PM Formalisation of
Micro Food Processing Enterprises (PM-FME) Scheme

Online Training of Master Trainers

HANDBOOK OF
Fish and Marine Products Processing

AATMANIRBHAR BHARAT

Organised by

ICAR - CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY

Indian Council of Agricultural Research
(Ministry of Agriculture & Farmers Welfare, Govt of India)
Matsyapuri P.O., Willingdon Island, Kochi - 682029, Kerala, India

In collaboration with

Indian Institute of Food Processing Technology

TRAINING OF MASTER TRAINERS
ON
FISH AND MARINE PRODUCTS PROCESSING

(4-8 January, 2021)

Under Prime Minister Formalization of Micro Food Processing Enterprises

Course Director

Dr. K. Ashok Kumar

Principal Scientist & Head, FP Division

Course Coordinators

Dr. George Ninan, Principal Scientist, Fish Processing Division
Dr Bindu J., Principal Scientist, Fish Processing Division

Course Co Coordinators

Dr. C.O. Mohan, Sr Scientist, Fish Processing Division
Dr Elavarasan K., Scientist, Fish Processing Division
Dr. Sreejith S., Scientist, Fish Processing Division
Dr. Sreelakshmi K. R., Scientist, Fish Processing Division

Organized by

ICAR - Central Institute of Fisheries Technology
(Indian Council of Agricultural Research)
Willingdon Island, Matsyapuri P.O.,
Cochin-682 029, Kerala, India

In collaboration with

Indian Institute of Food Processing Technology (IIFPT)
Ministry of Food Processing Industries (MoFPI),
Government of India
Pudukkottai Road, Thanjavur – 613005

Published by:
Director, ICAR-CIFT, Cochin-29

Compiled and Edited:
Dr. C.O. Mohan
Dr Elavarasan K.
Dr. Sreejith S.
Dr. Sreelakshmi K. R.

For citing the book:
Mohan, C. O., Elavarasan, K., Sreejith, S. and Sreelakshmi, K. R. (eds) (2021) Fish and Marine Products Processing, Central institute of Fisheries Technology, Cochin, India.

Example for citing a chapter in the book:
Mohan, C. O. (2021). Thermal processing of fish *In:* Mohan, C. O., Elavarasan, K., Sreejith, S. and Sreelakshmi, K. R. (eds) (2021) Fish and Marine Products Processing, Central institute of Fisheries Technology, Cochin, India pp. 81-91

FOREWORD

Fisheries is considered to be the ‘sunrise sector’ and is playing a significant role in increasing the food supply, generating job opportunities, raising nutritional level and earning foreign exchange. India is bestowed with a huge water resources and a variety of aquatic fauna and flora. This creates a huge opportunity to exploit these resources for domestic consumption as well as for expanding export market. Globally, the demand for fish is on rise due to its health benefits. Good handling practices, modern technological advancements in preservation and packaging techniques are necessary from the time of catch till it reaches the end user to prevent the spoilage and to retain the health benefits of this valuable commodity. Imparting technical know-how in setting up fish processing units, providing guidelines regarding the requirements of various regulatory bodies, updating information regarding markets and the technical skills can inculcate confidence in the entrepreneurs. Disseminating the technical knowledge to the different classes of population for attaining larger socio-economic goals is of the prime importance in today’s scenario.

The five day “Online Training of Master Trainers (ToMT) on Fish and Marine Products Processing" – under Capacity Building Component of PM Formalization of Micro Food Processing Enterprises (PMFME) Scheme of Ministry of Food Processing Industries, Government of India, assumes a greater importance as the technical expertise developed over many decades by the institute could be shared with researchers, trainers and extension officials of the country. I believe this training program will play an important role in disseminating knowledge to the master trainers which in turn will be transferred to the micro food processors, entrepreneur and other related stakeholders of the fisheries sector

Course content for this training program were carefully selected to give a complete know-how and comprehensive knowledge on areas like fish supply chain, design and regulatory requirements of fish processing units, fish handling practices, processing and preservation techniques, value addition, safety and quality assurance in fish and marine products processing. Waste management and its utilization strategies for the development of high value byproducts along with entrepreneurship development aspects are also covered. I congratulate the collaborating institute, Indian Institute Food Processing Technology, Thanjavur (IIFPT), for choosing an apt topic to accelerate the growth of fisheries sector. I compliment Head, Fish Processing Division, course coordinators, faculties and all the staff who are involved in this training program. I compliment the training coordinators who have taken keen interest in preparing this manual. I am sure that this training manual will be very useful for the trainees and other stakeholders involved in fisheries sector.

Dr. Ravishankar, C N
Director
ICAR-Central Institute of Fisheries Technology

Chapter 1

Overview of PMFME scheme

Dr. Sinija
Professor and Head, Food Processing Business Incubation Center, IIFPT
Email: sinija@iifpt.edu.in

Background

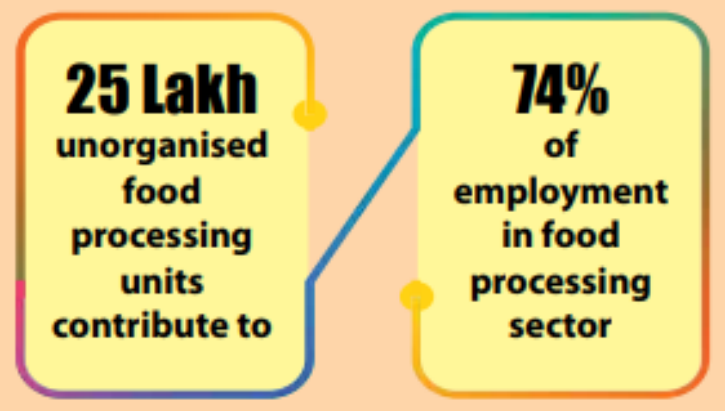
1.1 The unorganized food processing sector comprising nearly 25 lakh units contributes to 74% of employment in food processing sector. Nearly 66% of these units are located in rural areas and about 80% of them are family based enterprises supporting livelihood in rural household and minimizing their migration to urban areas. These units largely fall within the category of micro enterprises.

1.2 These units face a number of challenges which limit their performance and growth. These challenges include lack of access to modern technology and equipment, training, access to institutional credit, lack of basic awareness on quality control of products, and lack of branding & marketing skills, etc. Therefore, the unorganised food processing sector contributes much less in terms of value addition and output despite its huge potential.

2. Objectives

2.1 Taking cognizance of the contribution of the unorganized micro food processing enterprises and the challenges that impede their performance, Ministry of Food Processing Industries (MoFPI) has launched "PM Formalisation of Micro Food Processing Enterprises Scheme (PM FME Scheme)" through a package support and services. The objectives under the scheme, inter alia, include:

i. Capacity building of entrepreneurs through technical knowledge, skill training and hand holding support services;
ii. Increased access to credit to existing micro food processing entrepreneurs for technology up gradation;
iii. Support to Farmer Producer Organizations (FPOs), Self Help Groups (SHGs), Producers Cooperatives & Cooperative Societies along their entire value chain to enable microenterprises to avail common services.
iv. Support for transition of existing enterprises into formal framework for registration under regulatory framework and compliance;
v. Integration with organized supply chain by strengthening branding & marketing;

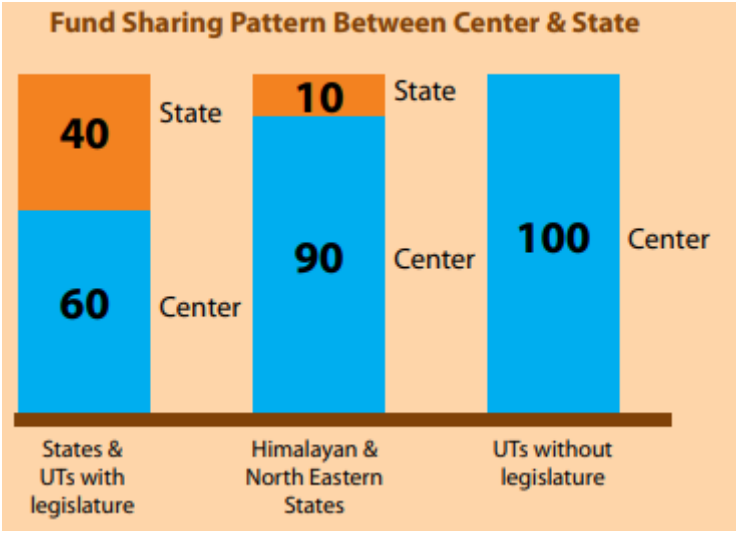


3. Coverage of States/ UTs and Funding Pattern

3.1 It is an All India Centrally Sponsored Scheme with an outlay of Rs. 10,000 crore for coverage of 2,00,000 enterprises over 5 years from 2020-21 to 2024-25. The expenditure under the scheme would be shared in 60:40 ratio between Central and State Governments, in 90:10 ratio with North Eastern and Himalayan States, 60:40 ratio with UTs with legislature and 100% by Centre for other UTs.

3.2 Expenditure in the first year 2020-21, whether incurred by the Centre or the States would be borne 100% by the Central Government. The expenditure made for the first year would be adjusted in ratio given above in the funds being transferred to the States equally in the next four years.

3.3 Funds under the Scheme would be provided to the States based on the approved Project Implementation Plan (PIP).



4. One District-One Product Approach

4.1 The Scheme will adopt a One District One Product (ODOP) approach to reap benefit of scale in terms of procurement of inputs, availing common services and marketing of products. One District One Product approach would provide framework for value chain development and alignment of support infrastructure. There may be more than one cluster for one product in one district. A cluster may also extend beyond one district. The States would identify food product for a district, keeping in perspective the focus of the scheme on perishables. The ODOP could be a perishable agri-produce, cereal based product or a food product widely produced in a district and their allied sectors. Illustrative list of such products includes mango, potato, litchi, tomato, tapioca, kinnu, bhujia, petha, papad, pickle, millet based products, fisheries, poultry, meat as well as animal feed among others. With respect to support to existing individual micro units, preference would be given to those producing under ODOP approach. However, units producing other products would also be supported. In case of groups, predominately, those involved in products under ODOP approach would be supported. Support to groups processing other products in such districts would only be for those already processing those products and with adequate technical, financial and entrepreneurial strength. Support for common infrastructure and marketing & branding would only be for products under ODOP approach. In case of support for marketing & branding at State or regional level, same product of districts not having that product as ODOP could also be included.

4.2 The scheme would also support strengthening of backward and forward linkages, provision of common facilities, incubation centres, training, R&D, marketing & branding, provision of which would primarily be for ODOP products. Further, this approach would also complement and benefit from the existing promotional efforts of the Government such as development of Agriculture Crop Clusters under the Agriculture Export Policy, the cluster approaches of the Ministry of Agriculture and the Ministry of Rural Development through the National Rurban Mission.

5. Support to Food Processing Units

Support to food processing units would be provided for the following:

i. Credit linked grant at 35% of the project cost with maximum grant up to Rs 10.0 lakh to existing unorganised food processing units for upgradation;
ii. Credit linked grant at 35% of the project cost to SHGs/FPOs/cooperatives for capital expenditure with maximum limit as prescribed;
iii. Seed capital @ Rs. 40,000/- per member to those engaged in food processing as a working capital;
iv. Credit linked grant at 35% of the project cost for common infrastructure with maximum limit as prescribed;
v. Support for marketing & branding up to 50% of the expenditure with maximum limit as prescribed.

6. Upgradation of Processing Units

6.1 Individual Category:

Individual micro food processing units would be extended credit-linked capital subsidy @35% of the eligible project cost for expansion/ technology upgradation with a maximum ceiling of Rs.10 lakh per unit. The beneficiary contribution should be minimum 10% and the balance should be loan from a Bank.

6.1.1 Eligibility criteria:

i. Individual / Partnership Firm with ownership right of the enterprise;
ii. Existing micro food processing units in the survey or verified by the Resource Person;
iii. The applicant should be above 18 years of age and should possess at least VIII standard pass educational qualification;
iv. Only one person from one family is eligible for obtaining financial assistance. The "family" for this purpose would include self, spouse and children.

6.1.2 Procedure for applying for upgradation:

6.1.2.1 Applications would be invited at the district level on an ongoing basis for units interested in availing the benefits under the Scheme. Existing food processing units desiring to seek assistance under the scheme should apply on the FME portal. Loan proposals would be recommended to the Banks after scrutiny. States would decide the appropriate level for short listing of the applications to be recommended to the Banks.

6.1.3 Procedure with Banks for Grant:

6.1.3.1 At the national level, a Nodal bank would be appointed for disbursement of subsidy to the banks and liaison with the banks extending loan to the beneficiaries. The bank sanctioning the loan would open a mirror account in the name of the beneficiary. Grant by the Central and State Government in 60:40 ratio would be deposited in this account of beneficiary in the lending bank branch by the State and Central Government. If after a period of three years from the disbursement of last tranche of the loan, the beneficiary account is still standard and the unit is operational, this amount would be adjusted in the bank account of beneficiary. Release of grant for groups and common infrastructure would also be done in their bank account following the same principle.

6.2 Group Category: The Scheme would provide support in clusters to groups such as FPOs/ SHGs/ producer cooperatives along their entire value chain. SHGs / FPOs / Producer Cooperatives would be provided the following support:-

i. Grant @35% with credit linkage for capital investment with maximum limit as prescribed;
ii. Training support;
iii. Support for marketing and branding for products under ODOP for developing common brand.

6.2.1 Eligibility Criteria:

i. It should be engaged in processing of ODOP produce for at least three years;
ii. In case of FPOs / cooperatives, they should have minimum turnover of Rs.1 crore and the cost of the project proposed should not be larger than the present turnover;
iii. The SHG / cooperative / FPO should have sufficient internal resources to meet 10% of the project cost and margin money for working capital.

6.3. Seed Capital to SHG:

The scheme envisages provision of Seed Capital @ Rs. 40,000/- per member of SHG engaged in food processing for working capital and purchase of small tools. Seed capital as grant would be provided at the federation level of SHGs which, in turn, will be extended to members as loan through SHG.

6.3.1 Eligibility criteria:

6.3.1.1 For Seed Capital, only SHG members who are presently engaged in food processing would be eligible. The SHG member has to commit to utilize this amount for working capital as well as purchase of small tools and give a commitment in this regard to the SHG and SHG federation.

