Table 13. Yield of hydrolysate in sampled marine fishes.

Sl. No.	Common name of fish	Species name	Yield of hydrolysate (g/100 g)
1.	Lizard Fish	*Saurida tumbil*	13.3
2.	Large spined flat head	*Platycephalus macracanthus*	11.0
3.	Ribbon fish	*Trichiurus sp.*	9.9
4.	Barracuda	*Sphyraena sp.*	11.9
5.	Jew fish	*Johnius sp.*	9.9
6.	Threadfin bream	*Nemipterus japonicus*	12.0
7.	Cat fish	*Taehysurus sp.*	10.9
8.	Anchovies	*Thrissocles sp.*	9.7
9.	Sole	*Cynoglossus sp.*	8.6

Enzyme nitrogen : Substrate nitrogen concentrations 1:3, pH 6.5, temperature 55°C

Protein hydrolysate incorporated beverages

Protein hydrolysates are bitter in taste and as such unpalatable. One of the best ways to make the hydrolysates tasty is to add malt, cocoa, sugar and fat to the hydrolysates and the fortification is spray dried to make it a fine powder which is highly hygroscopic and soluble in water. The formula developed at Central Institute of Fisheries Technology, Cochin is given below :

Recipe	% composition by weight
Fish protein hydrolysate	30
Malt	20
Sugar	20
Milk Powder	10
Fat	05
Cocoa	05

This product is highly acceptable to consumers with acceptability in respect of taste, flavour and odour was 90 percent. The Protein Efficiency Ratio of the product is 2.2 compared to casein (3.7) at 10% level of protein.

Surimi

Surimi is a washed refined fish mince, a wet frozen concentrate of myofilbrillar proteins of fish muscle (Lanier, 1986). The process of production and machineries of surimi plants are well documented (Gopakumar K., 1997).

Fish mince is the raw material for production of surimi. Freshness of the raw-material essentially determines the quality of surimi. The fish mince is thoroughly, washed to be free of water soluble proteins, pigments and lipids, leaving a protein concentrate, chiefly myofibrillar proteins, having excellent tensile strength and elasticity. To improve the stability and functional properties, additives like polyphosphate, sodium chloride, starch etc. are added to washed fish mince. The flow diagram for production of surimi is given below :

Raw fish	→	Washing (5.10°C)	→	Heading and gutting	→
Washing	→	Minced Fish	→	Dewatering 5-10°C	→
Washing (5-10°C)	→	Dewatering	→	Straining and debydration	→
Polyphosphate, Sugar, Salt, Stand	→	Blending	→	Stuffing -40°C, plate freezer	→
Freezing	→	Packing	→	-30oC Storage	

Figure 1. Flow diagram of Surimi Production.

Surimi from bycatches :

Surimi is usually prepared from Alaska pollack *(Theragra chalcograma)*. The reduced availability of this fish led the users now to turn their attention to non-traditional fish resources. Properties of surimi prepared from five important species are given below :

The capacity of gel-formation and water retention were seen quite good for all and the surimi prepared from bycatches were of high quality, especially lizard fish and threadfin bream both of which are now used for surimi production in India.

Table 14. Properties of surimi from five species of bycatches.

Properties	**Barracuda**	**Thread fin-bream**	**Ribbon Fish**	**Kalava**	**Lizard fish**
Fish Mince colour	Pale Brown	Light Pink	Dull white	Light Pink	Dull White
Yield of mince	41 ± 8.2	38 ± 2.5	34 ± 5.2	35 ± 5.3	45 ± 7.2
Yield of surimi	25 ± 7.8	24.4 ± 2.3	22 ± 4.1	26.9 ± 3.2	30.0 ± 4.5
Water retention of surimi on cooking	86.2 ± 8.3	94.49 ± 0.55	91.8 ± 1	82.5 ± .25	91.8 ± 1.3
Gel Strength g/cm	685 ± 19.7	746 ± 18.2	725 ± 39.2	630 ± 39.2	730 ± 55.1

Mean Value ± SD (n=5) Ref. Muraleedharan, et al (1997)

PRODUCT FROM WHOLE FISH

Fish Pickles

Pickle is a delicacy in many Asian countries. In India pickles made from mango and lime are very popular and consumed by all sectors. Fish pickles are also very popular and a variety of methods are available in India from traditional process to industrial methods. India today exports large quantities of fish pickles to the Middle East and other parts of the world to cater to the needs of people of Indian origin. Pickles are exported in sealed glass or plastic bottles with a net content of around 500 g. During 1996-97 India exported pickles valued Rs. 1.8 million and this market is steadily expanding (Anon 1998). Low-value fish like threadfin bream, scianeids, mackerel, perches etc. are ideal raw materials for the preparation of fish pickles.

Recipe :

Fish : *(dressed and cut into small pieces)*	1 Kg
Mustard seed:	10 g.
Green chilly *(cut into pieces)*:	50 g.
Garlic *(peeled)*:	80 g.
Ginger *(peeled and chipped)*:	80 g.
Chilly powder:	35 g.
Turmeric powder:	2 g.
Gingelly oil:	200 g.
Vinegar:	400 ml.
Salt:	100 g.
Sugar:	10 g.

Preparation:

Fillet the fish and remove the skin. Cut them into small pieces. Small sized species like anchoviella can be used as such after washing and cleaning. Mix with salt in the ratio 1:1 (w/w) and keep for 2-3 hours. Fry the fish in a minimum quantity of vegetable oil of choice like refined peanut oil, olive oil, palm oil, cotton seed oil etc.