7. Creation of Common Infrastructure

7.1 FPOs/ SHGs/ Producer Cooperatives /State agencies or private enterprises would be supported for creation of common infrastructure including for common processing facility, incubation centre, laboratory, warehouse, cold storage, etc. Eligibility of a project under this category would be decided

8. Branding and Marketing Support

8.1 Marketing and branding support will be provided to FPOs/SHGs/Cooperatives or an SPV of micro food processing enterprises under the scheme following the cluster approach for developing common packaging & branding with provision for quality control, standardization and adhering to food safety parameters for consumer retail sale.

8.2 Support for Marketing and Branding requires a minimum volume which can be generated through active involvement of FPO/ SHG/ Cooperatives to bring large number of producers together. These organisations would be supported based on DPR prepared by them indicating essential details of the project. Support up to Rs.5 lakh would be available from State Nodal Agency for preparing DPR for proposals for branding & marketing.

8.3 Support for branding and marketing would be limited to 50% of the total expenditure with maximum limit as prescribed. Proposal from states or national level institutions or organizations or partner institutions for branding & marketing will be supported for vertical products at the national level. No support would be provided for opening retail outlets under the scheme.

8.4 Procedure for Applying for Support:

8.4.1 In case of SHGs/FPOs/cooperatives or SPV interested in applying for support for branding and marketing under the Scheme, DPR should be prepared and submitted to State Nodal Agency (SNA). SNA would appraise the proposal and with recommendation from the State Level Approval Committee (SLAC) seek approval from MOFPI. Thereafter, the proposal would be recommended to a Bank for sanction of loan. Same procedure should be followed for applying for support for creation of common infrastructure as well.

9. Capacity Building & Research

9.1 Training is a critical component in technical up gradation and formalization of micro food processing enterprises. All individuals & institutions members receiving grant would undergo training for upgradation of their skills. In addition, training support would also be provided to other existing individual units and groups producing ODOP product in the district, even if they are not being supported through credit linked grant. Training support would also be provided for units that are part of support for Marketing & Branding or have potential to join such network.

9.2 National Institute for Food Technology Entrepreneurship and Management (NIFTEM) and Indian Institute of Food Processing Technology (IIFPT), two national level food processing technology institutions under MOFPI are given responsibility to spearhead capacity building and research. At the State level, they would partner with a State Level Technology Institution in food processing technology selected by the State Government for conducting capacity building and training.

9.3 Training to individual and group beneficiaries will focus on entrepreneurship development, essential functions of enterprise operations, book keeping, registration, FSSAI standards, Udyog Aadhar, GST Registration, general hygiene, packaging, marketing etc. Specific training designed on the model of ODOP and the vertical focus products will be undertaken nearer to the work place of the entrepreneurs. Existing infrastructure of Rural Self Employment Training Institutes (RSETI) and other institutions at the district level will be utilized for imparting training.

10. Partner Institutions

10.1 The scheme lays special focus on SCs/STs, women and aspirational districts and FPOs, SHGs and producer cooperatives. TRIFED, National SC Development Finance Corporation, NCDC, Small Farmer Agri-Business Consortium (SFAC) and National

Rural Livelihood Mission under Ministry of Rural Development have been working in these areas. The above institutions may converge their activities by facilitating identification of units / clusters of STs, SCs, cooperatives, FPOs and SHGs respectively and feed this into state PIPs.

11. Implementation & Monitoring Mechanism

11.1 The Scheme will have the following management structure at the Central, State and District level for eff ective implementation and monitoring of the scheme:

11.2 Inter-Ministerial Empowered Committee (IMEC): IMEC at the Central level, will be chaired by Minister for Food Processing Industries (MoFPI) for general superintendence, guidance and overall direction for implementation of the scheme, monitoring of progress and reviewing its performance. IMEC will approve scheme guidelines, Project Implementation Plan (PIP) of the State/ UTs under the scheme and various projects of capital investment by SHGs/FPOs/ cooperatives, common infrastructure facilities and proposals of marketing & branding for project size above Rs 10 lakh. A Project Executive Committee (PEC) will be constituted in MoFPI for

undertaking administrative function and regular monitoring of the scheme at operational level. A National Programme Management Unit (NPMU) will be set up to assist MoFPI to provide secretarial, managerial and implementation support.

11.3 State Level: State Governments would appoint a Nodal Department and a State Nodal officer to oversee the implementation of the Scheme. The Scheme will be implemented by a State Nodal Agency (SNA) assisted by the State PMU. A State Level Approval Committee chaired by the Chief Secretary will oversee the implementation of the Scheme. The Committee will sanction expenditure up to Rs 10 lakh on various activities related to the implementation of the scheme. A District Level Committee (DLC) would be constituted under the Chairmanship of District Collector.

11.4 District Resources Persons (DRPs) would be appointed by SNA for providing handholding support to the beneficiaries. Handholding support would be for preparation of DPR, taking bank loan, support for obtaining necessary registration and licences including food standards of FSSAI, Udyog Aadhar, GST etc.

12. Studies & Reports

12.1 State Governments should undertake the following studies:

I. Base-Line Assessments: A baseline study should be undertaken to identifying ODOP. This study should get concluded by 31 July, 2020 in each State. For this study, Rs. 2.5 – 10.0 lakh would be provided to the States.

II. State Level Upgradation Plan(SLUP): Once decision is taken on the ODOP, detailed studies should be carried out in the States detailing the number of units undertaking processing of that product in the district, farm level of operations, total volume and value of produce, technology, farm gate level processing, storage, warehousing, etc. This study should be concluded by 31 December, 2020. The amount provided for the above study would be Rs. 25.0 – 75.0 lakh to States.

13. Detailed Guidelines

Detailed guidelines of the scheme may be view at Ministry's website mofpi.nic.in

Chapter 2

Status, market size and scope of fish and marine food processing industry in India

Dr. M. Karthikeyan
Director, Marine Products Export Developmental Authority, Kochi
karthikeyan@mpeda.gov.in

Functions of MPEDA

Export Promotion

- Registration of entities (exporters, processing units, storages, handling centres etc)
- Export certifications (Catch certification, DS 2031 etc)
- Market promotion (Fair participation, BSM, trade delegation) & assistance schemes
- Capacity building of value chain (value addition, regulations, HACCP , BMPs)

Aquaculture

- Enrolment of farms / hatcheries
- Demonstration programmes / technology transfer on diversified aquaculture
- Financial assistance schemes
- SHAPHARI – certification of hatcheries & farms; launched pilot scheme for hatcheries

Quality Control

- Operation of QC and ELISA labs (NRCP, PHT) – NABL accredited & EIC approved
- Quality monitoring of processing units

Societies of MPEDA

RGCA

- R & D arm - promotes diversified aquaculture Cobia, mud crab, GIFT, Seabass
- Operates AQF, NABL accredited Aquaculture Genetics and Pathology lab, Multispecies Aquaculture Complex, BMC for vannamei
- Proposes NBC for vannamei, BMC for Black Tiger

NaCSA

- Promotes cluster farming
- Support farmers to follow BMPs / BAPs

- Operates AOCs
- E-SANTA : proposed e- commerce platform to connect farmers & exporters

NETFISH

- Capacity building of fishers and fish processing workers on fish quality management
- Capacity building on resource conservation & sustainable fishing.
- Support for catch documentation

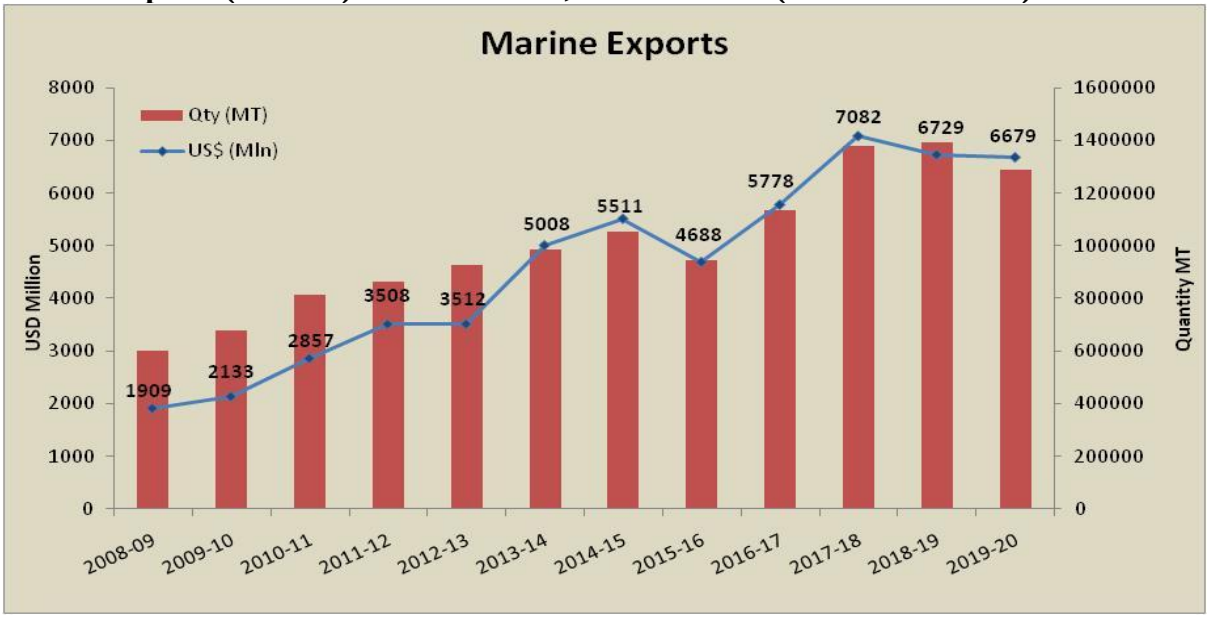
Seafood Export Scenario

- 3rd largest producer of fish in the world.
- 2nd largest aquaculture producer after China.
- 4th largest exporter of marine products
- Exporting to > 120 countries
- Seafood sector contributes 1.1% of GDP and 5.15% of Agriculture GDP
- World seafood trade - current level 4% CAGR

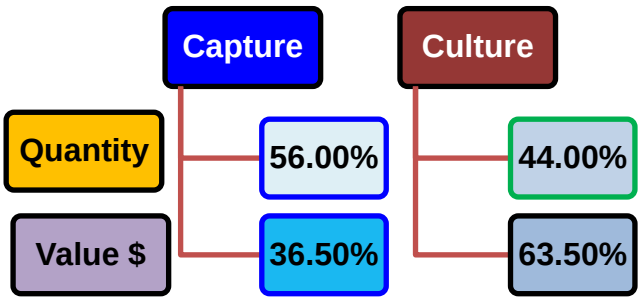
Rank	Country	Exports (USD bln)	% share
1	China	25.00	15.53
2	Norway	12.10	7.51
3	Vietnam	7.70	4.78
4	India	7.00	4.35
5	Chile	6.80	4.22
6	EU	6.50	4.04
7	USA	6.10	3.79
8	Thailand	6.00	3.73
9	Canada	5.40	3.35
10	Ecuador	5.00	3.11
	Others	73.40	45.59
	Total	161.00	100.00

Seafood Export Trend

- **Exports (2019-20): 12.9 lakh MT ; Rs. 46663 Cr. (US $ 6. 68 Billion)**



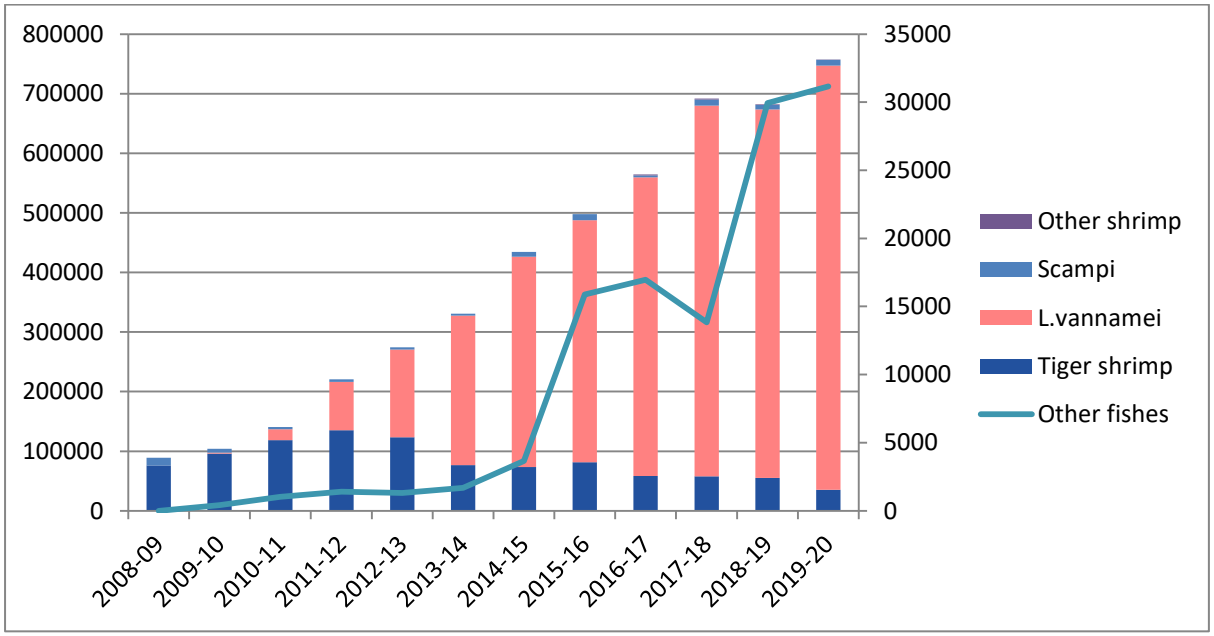
Share of Capture and Culture in Exports



Major species groups contributing to exports

Item	Species groups
Shrimp	Vannamei shrimp, Black Tiger shrimp, white shrimp, Flower shrimp, Brown & pink shrimps, Scampi
Fish	Ribbon fish, Croakers, Threadfin breams, Mackerel, Tuna, Pomfret, Grouper, Marlins etc.
Cephalopods	Squid, Cuttlefish, Octopus
Other species	Clams, lobsters, crabs, Whelks etc.

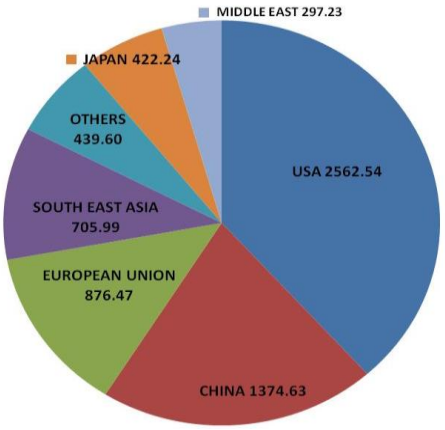
Export Oriented Aquaculture production



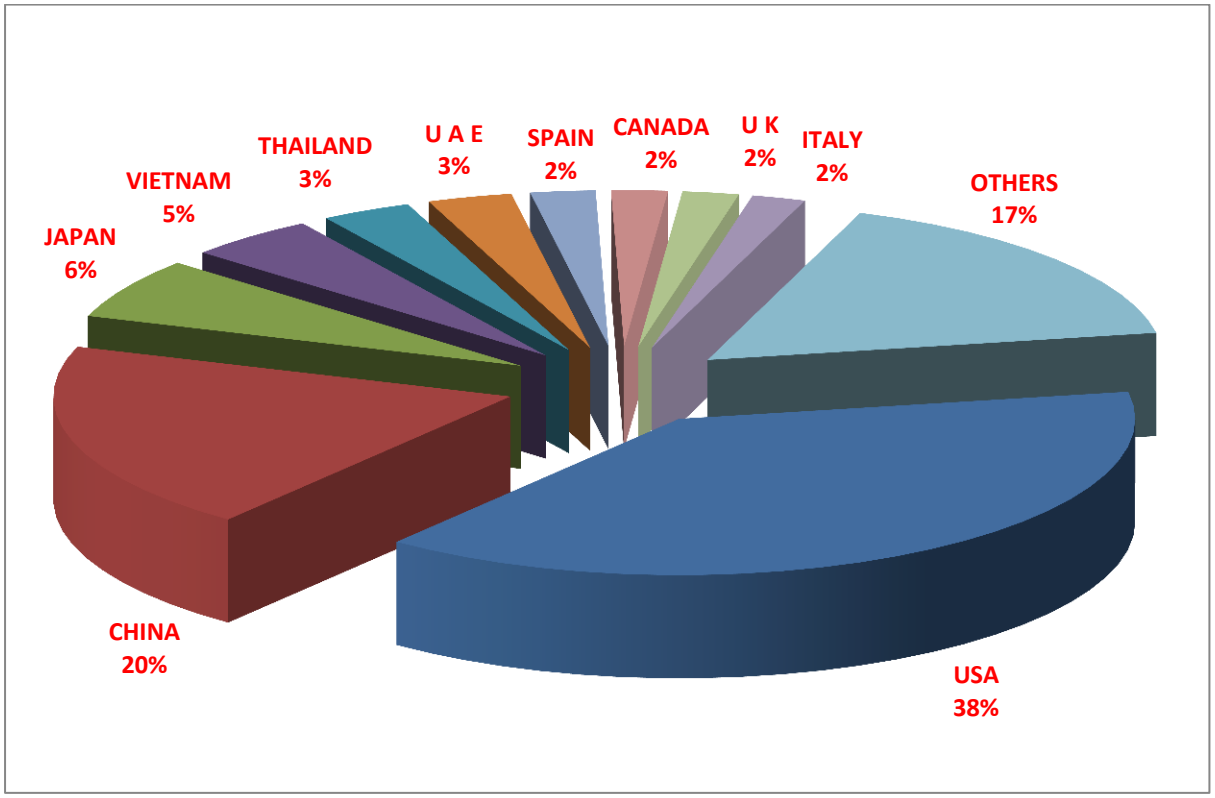
Export processing infrastructure in India

Facilities	Number /Capacity
Registered exporters	1476
Manufacturer Exporters	655
Total seafood processing plants	617
EU approved units	341
Non-EU units	276
Total installed capacity (MT/day)	34368 MT
Frozen Storages (MT)	388257.38 (Cold Storage) Nos.: 650

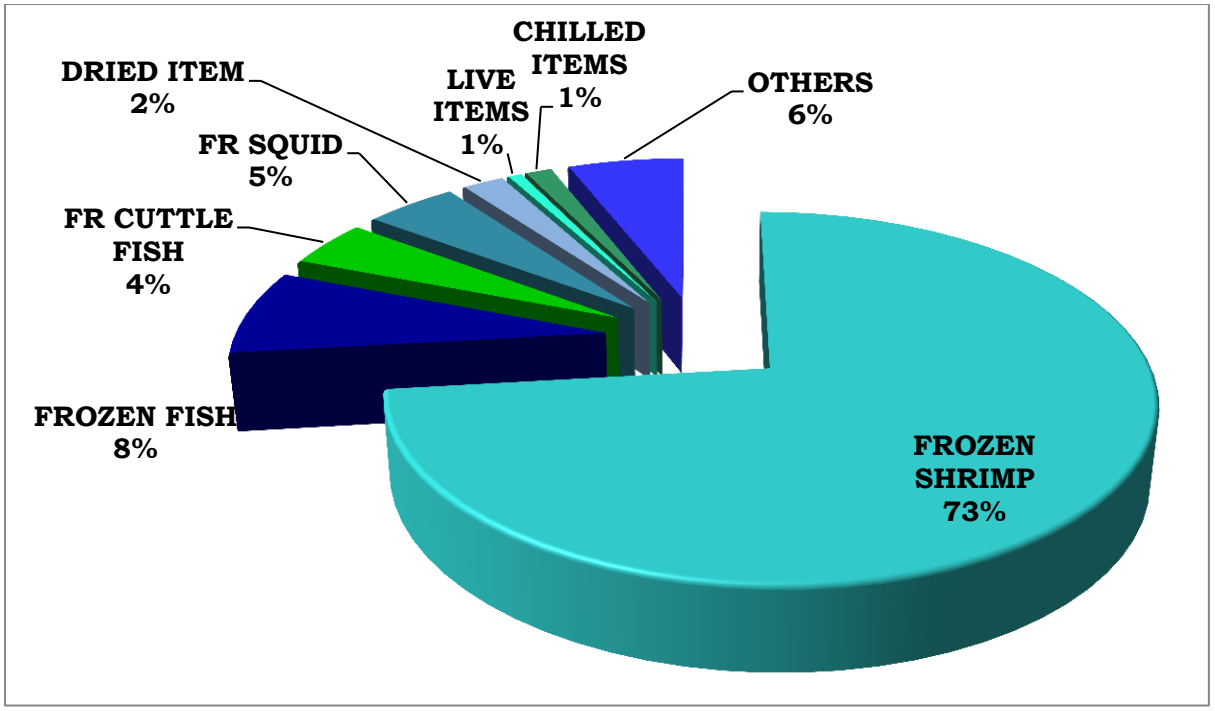
2019-20: Market Wise Seafood Export (USD Million)



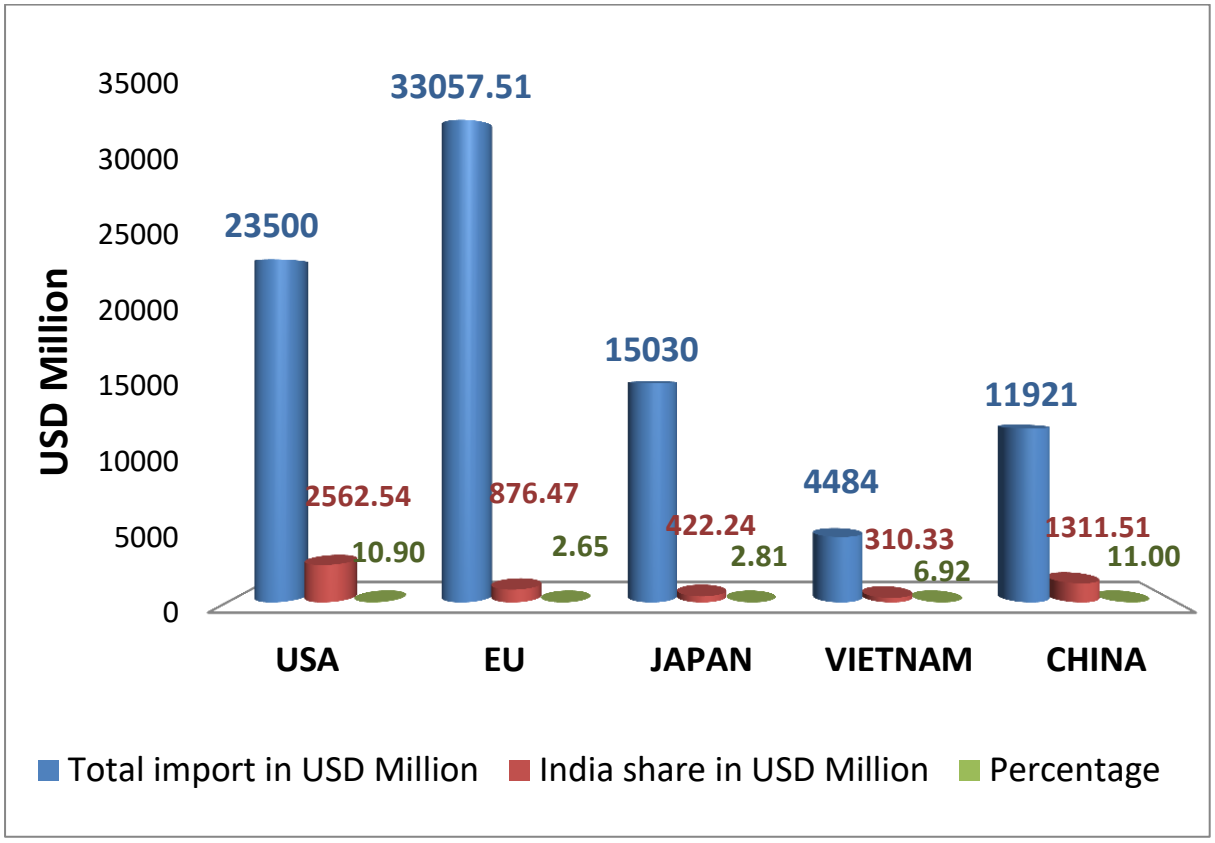
83% ($) of India's Seafood Export goes to 10 countries

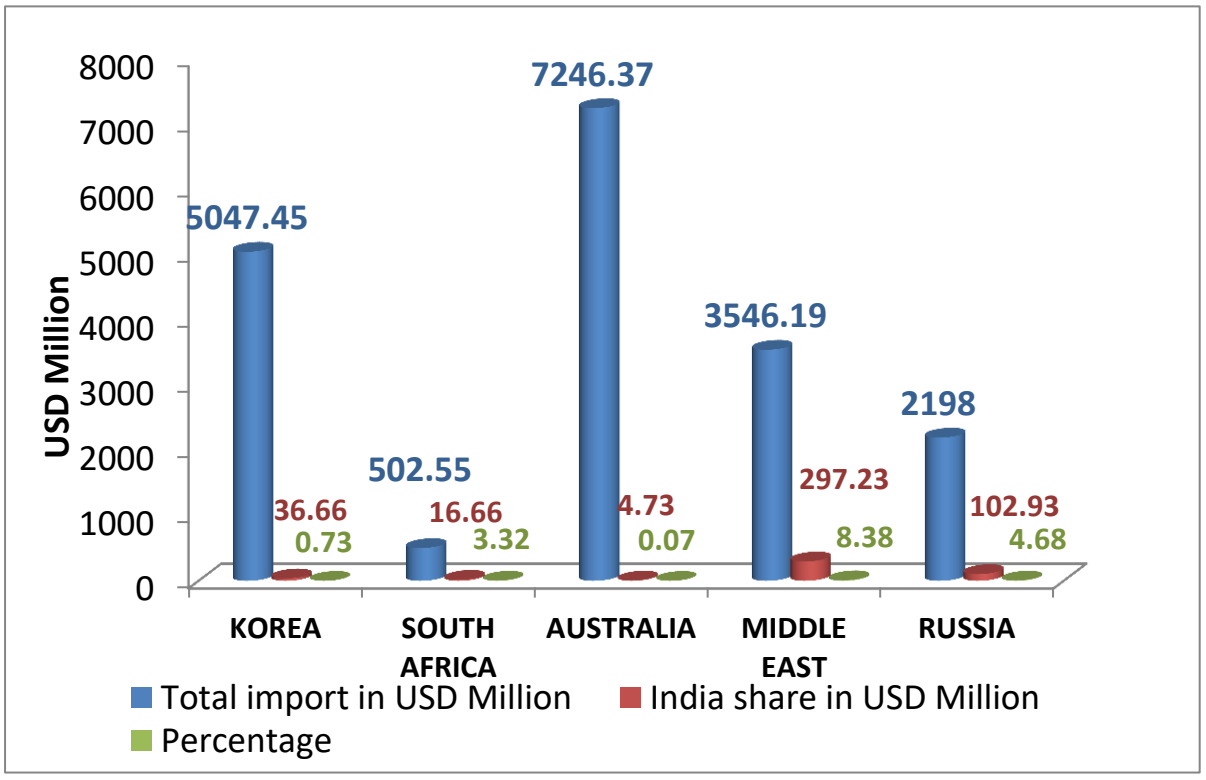


Item-wise share in export value 2019-20 (USD Mln)



Scope for increasing market share





Additional 5% share in these markets will increase exports by $ 6 billion to reach total $ 13 billion (~ Rs. 1 lakh Cr.)

MARKET CONCEPTS DRIVING INTERNATIONAL SEAFOOD TRADE

IUU fishing

- ***Illegal, Unreported, Unregulated fishing***
  - *Sourcing of fish by unlicensed fishing vessels, without following national / international regulations*
  - *No reporting of the catch*
  - *Affecting the legal sourcing and traceability of the harvest.*

- India needs to complies regulations such as Catch certification (EU), Seafood Import Monitoring Programme (USA), ICCAT document (Countries in Atlantic / Pacific) on IUU fishing.

- MPEDA undertakes online Catch certification including vessel –wise landing data collection to fulfil the requirements; and urge the coastal states to enforce the provisions of MFR Acts.

Traceability

- Major markets demand traceability from farm to fork or from boat to plate.
- Market requirements such as Seafood Import Monitoring Programme (SIMP) - USA, Catch certification (EU), and private certifications demand traceability up to fishing vessel or farm.
- MPEDA implements on line catch certification system and also enrols aqua farms with geo coordinates to ensure the traceability,

Quality

- Food safety is of high concern in most of the markets – and non-compliances invite alerts /consignment rejections / increased inspections, and import bans.
- Regulations on zero tolerance to banned antibiotic substances, MRLs heavy metals, bacterial and toxic contaminants etc. are in place in every market.
- MPEDA has set up QC and ELISA labs to test seafood, undertakes Pre Harvest testing of farmed shrimps for antibiotics, NRCP and MPRNL to monitor contaminants, assist to improve cold chain, and also capacity building to eliminate the use of banned antibiotics.