All other ingredients, except turmeric and chilly powder, are gently fried in the same oil, in the frying pan used for frying the fish. Turmeric and chilly powder are then added followed by the fried fish. Mix well and add sufficient quantity of boiled and cooled water just to cover the materials. If saltiness is not sufficient more salt should be added. Cool the contents and pack in airtight glass bottles. Acid resistant pilfer proof caps are used to seal the bottle.

Aging: Aging of pickle is very important. Aging for 2 to 3 months add new flavour and impart the traditional taste to fish pickles. In commercial process, pickles are prepared in large quantities and kept packed in large ceramic vats. They are then repacked into consumer packs based on market demands.

Shelf life	***:***	***One year under tropical conditions***
Storage	***:***	***Ambient temperatures***

Fish cutlet or cakes

This is a product, which can be prepared from whole fish or fish mince. Fish cutlet is a highly acceptable consumer product both for urban & rural people. They can be flash fried and kept stored upto 6 months.

Recipe

	Wt. in gm.
Minced meat (raw):	1000
Cooked, peeled potatoes:	300
Peeled chopped onions:	150
Common salt:	30
Ginger pieces:	15
Green chillies chopped:	10
Pepper powder:	2
Clove powder:	2
Turmeric powder:	2
Refined vegetable oil:	100 ml.

Preparation

Cook the fish and separate the meat. Cook the potatoes and peel and mash them. Add the cooked fish mince, salt and turmeric powder and other ingredients and then soft fry in a frying pan using vegetable oil. This may be added to the potato-fish mix and mix well. If spicy cutlets are to be prepared add spice mix at this stage and mix well. Mould 40 g. mix into round shape of around 2 cm thickness. They are then dipped in batter and rolled over bread-crumbs. The battered and breaded fish cutlets are flash fried in vegetable oil maintained at 160°-170°C for five seconds. They are then packed in consumer packets and kept stored under –20°C. Cutlets are to be deep fried prior to consuming.

Storage life : 6 months at –20°C

Fish soup powder

White flesh of many low value fish like threadfin bream, sciaenids, perches etc. can be used to prepare instant fish soup powder. This product has a high consumer acceptability and is now produced in India by several manufactures. Incidentally it is a high value item for the urban population. A common recipe is given below:

Recipe

	Parts by weight
Picked fish meat:	1500
Chopped onions:	1500
Hydrogenated vegetable oil:	200
Common salt:	340
Coriander powder:	35
Cassava starch:	500
Milk powder:	200
Sucrose/glucose:	45
Pepper powder:	36
Garlic:	10
Ascorbic acid:	3
Carboxymethyl cellulose:	6
Monosodium glutamate:	20

Preparation of Soup :

Take 15gm in a vessel. Add sufficient water to make a fine paste. Add 150ml water. Boil for two to three minutes. Serve hot.

Fresh fish
↓
Cook in boiling water --- remove bones and scales
↓
Cooked fish meat
↓
Add fried onions (brown)

↓
Grind to a fine paste
|
| All other ingredients
| (except milk powder)
↓
Grind for five minutes
↓
Spread to a thin layer
|
70°C
↓
Dry under vacuum
↓
Pulverise
↓
Sieve
↓
Mix with milk powder
↓
Pack

Packing *:Laminated pouches*
Shelf Life: *One year at ambient temperatures*

Figure 2. Preparation of fish soup powder.

Fish flakes :

Cooked fish meat or cooked fish mince is used for preparation of flakes. Flakes are to be fried in oil prior to use.

Recipe

Ingredients	Components by weight
Cooked fish meat	2
Corn starch	1
Cassava starch	2
Common Salt	0.05
Water	3.5
Total	8.85

How to use :

The flakes are to be fried in vegetable oil kept heated around 160-170°C. They swell to two to three times its initial volume. They are very crisp and delicious to eat. If dried at high temperature above 60°C. they lose their capacity to swell and become hard on frying. Spices can be added in the final stage of processing to make it appealing to the consumers.

Cooked Fish meat

| Add water (1:1 w/v)
| 30 min.

↓

Homogenize

↓

Fine Paste

|

Add starch, salt, water

↓

Homogenize

↓

Fine Paste

↓

Spread into layers in a tray (1-2 mm)

↓

Cooked under steam

↓

Gelatinized transparent layer

↓

cut of shape

↓

Dry at 60°C/sun

↓

Dried Flakes

↓

Pack

Figure 3. Preparation of Fish flakes.

Fish sauces :

Fermented fishery products are very popular in South east Asian countries. Among them fish sauce is most popular. Fish sauces are a delicacy in countries like Thailand, Vietnam, Philippines, Hongkong, China etc. They are called by different names. Some of the common fish sauces are listed below :

China	Yu-lu
Vietnam	Nuoc-mam
Malaysia	Budu
Thailand	Nam pla
Philippines	Patis
Japan	Shottu suru

Fish sauce is a heavily salted liquid product having salt content varying from 20 to 30 percent depending upon the method and source of preparation. Sauce manufacturing is highly modernized and the whole processing of packing and filling are automated.

Fish + Salt
3 : 1
↓
Mixing
↓
Cured fish ----> *Fermentation*
↓
Agitation
↓
Filtration -----> Residue used for fish paste
↓
Fish sauce
↓
Packing in bottles
↓
Storage

Figure 4. Preparation of sauce preparation.

Fish sauces have a developed market and they are also exported to Europe and America. The technology is very simple. It is one of the best ways of using low-value bycatches.

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