Sustainability

- Refers to responsible sourcing - with minimal environmental, social & resource impact.
- International regulations such as –US Sec 609 on Sea Turtles, US Marine Mammal Protection Act (MMPA), EU Catch certification, US SIMP, biosecurity regulations in China, Australia, Korea etc. and private certifications aim toward sustainability also.
- MPEDA issues DS 2031 certificate, recommended stock assessment of marine mammals, enrols aqua farms, collects catch data, supports fisheries sector on By catch reduction & to earn sustainable certification.

Trade barriers

Country	Issue	Barrier	Impact	Actions
USA	***US Presidential Task Force on IUU fishing & seafood fraud***	• Seafood Import Monitoring Program, - imported seafood shall show the source information w. e. f. 1st Jan 2018.	Exports from unregistered / non enrolled farms are affected.	• Enrolment of entities • Catch certification
	Marine Mammals Protection Act 2016	• Import of fish caught in commercial fisheries resulting in the accidental killing or serious injury of marine mammals in excess of United States standards from 01.01.2022.	Ban on all wild caught seafood (Rs. 2200 Cr./ USD 322 million)	MPEDA filed an interim progress reports & recommended stock assessment study of Marine Mammals in Indian seas. Regular studies to be undertaken
	Certification of Shrimp harvesting nations under Section 609 of US Public Law 101-162	Indian wild caught shrimps are not permitted as our harvest methods harm sea turtles.	Ban on all wild caught seafood (Rs. 2200 Cr./ USD 322 million)	• visit of US inspection team to survey or shrimp harvesting systems. Turtle Excluder Devices (TED) to be installed in trawl nets and use of gears like trammel net shall be stopped.
EU	**Antibiotic residue in farmed shrimps**	• increase in testing from 10% to 50% • De-listing of 14 establishments in 2016-17	• Exports loss - Rs. 1000 Cr • Unable to increase market share from 10% of 8 lakh MT	• Follow up in bilateral meetings (JWG)\ • NRCP • Pre Export Test • Pre Harvest

		• No new units are given approvals.	potential	Tests.
China	**Presence of shrimp pathogens in farmed shrimps**	• Chinese Customs rejects shrimp cargo due to presence of pathogens mainly White Spot Syndrome Virus (WSSV).	• Suspended imports from certain exporters detected with WSSV. • Not able to tap huge potential market	• Delegation visited China • Bilateral negotiations • To have more testing labs
Japan	**100% Compulsory inspection of Indian farmed Shrimps for antibiotic residues**	• Stringent norms like EU	• Adds to the cost on shrimp export trade. • Gives competitive edge to other nations	• Got a reduction in sampling frequency for Black Tiger shrimp from 100% to 30% w.e.f. April 2020. • Field level measures to reduce antibiotic usage in shrimp farming and stringent monitoring in *vannamei* farms.
Saudi Arabia, Kuwait, Australia, Canada, Korea and Thailand	**Presence of pathogens in shrimp**	• Restriction on raw shrimp imports from India due to presence of shrimp pathogens	• Loss in market potential	• Follow up with through Indian Missions

ANTIBIOTIC REJECTIONS IN MAJOR MARKETS

Year	Rejections								
	EU		USA		Japan		Total		% share of antibiotic rejections
	Total	Antibiotic	Total	Antibiotic	Total	Antibiotic	Total	Antibiotic	
2015	17	5	43	15	9	7	69	27	39
2016	27	5	61	28	3	3	91	36	40
2017	39	15	47	3	7	6	93	24	26
2018	37	13	52	8	5	4	94	25	27
2019	11	4	30	6	5	5	46	15	33
2020*	13	4	21	6	4	4	38	14	37

MPEDA Quality Control Labs

1. Kochi (Kerala) – Established in 1976 as in-plant inspection lab & further upgraded in 2003
2. Bhimavaram (AP) – Established in 2004
3. Nellore (AP) – Established in 2004
4. Bhubaneswar (Odisha) – Established in 2006
5. Porbandar (Gujarat)- Established in 2020

Quality Control – Laboratory Division

Activities:

1. National Residue Control Plan (NRCP)
2. Pre-Harvest Testing (PHT)
3. Monitoring of Pesticide Residues at National Level (MPRNL)

MISSION 2030

Export scenario - 2030

- At the current level of 4% CAGR - USD 11 billion
- At 8.33% CAGR – USD 17.8 billion

Investment required:

- Rs. 42,755 Cr. *(with Rs. 18023 Cr. Govt. Assistance)*

Interventions proposed

a. Capture Fisheries
b. Aquaculture
c. Quality Assurance
d. Value Addition
e. Brand Promotion

Interventions Envisaged

Capture fisheries	Aquaculture	Quality assurance	Value addition	Brand Promotion
• Stagnated marine catch • Increase unit value by quality improvement ✓ **upgrading the handling facilities in major fishing harbours** ✓ **upgrading the handling facilities onboard fishing vessels**. • Promote deep sea fishing to harness oceanic resources.	• The only scope for increasing export oriented aquaculture production. • Strategy ✓ **expansion of area** (from 1.34 lakh Ha to 2.50 lakh Ha) ✓ **increase in productivity** (from 5 MT to 10 MT/Ha) ✓ **diversification of aquaculture species** (Seabass, Tilapia, Mud crab etc).	• Setting up of more advanced laboratories to monitor and test chemical hazards and pathogens	• Current share of value added products in our exports- 6% (Thailand - 64%; China – 40%; Vietnam - 26%) • Facilitate import of raw material by simplification of SIP	• Market and brand promotion efforts; strengthening of MPEDA network.

Interventions taken by MPEDA during the COVID

- Brought out Covid-19 Guidelines for Seafood Sector to minimise the disease risk while handling seafood at various level in the stakeholder chain right from production to exports
- Organized a trainer's training programme for its field officers on the Covid-19 guidelines for seafood sector.
- Online issue of export certificates such as CoO, DS 2031, Catch certificate etc.
- The certificates of registration of exporters were renewed online, and facilitated endorsement of processing tie up agreements between exporters and processing units online
- Interventions in trade issues faced by exporters in markets such as Vietnam, US, EU, Indonesia. Middle East etc.
- Operated all MPEDA labs to test raw material
- Intervened to facilitate movement of labour, raw material and finished goods.
- Operation of AQF to facilitate import of brooders to ensure seed availability.
- Organized a series of Webinars on the market prospects of major markets such as USA, China, Japan, Spain, Singapore etc. and virtual Buyer Seller meets to benefit the exporters
- Brought out a promotional film for the international buyers that covers the precautionary measures adopted by the value chain to alleviate COVID19 related risks

Market	Issues
USA	• Food Service Segments (restaurants /hotels), constituting 70% of seafood consumption is largely closed / offer only takeaways. • Strong sales reported in supermarkets /retail segment.
China	• Delayed cargo clearance (upto 14 days) as consignments are cleared after covid-19 tests • 27 swab samples taken for Covid-19 test from each container. • Payment realized only after Covid-19 test clearance. • Demand is expected to pick up by November end in view of Chinese new year.
EU	• Demand is sluggish as food service segment is opening up slowly.
Japan	• Demand is sluggish as hospitality sector demand remains low. • Japan market may see recovery by end of the year.

Investment opportunity in Aquaculture and Seafood processing in India

- 100% FDI is permitted under the automatic route in aquaculture and seafood processing industry.
- **Entry Route-Automatic Route:** the non-resident investor or the Indian company does not require any approval from Government of India for the investment.

Factors supporting investment in seafood sector in India

- Availability of raw material resources for value addition.
- Strong production base in shrimp aquaculture.
- Large number of processing facilities matching with international standards.
- India is one of the largest producer of shrimp and major supplier of cephalopods in the world.
- Availability of potential areas for aquaculture and mariculture.
- Excess capacity for processing.
- Availability of sea port and airport connectivity.
- Consumer preference for convenient products.
- Availability of technically qualified man power.

References

- **https://mpeda.gov.in/**
- **Annual reports of MPEDA**

Chapter 3

Fish supply chain in India

Dr. Nikita Gopal
Principal Scientist, EIS Division, ICAR-CIFT
Email: nikiajith@gmail.com

Fish is one of the most traded commodities globally, and India is one of the largest producer and exporters of fish. Its global contribution to production in 2018-19 was 7.58% Fish also contributes 1.24% to India's Gross Value Added (GVA) and 7.28% (2018-19) to the agricultural GVA. Fisheries also contribute significantly to food and nutritional security, as well as livelihood and employment generation. Aquaculture also happens to be one of the fastest growing food production systems in the country. The average annual growth rate of fisheries sector over 2014-15 to 2018-19 has been 10.88%. The exports stood at 13.93 lakh metric tonnes bringing in Rs. 46589 crore in 2018-19.

Much of the fish traded globally is from the poorer to the richer countries. There is also is significant domestic trade in most fish producing countries and a significant fish eating population in them. The supply chains in fisheries are often thus complex.

A supply chain, sometimes called a value chain, can be defined as a set of producers, manufacturers, intermediaries, traders, processors, retailers, consumers and/ or any other companies, organizations or entities directly connected by one or more inward and outward flows of products, services, finances, or information from a source to a customer. **Supply chain management** is the efficient coordination, utilization and management of the components of such a chain for maximizing value or/and minimizing the costs. Supply chain management can be defined as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally

While the focus of supply chains is the customer, supply chain management makes it happen and is a process that covers and includes the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes coordination and collaboration with channel partners, which may be suppliers, intermediaries, third-party service providers, or customers. Supply chain management integrates supply and demand management within and across companies.

Supply chain management addresses the following problems:

- Configuration and designing of distribution networks.
- Formulation of procurement, production and distribution strategies.
- Logistics decisions.
- Obtaining, processing and utilizing information to make informed decisions.
- Inventory management
- Panning Cash flows.

Globalization, sustainability and supply chains:

With the increased globalization of business, the globalization era, Supply chains have expanded over national boundaries and into other continents. Since the late 1980s, a considerable number of organizations started to integrate global sources into their core business. Now organizations have to work with the goal of increasing their competitive advantage, adding value, and reducing costs through global sourcing.

Thus, it has become important for companies to understand socio economic, political, environmental and cultural factors to add value to their businesses. International price fluctuations, demand and supply analysis, currency fluctuations, sustainability issues and governmental policies have become key factors in the planning and managing of global supply chains.

Consumers have become more aware of the environmental impact of their purchases and companies' , along with non-governmental organizations (NGOs), are setting the agenda for transitions to organically grown foods, anti-sweatshop labour codes, and locally produced goods that support independent and small businesses. Because supply chains may account for over 75% of a company's carbon footprint, many organizations are exploring ways to reduce this and make supply chains more sustainable.

Fish supply chains

A fish supply chain can be described as a set of independent fishers, agents, processors, distributors, and wholesalers/retailers/food services who work together to supply a fish or derived product to the consumer. No individual organization or entity within the fish supply chain is independent. They are interlinked because actions taken by one member of the supply chain can affect, improve or disturb the complete chain and also the livelihoods of fishermen who have fishing as their primary source of income. Fish supply chains have high variation based on factors like fish species and products, harvesting techniques, end users apart from differences in socio economic, environmental and cultural differences among different countries and regions.

Fish supply chains in India can be focussed on the domestic consumer or the export markets.

Different factors that influence fish supply chain:

- Product and country of origin.
- Final destination of the product (Domestic consumption or export)
- Intermediary processes required like peeling, cleaning, smoking, pickling, salting, canning, breading, cooking etc.
- Integration of different links within the supply chain.
- Harvesting techniques.

We could also include production system as a factor as we have two broad systems – capture which is based entirely on wild catching and aquaculture which is akin to farming.

Main problems in achieving efficiency:

- Difficulties in procuring and assembling from different production sites.
- Wide variation in prices and arrivals location wise and time wise.

- Restricted entry into auctioning and whole sale trading.
- Changing consumer preferences in export domestic markets.
- Lack of forecasting mechanisms.
- Lack of proper roads and transportation facilities.
- Structural inefficiencies: This includes the current method of dividing the activities of the supply chain into multiple roles results in fish preservation and handling practices that are based on antiquated cold storage technology. Other issues are indirect quality accountability for fishers, price bullying on the part of processors, staggering waste and financial losses for processors and distributors when flows of supply and demand for fresh fish are not synchronized.
- Disempowered/Poor/Small scale or individual Fishers
- *Traceability Roadblocks:* While all parties in the supply chain agree that traceability is critical for ensuring sustainability, preventing fraud, and ensuring food safety, yet it is not a common practice for accurate data about species, origin, or catch method to accompany a fish through the supply chain. Traceability is now being increasingly stressed as importing countries insist on this and attempts are being made to put systems in place by agencies like MPEDA. Many current realities prevent players from easily sharing information, investing in enabling services and systems, or creating simple, affordable verification systems in a practical way—particularly because the return on these activities is sometimes unclear. An approach that removes key barriers for individuals at all levels of the supply chain can drive more widespread adoption of methods that support traceability as the industry standard.

Quality and other factors influencing Fish Supply Chain

As a raw product, fish is a fresh and perishable and must be delivered to the consumer or the processor in the shortest time span. The factors of high perishability and concerns about quality, quality assurance mechanisms become important. Quality issues reflect not only on freshness, taste, colour, smell, method of harvest, how the fish is handled after landing, and timeliness of delivery.

Suppliers of fish products to the retail sector are small, individual or exporting companies. Food market is now dominated by giant retailers operating in several countries with strict quality, and labelling requirements. Volatility in international markets in terms of supply, demand and prices, problems and standards of traceability of products from origin to end user and variation in quality pose additional problems.

However, labelling and traceability become a problem in capture fishing or marine fisheries. It is quite difficult to tag wild fish at birth. Processed fish products can be labelled easily and can provide quality assurance to the consumer. Thus, different policy initiatives associated with establishing and enforcing quality parameters and standards, initiatives of NGOs like Greenpeace, measures taken by retailers like Wal Mart, ASDA, and Carrefour will be discussed.

Role of Retail chains and key factors influencing and impacting the supply chain of fish

In traditional fisheries economics papers the price is assumed to be exogenous or given (read fixed). In such situation, one need not have much concern with the market. However, the seafood market is highly segmented. Hence, even if the price is exogenous, it matters which market one is targeting. Seafood supply chains have traditionally consisted of many independent. In the past few years, the seafood market and the supply chains for seafood are changing rapidly due to globalization, rise in aquaculture and changes in retail

chains. The COVID-19 pandemic has added another dimension in showing how vulnerable the supply chains actually are as the adjustments needed to meet the shifting consumer demand were tricky and complicated.

Increasing control with the production process in aquaculture leads to productivity growth and market development. Between 1970 and early 2000s, the share of aquaculture in the total supply of seafood has grown 8 times in many countries. New technologies have led to an enormous increase in production. More than 60% of fish exported is now from the aquaculture sector and its contribution to fish production in the country is also increasing, while capture fisheries has plateaued.

Transformation of the seafood market with retail chains

Globalization increases the opportunity for those who are competitive. Seafood supply in the EU, Japan and US is increasing because these markets have the highest ability to pay. Improved logistics and transportation makes these markets increasingly accessible for producers from all over the world. Supply used to be local and regional, now it is increasingly global. Supply has also become more concentrated. Between 1987 and 2005 the top six seafood products went from accounting for 60.1% to 80.3% of total US seafood consumption. The farmed species in the top six have also increased from being only shrimp in 1987 to shrimp, salmon, catfish and Tilapia in 2005.

The retailing sector and logistics are also seeing rapid changes. Retail chains allow for economies of scale and scope in marketing, retailing, logistics and distribution. Very few seasonal products and small scale suppliers get access to the shelves because of higher cost. In most European countries retail chains make up more than 80% of retail sales. Because of this, Traditional outlets like fish mongers disappear

The retail chains are demanding customers

I. Price:

(a) Price level, (b) linkage to market prices, (b) quantity discounts.

II. Volume and timing:

(a) Total volume; (b) regularity of deliveries; (c) flexibility in deliveries;
e.g. in relation to ‘normal’ volumes and times of delivery.

III. Raw material attributes:

(a) Size distribution, e.g. fillets, (b) quality attributes, e.g. colour, fat, texture, taste, (c) fresh vs. frozen, (d) uniform quality, (e) shelf life.

IV. Product range and differentiation:

(a) Fish species, (b) Product varieties, e.g. easy-to-cook, ethnic foods, healthy foods, (c) private labels / brands, (d) consumer advertising.

V. Production process:

(a) Raw materials in feed, (b) environmental effects of production, (c) animal welfare, (d) third party certification, e.g. ISO, EMAS, (e) traceability.

VI. Transaction costs:

(a) Negotiation, (b) planning, (c) control and enforcement, (d) transportation, (e) storage

Industrial buyers also give importance to factors like volume, timing and frequency, flexibility, cost efficiency in distribution and food safety.

The set of extra services and requirements imposed by retailers and industrial customers increase the complexity of the composite product that a supplier is providing and makes it more challenging to manage the supply chain.

Other issues related to fish supply chain

1. Problem of collapsing fish stocks in marine fisheries

The fish and fish products sector is facing the problem of fish stocks collapsing or depleting rapidly. The primary reason for this is the unsustainable consumption and production patterns like increasing levels of consumption, over fishing, excessive aquaculture, and climate change, urbanization of coasts and destruction of biodiversity among the species.

The causes of this problem are lack of ecosystem based approach leading to over fishing, subsidy policies of different governments, unsustainable fishing practices, and IUU fishing.

2. Differences between supply chain issues in sea food commodities

There are two popular product preparations in fish products. And both these types require different strategies at every step of the supply chain.

- Fresh and frozen fillets.
- Prepared and preserved fish.

Frozen and fresh fish fillets are the second largest category of seafood traded globally after shrimp. This includes products like cod, salmon and trout. The most important of prepared and preserved fish is tuna. Tuna is the 3rd most valuable traded seafood and majority of internationally traded tuna is canned. The world's largest exporters of tuna sources most of its tuna from Indian and pacific oceans as chilled domestic fish or frozen chilled fish. Once caught, the fish is sold by tuna trading companies who sell it to tuna processors. Trading companies coordinate trans-shipment onto reefer carriers from multiple vessels and offer volume and continuity of supply to processors as well as economies of scale to vessels owners. The raw fish is selected and after precooking with white meat is sent for human consumption or pet food. After further processing the tuna meat is canned. In tuna sector, many of the processors are contracted and never actually own the fish. Tuna trading companies play a central role in supply, procurement and onward sale of canned tuna.

3. Policy issues that influence fish supply chain:

- International trade policies with specific emphasis on WTO, USFDA regulations, European Union standards etc. and how they influence Indian business.
- Issues like mercury contamination in Tuna.
- Environmental policies and sustainable aquaculture.

4. Wastage in fish supply chain

Waste arises in the supply chain from fishing, aquaculture, processing, transportation, retail, and foodservice and consumer waste. The aim of differentiating between unavoidable waste and avoidable waste, which could potentially be prevented, many fish species contains a high proportion of nonedible components, which must be removed at some point within the supply

chain. It must be noted that in many supply chains this non-edible material is a valuable co product, which is utilized by the fishmeal industry and therefore is not considered to be a waste.

One major reason for wastage is discards. The reasons for discarding fall into two main categories, either what has been caught has little or no market value, or the fish are discarded because of management regulations (like the ban on landing of juveniles sometimes having legal implications). The levels of these discards can vary widely between fisheries. Some fisheries discard very little whilst others discard more than they retain. Some discards are not problematic, as in some cases the fish can be returned to the sea and survive; for example crabs, lobsters, sole, plaice and dogfish all have high survival rates. Otherwise discards account for a large amount of the waste of the fishery resource. To reduce discards, measures should be implemented like improvements to the design of fishing gear in order to minimize the catch of prohibited or unwanted fish, introduction of innovative conservation measures.

Domestic channels of fish supply

A significant proportion of fish caught in the country is traded internally. While the traditional channels still continue to throve, there are also innovations in the same in recent years. The traditional channels include direct selling from the producer to the consumer as well as selling thorough a series of intermediaries that could include the commission agent to wholesaler to big and small retailers. The longer chains are more prominent in the capture sector. The new innovations include online buying and selling, which is an increasing phenomenon in the urban areas. The product profiles have also undergoing changes with cleaned fish being more preferred than whole fish even in the domestic market. Increasing consumer awareness on quality is also a factor that needs to be taken care of.

Fish supply chains are similar to other supply chains in its main components but the intricacies differ due to the inherent characteristics of the product and the length and complexity of the chains. The logistics of the domestic and export trade are different and need to be differently addressed.

References

- https://cscmp.org
- Hines, T., 2004. Supply Chain Strategies: Customer-driven and Customer-focused, published by Butterworth-Heinemann, pp.395
- Future of Fish. Making Sense of Wild Seafood Supply Chains. A report created for The Nature Conservancy. 2015

Chapter 4

Design and layout of Fish Processing Units

Dr. Ashok Kumar K
Principal Scientist, Fish Processing Division,
ICAR-CIFT, Cochin 682029

Manufacture of products, which are safe and of high quality is the aim for any food manufacturer. The products made should be traceable and free from contamination of any kind. It is in this context that the designing of a food manufacturing plant assumes importance. The Codex Alimentarius Commission (CAC) defines food hygiene as 'all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain'. Similarly, the EU's General Food Hygiene Directive has defined food hygiene as 'all measures necessary to ensure the safety and wholesomeness of foodstuffs'. The Directive includes all stages of the supply chain in this definition, from harvesting to the point of consumption.

A good plant design is one which has incorporated measures to prevent contamination of the food manufactured there in broad terms, from a physical, microbiological or chemical source, at any stage of production. In the US there is greater focus on the concept of food sanitation defined, for example, as the 'hygienic practices designed to maintain a clean and wholesome environment for food production, preparation and storage. This second definition links hygiene more specifically with maintaining a clean working environment during food processing.

Hygienic plant design

We should always bear in mind that plant is a food processing facility which provides an appropriate environment for processing operations, while ensuring compliance with all applicable building safety and environmental regulations. The design must be legally compliant to all food laws. Layouts, for example, should allow ready access to equipment for installation and both routine and non-routine maintenance. Materials selected should be sufficiently rugged and non-corrosive to withstand wet conditions prevailing inside the plant.

General considerations

The primary aim of hygienic plant design should be to set up effective barriers to all sort of contamination. Contamination includes Biological, chemical and physical. When we design a plant be constructed these concept should be borne in mind to effectively tackle entrance of contaminants. Within a plant itself, there will be areas with differing levels of hygienic requirements. Broadly, these can be classified into three viz. Non-production areas, finished goods handling area and processing area

Non-production areas include office space for management and administrative staff, facilities for production staff such as canteens and rest rooms, car parking and storage facilities, for example. Hygienic design requirements and procedures will be less stringent than in other parts of the plant. Non-production areas must be clearly segregated from production areas so that unauthorised staff, for example, is not allowed to move from one area to the other, contaminating production areas in the process. Toilet and washroom facilities must be sufficient to allow production staff to maintain appropriate levels of personal hygiene. Premises and storage areas must, for example, be designed to be easily maintained, and be kept in good order, if they are not to attract pests and become sources of contamination themselves. Poor hygienic design and operation in this area will increase the contamination 'load' on barriers protecting production areas and make it more likely that they will be breached.

Finished goods handling areas include food processing operations dealing with contaminated product. These include any food components of the final product that have not been decontaminated so that they are effectively free of bacteria prejudicing or reducing the microbiological safety or shelf-life of the finished product.

As an example, the layout of processing areas should be designed on the unidirectional flow principle to prevent cross-contamination. That means the flow should start from the raw material receiving and extend up to the finished products section in a single channel mode Please note that material should not be handled by personnel also handling finished product (except with the appropriate hygiene controls and separation), or allowed to enter high risk areas. Hygienic areas should be designed and constructed for easy cleaning so that high standards of hygiene can be achieved to prevent pathogens.

The final and most stringent level of hygienic design and operation is 'high-risk areas' (HRA). A high-risk area is a well-defined, physically separated part of a factory which is designed and operated specifically to prevent the contamination of ingredients and products after completion processing, assembly and packaging.

The factory site

The management of the premises and site will give us ample opportunity to build up our first line of defence against contamination. The site should ideally be in an area with good air quality, no pollution problems (e.g. from other industrial plants), uncontaminated soil, well-planned and with an ample supply of uncontaminated water. It should be noted that properly maintained landscaping of the grounds can assist in the control of rodents, insects and birds by reducing food supplies and breeding and harbourage sites. Figure 1 shows a layout of a factory with key barriers

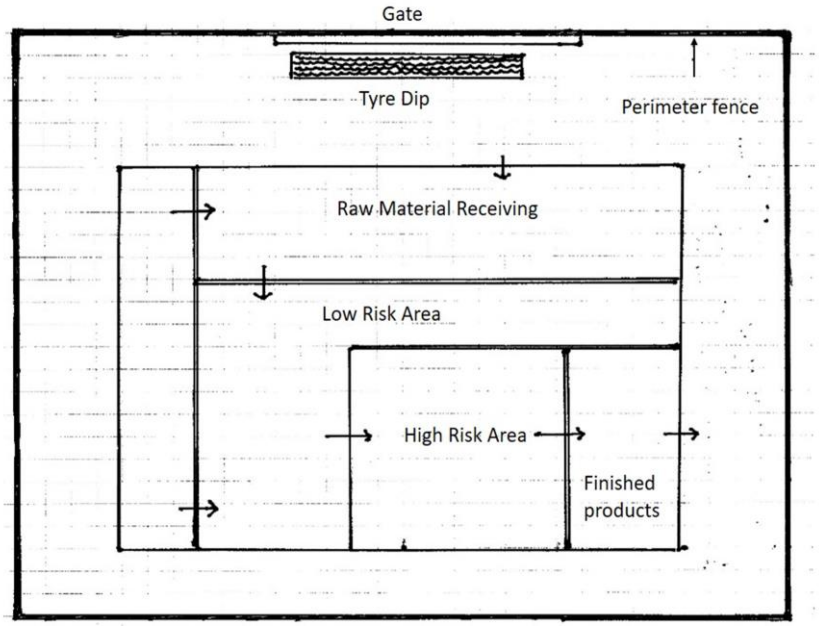


Figure 1: A layout of a factory with key barriers

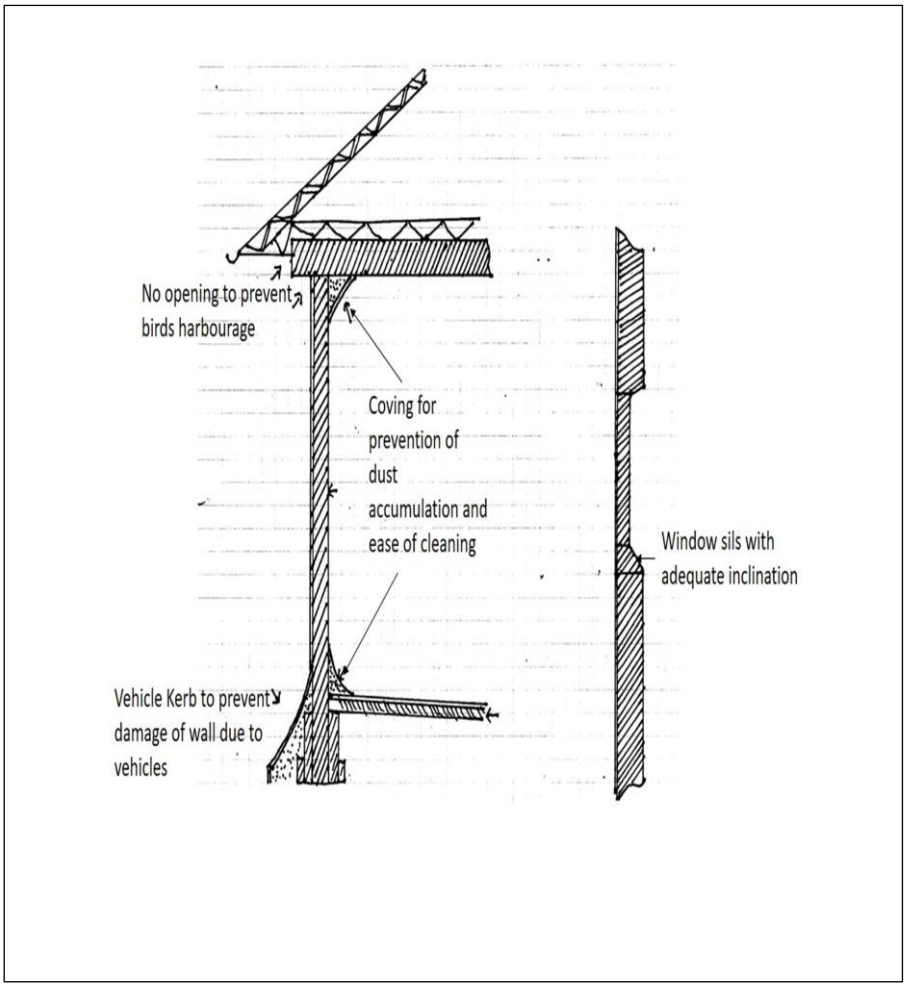
According to European Union guidelines, the area immediately adjacent to buildings be kept free of trees and bushes, and that it also be kept grass-free and preferably concreted, without any water logging. Landscaping and concreting will reduce the dust blown into the factory. Some agencies also recommend a tyre wash system built near the gates to decontaminate the tyres of vehicles brining raw materials and other goods to the factory. Facility to place at least two lines of rodent baits in every 15-20 m of the perimeter, near the entrances and near the foundation walls should be made. Kindly note that these traps should be glue based and crushing type of traps should be avoided.

It is also stressed the importance of ensuring that waste material is not left in uncovered containers and that any spillages of raw material are cleared up promptly so as not to attract birds, animal or insect pests. All areas where water could collect or stand for prolonged periods of time need to be removed or controlled. Experts suggest the use of high pressure sodium vapour lamps instead of mercury lamps to minimise the attracting of flies.

The building

The building is the second major barrier which provides adequate protection for raw materials, processing facilities and manufactured product from contamination or deterioration. The building should have adequate protection from rain, wind, water from surface run off, dust, pests and uninvited people. While designing the factory, consideration also should be given to facilitate installation and maintenance of factory equipment.

All points where cables, drains and services pass through foundation walls and floors must be sealed. Drains and sewers must be proofed and regularly maintained to prevent rodents gaining access and using them as arbourage or as a means of entry to buildings. Any defective drains must be located and repaired. Inspection chambers, covers, hatches and rodding caps must be inspected regularly and all disused lengths of drain either filled with concrete to the connection with the sewer or collapsed and the trench filled with dense hard-core.



Any storm water drains should be protected with top-hung flaps and maintained regularly to remove silt and leaves. Swan neck pipes should be used to prevent rodents from entering and climbing the inside of rainwater pipes at ground level. Roofs should preferably be made of concrete and should be kept in good repair, regularly inspected and any damages should be repaired immediately. It is desirable to have roofs or ceiling washable with electric fittings in flush with it to prevent accumulation of dust above it. Any ventilation or exhaust fan opening should be proofed with 10 mesh steel mesh mounted in a removable frame of metal or PVC to allow regular inspection and cleaning. Exhaust fans should be fitted with shutters which are self-closing when the fan is idle.

In general, openings such as windows and doors should be kept to a minimum. It is a general observation that 'Regardless of the sophistication of the heating, ventilating and air-conditioning systems, there are always those who are uncomfortable with the surrounding temperature conditions and feel the need to open a window or a door.'

Doors should be designed in such a way it can be opened in both ways and should have a kick plate; Door handles should not be present at any cost. The material for window frames should be a low maintenance type such as UPVC or steel. Windows should be provided with Window sills. Internal sills should be sloped (20º–40º) to prevent their use as 'temporary' storage places, with external sills sloped at 60º to prevent birds roosting.

External doors may be one of the following types chosen for its security, hygienic and/or practical application:

- Swing
- Horizontal sliding
- Roller shutter
- Hinged
- Folding sliding
- Vertical sliding.

In all cases, the following design criteria should be met:

- A tight fit is achieved between the door and its frame.
- The correct material is used.
- Each door is self-closing.
- Opening and closing is smooth.
- Surfaces are cleanable.
- Door handles are easily cleaned and do not trap dirt (it is preferable not to have door handles)
- The design is hygienic, having a smooth finish, radiuses edges and minimal seams.

All external doors should be self-closing and fit closely in the opening with no gaps exceeding 6mm and preferably less than 3 mm. All external door frames should be sealed at the junctures with the walls and floors and kept in good repair. Doors should be provided with vision panels, kick plates and push plates.

All doors which have to remain open for entry and/or loading can be proofed by installing heavy duty PVC strip curtains with the correct overlap, as specified by the manufacturers. These type of doors has to be fitted with air curtain outside. The use of air curtains can be effective against insects.

Access to processing areas from outside should be via double doors with an air lock or by use of a lobby with a door at each end

General design issues for the factory interior

The main principles of hygienic design of the interior of a factory unit should be to remove any potential internal sources of contamination and to prevent any external contaminants from accumulating. The first principle can be achieved in a number of ways, including the following:

- Materials in the proximity of food processing operations should be non-toxic.
- Glass, wood and other materials that could present a serious hazard to consumers, if fragments, contaminate food, should be avoided.
- Materials must be durable and able to withstand the operational environment, including extremes in temperature, physical impact vibration, moisture and corrosion from food materials (e.g. those containing organic acids).
- Services such as water or steam should be designed so they do not provide a growth medium for contaminants (e.g. through condensation) or become contaminated themselves.
- The pipe carrying treated water for the processing should be colour coded and should be easily distinguishable from those carrying non potable water.
- No inaccessible areas, cavities or seams where dirt can gather.

- All areas and corners easily accessible for inspection and cleaning.
- Surfaces should flow off (at > 3º) to prevent dirt or fluid accumulating.
- No horizontal surfaces. If there is possibility dirt can gather, a vertical gradient of 45º is recommended with a round or half-round profile. Joints such as welds should be continuous and smooth with the surrounding surface.
- No sharp corners or right-angles. Corners should be radiused with the use of coving.
- Materials should be easily cleaned, smooth and non-porous so that dirt cannot accumulate.

Walls

Hygiene standards for walls as defined in various EC Directives require that they must be constructed of impervious, non-absorbent, washable, non-toxic materials and have smooth crack-free surfaces up to a height appropriate for the operations (Normaly 6-7 ft). For high-risk areas the standard of construction and finish must apply right up to ceiling level. The same hygienic assessment techniques as described for flooring materials are also directly applicable to wall coverings and finishes. Materials need to be resistant to corrosion from food materials (for example those containing organic acids). They should also be resistant to temperatures up to 85ºC.

Modular insulated panels are now used very widely for non-load-bearing walls. The panels are made of a core of insulating material between 50 and 200mm thick, sandwiched between steel sheets, which are bonded to both sides of the core. Careful consideration must be given, not only to the fire retardation of the wall insulation or coating material, but also to the toxicity of the fumes emitted in the event of a fire as these could hamper a fire-fighting operation. The steel cladding is generally slightly ribbed to provide greater rigidity and can be finished with a variety of hygienic surface coatings, ready for use. The modules are designed to lock together and allow a silicone sealant to provide a hygienic seal between the units. The modules can be mounted either directly (in a U shaped channel) onto the floor or on a suitable concrete basement.

The overall shape of the wall is also important. The presence of ledges and similar features (e.g. around windows) can result in a significant hazard as regards accumulation of debris, and this has to be considered at the design stage.

Having installed hygienically suitable floors and walls, it is important that floor-to-wall, wall-to-wall and wall-to-ceiling joints are hygienically constructed. Covings should provide an easily cleaned surface at wall, floor and ceiling junctions. A 50mm radius curve is generally considered to be large enough to enable easy cleaning (although extra consideration will have to be made to prevent damage from moving traffic such as trolleys and fork-lift trucks).

Ceilings

Ceilings should be smooth with no seams. Seams should be sealed. If the ceiling is suspended the space above the ceiling should be accessible and cleanable. A minimum clearance of 1.5m is advisable to allow access. Suspended ceilings can be constructed using suitable load-bearing insulation panels or suspending sections of insulated panels, as used for the internal walls, from the structural frame of the building. Cables may be run in trunking or conduit but this must be effectively sealed against the ingress of vermin and water. All switchgear and controls, other than emergency stop buttons, should, whenever possible, be

sited in separate rooms away from processing areas, particularly if wet operations are taking place.

Lighting may be a combination of both natural and artificial. Artificial lighting has many advantages in that, if properly arranged, it provides illumination over inspection belts and a minimum of 500–600 lux is recommended. Fluorescent tubes and lamps must be protected by shields, usually of polycarbonate, to protect the glass and contain it in the event of breakage. Suspended units should be smooth, easily cleanable and designed to the appropriate standards to prevent the ingress of water.

Floors

The floor in a food factory forms the basis of the entire processing operation, and a failure in the floor often results in lengthy disruptions of production and financial loss while repairs are carried out. Unsatisfactory floors increase the chances of accidents, cause difficulties in attaining required hygiene standards and increase sanitation costs. Both its physical durability and hygienic qualities have to be considered. The overall design of the floor must be such that it can be effectively cleaned and disinfected, is safe in use (e.g. antislip) and that it is stable under these cleaning regimes and to normal processing activities (i.e. does not begin to disintegrate, which may result in microbial or physical contamination of the food being processed). A further aspect that needs to be considered is whether the proposed floor meets legislative requirements.

Floors should be ‘waterproof’ or ‘impervious’ and ‘cleanable’. Water uptake is unacceptable because if fluids are able to penetrate into flooring materials, microorganisms can be transported to harbourage sites that are impossible to chemically clean and disinfect. When considering the selection of flooring materials, therefore, evidence for imperviousness and ease of cleaning should be sought. The floor should be coved where it meets walls or other vertical surfaces such as plinths or columns as this facilitates cleaning. As part of the design of floors, allowance has to be made for adequate drainage of water – that is, the physical shape of the floor should allow water to drain away easily. A slope (or ‘fall’) of 1 in 60 is normally adequate; 1in 40 may be required for floors that are habitually very wet, whilst 1 in 80 may be sufficient for normally dry tiled.

Drainage

The drainage is often neglected and badly constructed. Detailed consideration of the drainage requirements is an important aspect of floor design. Ideally, the layout and siting of production equipment should be finalised before the floor is designed to ensure that discharges can be fed directly into drains. In practice, this is not always possible, and in the food industry in particular there is a greater chance that the layout of lines will be frequently changed. Equipment should not be located directly over drainage channels as this may restrict access for cleaning. Discharges from equipment, however, should be fed directly into drains to avoid floor flooding. Alternatively, a low wall may be built around the equipment from which water and solids may be drained. Where the channels are close to a wall they should not be directly against it to avoid flooding of the wall-to-floor junction.

Satisfactory drainage can be achieved only if adequate falls to drainage points are provided. A number of factors should be taken into consideration when establishing the drainage system.

- *Volume of water:* wet processes require a greater fall.

- *Floor finish:* trowelled resin surface finishes require a greater fall than self-levelling ones. Otherwise 'puddles' created by small depressions in the surface may remain.
- *Safety:* falls greater than 1 in 40 may introduce operator safety hazards and also cause problems with wheeled vehicles.

The type of drain used depends to a great extent upon the process operation involved. For operations involving a considerable amount of water and solids, channel drains are often the most suitable. For operations generating volumes of water but with little solids, aperture channel drains are more favourable. In most cases, channels should have a fall of at least 1 in 100, have round bottoms and not be deeper than 150mm for ease of cleaning.

They must be provided with gratings for safety reasons. The channel gratings must be easily removable, with wide apertures (20mm minimum) to allow solids to enter the drain. In recent years there has been a marked increase in the use of corrosion resistant materials of construction, such as stainless steel for drain gratings.

The drainage system should flow in the reverse direction of production (i.e. from high to low risk) and, whenever possible, backflow from low-risk to high risk areas should be impossible.

Solids must be separated from liquids as soon as possible, by screening (with, for example, removable sediment baskets), to avoid leaching and subsequent high effluent concentrations. Traps should be easily accessible, frequently emptied and preferably outside the processing area.

Services

Hygienic building design must take account of service equipment such as pipework for water, eliminates a major source of contamination from the process area. Service pipes should be routed outside the process area and pass through walls local to their point of usage. Where this is not possible, services should be grouped 50mm apart on a stainless steel structure around the plant with minimum support rackets to walls or plant.

Overhead pipes should not pass over open vessels or production lines. This is to prevent dripping of condensation droplets, which may form if the pipes are above a process area, and contamination from leakage, lagging, flaking paint or dust. Services should not be positioned too closely to walls and floors in production areas and should have a minimum 50mm clearance to allow for cleaning, inspection, maintenance and repair.

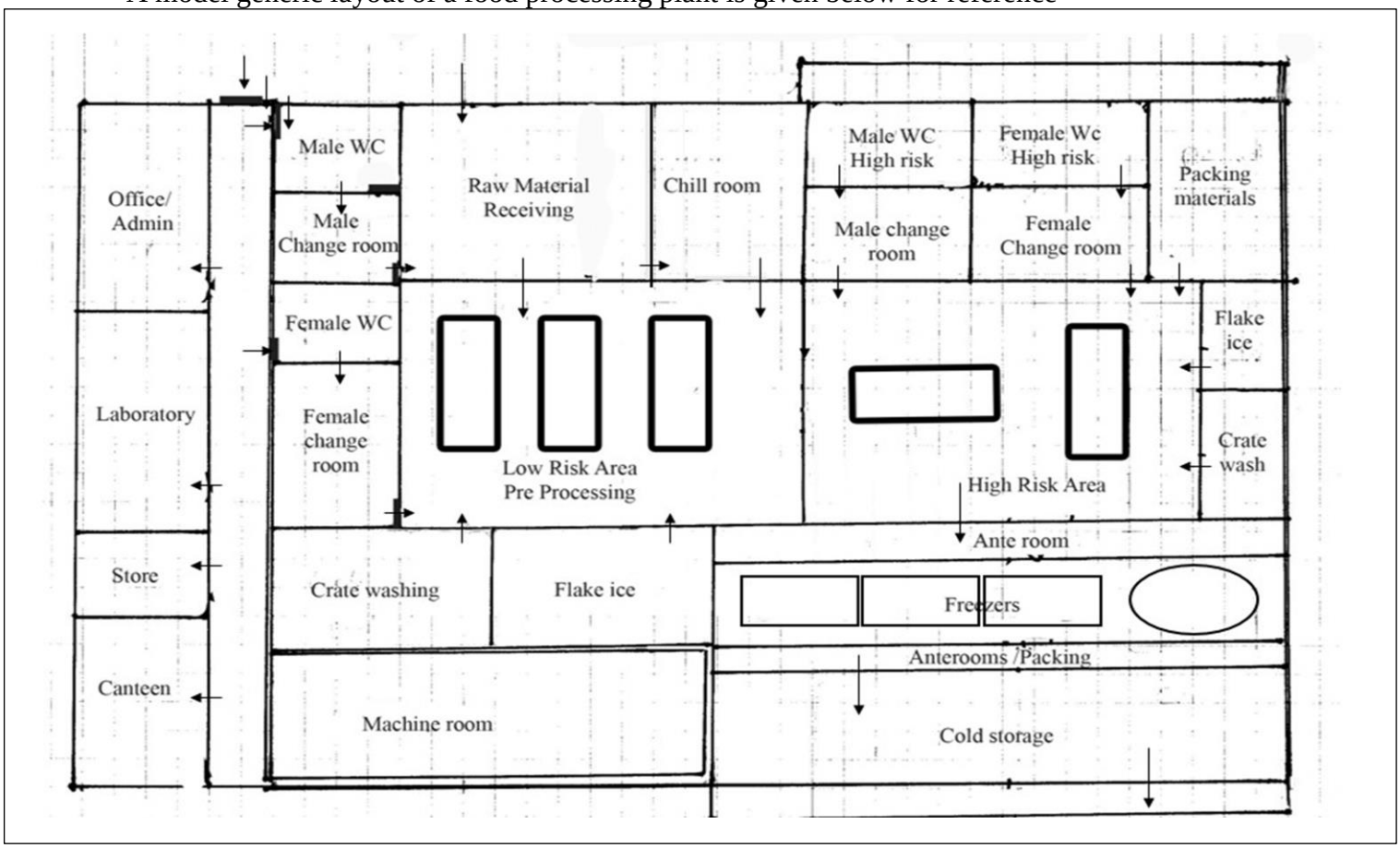
Pipework entering production areas should be grouped together and sheathed in an appropriate material. The number of openings in walls around the process area should be kept to a minimum in order to prevent pest access, limit the ingress of airborne contamination, and facilitate environmental control. All pipes and cables passing through internal walls and floors should be built in to prevent pests from using them as runways.

Ideally, all cables should be situated behind walls or above the ceiling. If this is not possible cables in production areas should be placed in enclosed, rounded conduits or racks which will not accumulate dirt and are accessible for cleaning, pest control and maintenance. No cables should be routed above processing machinery. To avoid dirt accumulating, cable racks should preferably have vertical rounded supports. Light fittings should fit smooth

against surfaces like the ceiling or construction parts. Good lighting is essential to ensure clean conditions, encourage good housekeeping and safety and facilitate maintenance. Lighting levels should be no less than 500 lux in most areas where operators are required. This level may be less in areas such as loading bays or conveyor halls or more in areas such as inspection, filling or packaging.

Natural ventilation should be avoided in most instances because it varies and therefore cannot be controlled. Extraction systems are a relatively inexpensive way of drawing out hot or stale air and steam, but excessive use of this method results in the build-up of negative pressure unless there is a corresponding supply of fresh air to balance the atmosphere.

A model generic layout of a food processing plant is given below for reference



Reference:

- Ayyappan Pillai, S., 1983. Model layout of fish processing plant. Fish Technology News Letter. Vol.3 No.9-11
- Hall, G.M. and Köse, S., 2014. Fish processing installations: Sustainable operation. Seafood Processing, pp.311-342.
- Van Donk, D.P. and Gaalman, G., 2004. Food safety and hygiene: systematic layout planning of food processes. Chemical Engineering Research and Design, 82(11), pp.1485-1493.
- Graham, J. (ed.), Planning and engineering data. 3. Fish freezing. FAO Fish.Circ., (771):126 p.1984

Chapter 5

Handling, Chilling and Freezing of Fishery Products

Dr. George Ninan
Principal scientist, ICAR-Central Institute of Fisheries Technology
Cochin-682029, Kerala, India
George.Ninan@icar.gov.in

Maintaining the quality of fish begins with harvest and carries through the harvest -to-consumption chain. Careful handling of fish and shellfish while harvesting and during transport to the processing plant is critical if the high quality of the product is to be maintained. There are, however, several constraints on handling the fish; the important among them are the bacteriological, chemical and physical processes that cause degradation of fish. The surface of dead fish is an ideal growth habitat for bacteria and the end result of such activity is spoiled fish. Reduction of temperature can prevent the growth of many bacteria that cause the spoilage. Chemical breakdown due to oxidative and enzymatic reactions can lead to off odors and flavors and rancidity. Digestive enzymes can initiate decomposition in the dead fish. Physical factors can enhance the bacteriological or chemical processes: bruising, tearing, cutting etc. can expose fish muscle to more rapid bacteriological growth, cause internal bleeding which darkens the fillets and expose greater surface area for chemical oxidation.

Since fish is a highly perishable item of food, it has to be immediately processed to various products to preserve the quality and to increase the shelf life. Fish requires proper handling and preservation to increase its shelf life and retain its quality and nutritional attributes. The objective of handling, processing and preservation is to control or reduce the spoilage process so that the final product is wholesome and safe for the consumer. Fish and fishery products brought to market in a well-preserved condition will generally command higher prices, both at wholesale and retail levels, and thus give better returns to the fishing operation.

Handling

The earliest practice of fish handling in many parts of the world to avoid spoilage and loss of quality is to keep caught fish alive until cooking and consumption, particularly in China where live carp trade has been practiced for more than three thousand years. Till date, this remains to be one of the common fish-handling practices. A large number of fish species are usually kept alive in holding basins, floating cages, wells and fish yards. Holding basins, normally associated with fish culture companies, can be equipped with oxygen control, water filtering and circulation and temperature control. Simpler methods are also used viz., keeping fish in floating cages in rivers or simple fish yards constructed in backwaters. Also, the transportation of live fish ranges from very sophisticated systems installed on trucks that

regulate temperature, filter and recycle water and add oxygen, to very simple artisanal systems of transporting fish in plastic bags with an atmosphere supersaturated with oxygen.

For harvested fish, the general handling operations after capture are: Transferring catch from gear to vessel, holding of catch before handling, sorting/grading, Bleeding/gutting/washing, Chilling, Chilled storage and unloading. These operations range from manual methods to fully automated operations. The number of operations and the order in which they are performed depend on the fish species, the gear used, vessel size, duration of the voyage and the market to be supplied. It is crucial to provide a continuous flow in handling and to avoid any accumulation of unchilled fish, thereby bringing the important time-temperature phase under complete control. Icing is the oldest method of preserving fish freshness by chilling and it is widely used. Mechanical refrigeration makes ice readily and cheaply available. In addition, ice keeps fish moist, has a large cooling capacity, is safe, and is a portable cooling method that can be easily stored, transported and used by distributing it uniformly around fish. Block ice is used in crushed form to chill fish. The use of ice at various stages of handling and processing require suitable insulated containers. These containers are designed and constructed locally, using natural or artificial insulating materials, with enough handling flexibility.

The most important factors to be considered in the initial handling and transport are the temperature, duration of storage/transport and the hygiene in all respects including that of the handlers. The important requirements are cleaning the fish from dirt and debris, chilling it immediately to prevent its temperature from rising and maintaining high standards of cleanliness at all stages. Fish, which has struggled for long in the net or onboard, is likely to spoil more quickly than a fish, which dies instantaneously or is killed quickly. Similarly, fish with its stomach full while catching, will spoil more quickly and fish, which is bruised while catching or handling, will spoil more quickly than a physically sound fish.

Washing and sorting of fish

The harvested fish should be washed well with potable water to free it from dirt and other extraneous matter. Water chlorinated at 10 ppm level is ideal for initial cleaning. Most of the surface bacterial load is cleared by washing. In some freshwater species viz., eel carp and trout, slime constitutes 2-3% of the body weight (Venugopal,2006) The excretion of slime which stops before rigor, creates a perfect environment for bacterial growth. Hence the carcass has to be thoroughly washed to remove slime. After washing the catch should be sorted species – wise and size – wise. Bruised, damaged and decomposed fish shall be separated from the catch during sorting.

Dressing

It is desirable to avoid the struggling of large fish by instant killing. The more the fish struggles, the faster will be the fall of pH after death. A pH of 6.0 encourages protein denaturation of muscle during frozen storage (Robb, 2001). The dressing operations of the catch include heading, bleeding and gutting have to be carried out as fast as possible without significant bacterial contamination. Gills and viscera harbor several spoilage bacteria in large numbers. Partially digested food in the viscera may become sour or putrid due to bacterial action. The powerful digestive enzymes in the viscera can bring about accelerated spoilage of fish. Therefore, wherever possible, it is advisable to remove the gills and viscera before the fish is preserved and stored. Gutting or evisceration should not cause any bruise on the exposed belly portion. Retention of any visceral parts can easily contaminate the soft belly and bruises can cause accelerated spoilage by permitting easy penetration of bacteria. The

fish should be washed thoroughly after each operation. The larger fish are gutted by hand, washed and iced. Gutting helps to remove digestive enzymes and foul-smelling compounds associated with gut. It also prevents accumulation of bloodstains and control haemoglobin catalyzed lipid oxidation in the fillets (Hultin, 1992).

The blood in the fish can clot and turn black or brown in colour adversely affecting the colour and appearance of the meat. Therefore, bleeding is done to preserve the quality of the meat. Bleeding and evisceration can be done only to fish of reasonably large size. Slitting the throat followed by hanging the fish by tail or slitting the throat and immersing in cold water are the methods for bleeding.

Good Handling Practices

The type of handling the fish receive on land during preprocessing and processing will determine the quality of the final product. Every stage from capture, handling and processing, and eventually to sale, to the consumer, involves some loss of quality. Different raw material specifications are used for each product. For example, chilled fish for immediate sale on the local market may not be perfectly fresh but may still be acceptable to the consumer. But in the case of a product such as frozen fillets, fresh raw material will be required as it will have to withstand the rigors of the freezing process and extended cold storage before it reaches the consumer. Hence during pre-processing stage raw material is graded according to the suitability for various processing methods. Handling the fish (raw material) during processing varies with type of the fish, the processing methods and the intended final product. However, there are some important good practices to be followed in general, which are described below:

- As far as possible, every precaution should be taken to avoid the warming of fish, as this will favour the action of enzymes and bacteria.
- Avoid mishandling of the fish. This will damage the skin and flesh and accelerate the process of bacterial contamination and enzymatic action.
- Cool the fish as quickly as possible by any convenient method. Whatever be the method, it is important to cool the entire fish.
- The fish, which are caught at different times, have to be kept apart since they will be at different stages of spoilage.
- Small fishes have to be kept separately from large fishes, as they tend to spoil more rapidly than the latter.
- Soft-bellied fishes are to be kept separately and if the guts are being removed or the belly has burst, the body cavity has to be washed to remove any traces of the gut.
- The containers used for the transportation of fish should be cleaned after every use. Chlorinated water should be used, whenever possible for every fish washing operation.
- Do not put fish on the ground; it can be kept on simple concrete / wooden platforms, which, if frequently cleaned, will reduce contamination.
- Fish handlers at every pre-processing and processing stage should learn about and adopt good hygienic practices.

Low temperature preservation by chilling and freezing methods are widely practiced to maintain the quality and freshness of fish and fish products. Chilled storage method, i.e., keeping the fish in the unfrozen condition has only limited shelf life and it will vary between 4 and 20 days depending on the condition and species of fish. In frozen storage also, the shelf life is restricted but it varies from few weeks to years. The various factors that affect the

frozen storage shelf lives are condition of fish at the time of catch, handling, processing and product development, packaging and glazing of the product, freezing method adopted, frozen storage temperature, stacking methods and transportation techniques. These factors can be put together and can be termed as 'Product, Processing and Packaging' (PPP) and 'Time Temperature Tolerance' factors (TTT).

Chilled storage

Chilling is an effective way of reducing spoilage in fish if it is done quickly and if the fish are kept chilled and handled carefully and hygienically. Immediate chilling of fish ensures high quality products (Connel, 1995: Huss, 1995). For every 10 ^{0}C reduction in temperature, the rate of deterioration decreases by a factor of 2-3 (Hardy,1986). The objective of chilling is to cool the fish as quickly as possible to as low a temperature as possible without freezing. Chilling cannot prevent the spoilage together but in general, the colder the fish, the greater the reduction in bacterial and enzyme activity.

The important chilling methods of fish and fish products at non-freezing temperature are:

- Iced storage.
- Chilled seawater (CSW) storage.
- Chilled freshwater (CFW) storage.
- Mechanically Refrigerated seawater (RSW) storage.
- Cold air storage.

The most common means of chilling is by the use of ice. Although ice can preserve fish for some time, it is still a relatively short-term means of preservation when compared to freezing, canning, salting or drying, for instance. When used properly it can keep fish fresh so that it is attractive in the market place.

Ice is available in several forms such as blocks, plates, tubes, shells, soft and flakes. Of these, flake ice is the most popular form for industrial use because of its cooling efficiency. It is also relatively dry and will not stick together to form clumps when stored. Cooling capacity is more for flake ice due to a large surface area for heat exchange. It also causes minimum damage to the flesh. To ensure maximum contact of ice with the fish, proper selection of the size of ice particles and good stowage practices are needed. The rate of chilling is governed by:

- The size, shape and thickness of fish;
- The method of stowage;
- Adequate mixing of ice, water and fish (in ice slurries);
- Adequate contact of ice with the fish;
- The size of the ice particles.

Icing is widely employed for chilled storage of freshwater fish in the country. The dressed and cleaned fish is kept in a chill store in insulated boxes with proper icing prior to preprocessing. The major advantage of using ice for chilling the fish is that it has a high latent heat of fusion so that it is capable of removing large amount of heat as it melts without changing the temperature at 0 ^{0}C. During transition from ice to water 1 kg of ice absorbs 80 k cal of heat and this will be sufficient to cool about 3 kg of fish from 30 ^{0}C to 0 ^{0}C. Hence

theoretically about 30 % of ice is needed to bring down the temperature from ambient conditions to 0^0C. However, ice is needed to maintain the temperature as well as to accommodate the heat from the environment. Hence in tropical conditions a 1: 1 fish to ice ratio is ideal for ice storage. Fish of the same size and species are placed in the same boxes. It is always recommended to add about 12-20% extra ice to the fish in order to compensate for water loss from melting and bad handling (Zugarramurdi, et. al,1995). The effectiveness of chilling by temperature exchange depends on the thickness of the layers of fish and the distribution of ice. The rates of cooling of fish are given in Table 1.

Table 1. Rates of cooling of fish *

Distance to centre of fish/fish layer (cm)	Time to cool from 25 ^{0}C to 1 ^{0}C (hours)
1	0.33
2	1.25
4	5.00
10	31.25
20	125.00
40	500.00

**Clucas, I.J. and Ward, A.R.(1996) Post – harvest Fisheries Development: A Guide to Handling, Preservation, Processing and Quality. Natural Resources Institute, Chatham, Maritime, Kent ME4 4TB, UK pp 73 – 141.*

Chilling versus freezing of fish

There are many factors to be considered when considering the differences between chilling and freezing of fish products for various markets. Both chilling and freezing operations can produce stable products and the choice of one or the other depends on many factors.

Table 2 lists some of the advantages and disadvantages of the two methods. It can be used to help decide whether freezing or chilling is the option most appropriate to a particular situation.

Table 2 . Advantages and disadvantages of chilling and freezing *

Chilling	Freezing
Short-term storage (up to one month maximum for some species, only a few days for others)	Long-term storage (a year or more for some species)
Storage temperature 0 °C	Storage temperature well below zero, e.g. -30 °C
Relatively cheap	Relatively costly
Product resembles fresh fish	If poorly done can badly affect quality
Relatively low-tech	Relatively high tech
Low skills required	High skills required
Portable refrigeration	Generally static operations

** Shawyer, M.; Medina Pizzali, A.F. (2003) The use of ice on small fishing vessels. FAO Fisheries Technical Paper. No. 436. Rome, FAO,108 p.*

Determination of spoilage rates

Spoilage of fish is linearly related to storage temperature since the enzymatic and microbial activities are directly related to temperature. If the shelf life of a fish at 0 ^{0} C and at another temperature (t ^{0} C) are known, their ratio gives the relative rate of spoilage (RRS) at t ^{0} C. The RRS for tropical fish are more than twice as estimated for temperate fish species.

$$\text{Relative rate of spoilage (RRS) at t °C} = \frac{\text{shelf life at 0 °C}}{\text{shelf life at t 0 °C}}$$

Factors affecting the rate of spoilage in chilled fish

The main factors that affect the rate of spoilage in chilled fish are:

- Temperature
- Physical damage
- Intrinsic factors

Temperature

It is well known that high temperatures increase the rate of fish spoilage and low temperatures slow it down. Therefore, if the temperature of fresh fish is low, then quality is lost slowly. The faster a lower temperature is attained during fish chilling, the more effectively the spoilage activity is inhibited. Generally, the rate at which fish loses quality when stored in ice (0 °C) is used as the baseline when comparisons are made regarding shelf-life at different storage temperatures. The effect of temperature reduction on the rate of spoilage and shelf life of fish is given in Table 3.

Table 3. Effect of temperature reduction on fish spoilage *

Reduction in Temperature (0 ^{0} C)	Rate of spoilage (%)	Extension of shelf life
0	100	-
5	50	× 2
10	25	× 4
15	12.5	× 8
20	6.25	× 16

**Clucas, I.J. and Ward, A.R.(1996) Post – harvest Fisheries Development: A Guide to Handling, Preservation, Processing and Quality. Natural Resources Institute, Chatham, Maritime, Kent ME4 4TB, UK pp 73 – 141.*

Physical damage

Fish is soft and easily damaged; therefore rough handling and bruising result in contamination of fish flesh with bacteria and allow releases of enzymes, speeding up the rate of spoilage. In addition, careless handling can burst the guts and spread the contents into the fish flesh.

Intrinsic factors

The intrinsic factors affecting the spoilage rate of chilled fish are shown in Table 4.

Table 4. Intrinsic factors affecting the spoilage rate of chilled fish*

Intrinsic factors	Relative spoilage rate of fish stored in ice	
	Slow rate	Fast rate
Shape	Flat fish	Round fish
Size	Large fish	Small fish
Fat content in the flesh	Lean species	Fatty species
Skin characteristics	Thick skin	Thin skin

**Huss, H.H (1995) Quality and quality changes in fresh fish, FAO Fisheries Technical Paper No. 348. Rome. 195 p.*

Shelf life of iced fish

Shelf life can be defined as the maximal period of time during which the predetermined attributes of the food are retained (Daun, 1993).The different expressions of shelf life related to the product, process and context is given as Annexure 1.

The chilled storage life of fish is primarily determined by sensory evaluation. Apart from the factors discussed in the previous session, chilled storage life of fish depends on several factors such as composition, microbial contamination and the type of microflora present in the fish (Venugopal,2006). The fish spoilage pattern is similar for all species, with four phases of spoilage as outlined in Table 5.

Table 5. The four phases of fish spoilage*

Phase I (Autolytic changes, caused mainly by enzymes)	Fish just caught is very fresh and has a sweet, seaweedy and delicate taste. There is very little deterioration, with slight loss of the characteristic odour and flavour. In some tropical species this period can last for about 1 to 2 days or more after catching.
Phase II (Autolytic changes, caused mainly by enzymes)	There is a significant loss of the natural flavour and odour of fish. The flesh becomes neutral but has no off-flavours, the texture is still pleasant.
Phase III (Bacteriological changes, caused mainly by bacteria)	The fish begins to show signs of spoilage. There are strong off-flavours and stale to unpleasant smells. Texture changes are significant, flesh becoming either soft and watery or tough and dry.
Phase IV (Bacteriological changes, caused mainly by bacteria)	Fish is spoiled and putrid, becoming inedible.

** Shawyer, M.; Medina Pizzali, A.F. (2003) The use of ice on small fishing vessels. FAO Fisheries Technical Paper. No. 436. Rome, FAO,108 p.*

There have been many research studies regarding the shelf-life of fish stored in ice. Based on these studies, it is generally accepted that some tropical fish species can keep for longer periods in comparison to fish from temperate or colder waters. The normal life of coldwater fish chilled to 00C immediately postmortem is 1-2 weeks, while fish from tropical waters remain in good condition for longer periods (Venugopal, 2006). This can be attributed to differences in the bacterial growth rates, with a 1-2 week slow growth phase (or period of adaptation to chilled temperatures) in tropical fish stored in ice. However, due to differences in the criteria used to define the limit of shelf-life, and methodologies used, comparison between shelf-life of fish from tropical and temperate waters is still difficult. Up to 35% yield of high value products can be expected from fish processed within 5 days of storage in ice, after which a progressive decrease in the utility was observed with increase in storage days and beyond 9 days of ice storage no high value products could be processed (Venugopal and Shahidi, 1998). Delay in icing also can adversely affect the shelf life (Table 6). The shelf-life of several fresh water fish species stored in ice is summarized in Table 7.

Table 6. Effect of delayed icing on the storage life of some tropical species *

Species	Delay (Hours)	Storage life in ice (days)
Mackerel (Rastrelliger spp.)	0 3 6 9	9 7 4 ≈1
Tilapia (Oreochromis spp.)	0 4 8 12	16 13 5 < 1
Milk fish (*Chanos chanos*)	0 4 8 12	14 12 6 ≈1
Oil sardine (*Sardinella longicepes*) Nov-Dec. period	0 3 6	7 5 1
Farmed white prawn (*Fenneropenaeus indicus*)	0 3 6 9	16 14 9 4

** Ninan, G. (2003) Handling and Chilled Storage of Fish In: Product development and seafood safety. Central Institute of Fisheries Technology, Cochin, India, pp 43-58.*

Table 7. Shelf-life of freshwater fish & shell fish species stored in ice*

Species	Shelf-life (days in ice)		References
	Temperate waters	Tropical waters	
Catfish (Lean)	12-13	15-27	(Huss, 1995)
Trout (Lean)	9-11	16-24	(Huss, 1995)
Rohu, Mrigal & Catla (Lean)		15 - 18	(Joseph et.al.,(1990)
Labeo sps. (Medium)		9-18	Bandhopadhyay et. al., (1985)
Clarias sps. (Medium)		10 -15	Bhattacharya et.al.,(1990)
Channa sps. (Lean)		8-9	Perigreen,et. al.,(1987)
Tilapia (Lean)		10-27	(Santos Lima Dos et. al., 1981)
Common carp (Medium)		24-25	Santos Lima Dos et. al., (1981)
Freshwater prawn (Lean)		10 -12	Ninan et. al.,(2003)

* Fat content and shelf-life are subject to seasonal variations.

Requirement of ice during handling and transportation

The weight of ice needed to chill 1 kg fish (0°C) can be calculated theoretically as shown below in Table 8.(in practice some more ice will be needed).

Table 8. Theoretical weight of ice needed to chill 10 kg of fish to 0 °C from various ambient temperatures *

Starting temperature of fish (°C)	Weight of ice needed (kg)
30°	3.4
25°	2.8
20°	2.3
15°	1.7
10°	1.2
5°	0.6

**FAO (1984). Planning and engineering data 4. Containers for fish handling, J. Brox, M. Kristiansen, A. Myrseth & Per W. Aasheim (Eds.) Fisheries Circular No. 773. Rome, Italy, 53 p.*

The necessary quantity of ice required to maintain the fish chilled will depend upon the ambient temperature, the insulative properties of the container, the place of the individual box within the load and the length of the storage. The following table (Table 9) gives an example of ice requirements to chill and maintain the chill condition of fish held in individual boxes and within a stack of boxes.

Table 9. Ice requirements for chilling and storage of fish*

	Melting of ice per box of 50 kg fish					
	1 box			35 boxes		
Surrounding temperature (°C)	+30	+20	+10	+30	+20	+10
Chilling fish (kg)	21	14	7	21	14	7
Keeping chilled (kg/h)	3	2	1	1	0.7	0.3

**FAO (1984). Planning and engineering data 4. Containers for fish handling, J. Brox, M. Kristiansen, A. Myrseth & Per W. Aasheim(Eds.) Fisheries Circular No. 773. Rome, Italy, 53 p.*

For practical purposes the following rules of thumb can be given to calculate ice requirements:

l. Fish boxes: Ice to fish ratio in tropics are 1 kg ice to 1 kg fish, and ice to fish ratio in temperate climate and in insulated van are 1 kg ice to 2 kg fish.

2. Insulated tanks: Water to ice to fish ratio in tropics are 1 kg water to 2 kg ice to 6 kg fish and in temperate climate 1 kg water to 1 kg ice to 4 kg fish.

Necessary volume of ice to chill the fish down to a temperature of 0°C is included in the above mentioned rules. If the fish is already chilled the volume of ice can be reduced accordingly.

The fish carrying capacities of various boxes and containers depend on the density of the mixture of ice and fish. Table 10 shows the densities of different types of ice.

Table 10. Density of different types of ice*

Type of ice	Bulk weight kg/dm³ = l	Specific volume m³/ton
Crushed block	0.690	1.45
Tube	0.565	1.80
Plate	0.570	1.75
Flake	0.445	2.25

**FAO (1984). Planning and engineering data 4. Containers for fish handling, J. Brox, M. Kristiansen, A. Myrseth & Per W. Aasheim(Eds.) Fisheries Circular No. 773. Rome, Italy, 53 p.*

Disadvantages of icing

Icing in the conventional method using crushed ice can bruise the flesh which results in leaching of flavour compounds and water-soluble proteins. Prolonged ice storage can cause changes in the texture of the muscle, particularly the reduction in breaking strength and hardness of fillets. Muscle proteases including cathepsin D and cathepsin L, calcium activated proteases (calpains), trypsin, chymotrypsin, alkaline proteases and collaginases are involved in softening of fish tissue during storage (Bremner, 2000)

Ice storage has been found to adversely influence protein stability and water holding capacity in salmon and cod fillets*. Icing cannot completely arrest the activities of psychrotrophic organisms in fish, which is a quality problem in refrigerated food (Olssen, 2003).

Transportation of Chilled fish

Land transportation of chilled fish is carried out in insulated or mechanically refrigerated vehicles. The refrigerated vehicle used for chilled fish transportation should have a minimum inside temperature of 7 ^{0} C (Venugopal, 2006). Boxes for land transportation are made of wood, aluminium, high density polyethylene, expanded polystyrene or polyurethane. The ideal fish transportation box should be light weight yet strong enough to withstand the combined weight of fish, ice and stacking and should have good insulating properties. The boxes should be easy to clean. Boxes are usually made of double bottom to collect the melt water. Containers used for air transportation of chilled fish should be water tight.
Air shipment of chilled fish requires a lightweight and protective container. Modern insulated containers are made of high–density polypropylene with polyurethane insulation sandwiched between the inner and outer walls of the double walled container. Instead of ice, pads of nonwoven fabric encapsulating synthetic absorbent powder are used for chilling of air shipped fish. These pads could be soaked in water and deep frozen for use (Venugopal, 2006). Special thermal barrier films are used in combination with the pads to protect fish containers from heat (Subsinghe, 1996)

Freezing

Freezing is the most accepted method for long term preservation of fish and fishery products. Freezing reduces the spoilage activity and extends the shelf life of the product. Freezing represents the main method of processing fish for human consumption, and it accounted for 55.2 % of total processed fish for human consumption and 25.3 % of total fish production in 2010. (Anon.2012). Freezing involves the cooling down of materials from ambient temperature conditions to a temperature below the freezing point. Generally, the freezing process has three stages; in the first stage (pre-freezing stage) corresponds to removal of heat from the food, when the temperature is reduced to freezing point. The second stage (freezing stage) is the period of transformation of water to ice through the whole mass of food. Between the first and second stages there is a transitory super cooling period when the temperature falls below the freezing point which is not observed in some cases. In the third stage nearly 75% of the water in the muscle turns into ice which leads to further rapid drop in temperature, as the thermal diffusivity of ice being much higher than water. Bound water, which forms the integral part of the tissue will be frozen at extremely low temperature of about -55 ^{0} C.

As the water in fish freezes out as pure crystals of ice, the remaining unfrozen water contains higher concentration of salts and other compounds which are naturally present in the fish muscle. The increasing concentration of the salts will depress the freezing point of the unfrozen water. Hence unlike pure water, conversion to ice will not occur at 0 ^{0} C but proceeds over a range of temperature. Thus, even at -30 ^{0} C, a portion of water in the fish muscle will remain in unfrozen state. Slow freezing produce ice crystals of comparatively larger size and few in numbers which may cause rupture of the cell walls and result in fluid loss and textural changes on defrosting. In contrast fast freezing produce large number of small crystals, thus reducing the possibility of shrinkage or rupture. In fish, however, the cell may be considered sufficiently elastic to withstand excessive damage from the growth of large crystals, therefore this does not account for the drip loss on thawing the frozen fish (Garthwaite, 1997). The drip loss on thawing of fish occur mainly due to denaturation of protein during freezing which result in the loss of water binding capacity of the protein. The optimum range of temperature for denaturation is -1 ^{0} C to -2 ^{0} C; thus, in order to reduce the thaw drip to minimum the time spent in this temperature zone should be minimum.

Quick freezing is a general term applied to most of the freezing processes which result 'Individual Quick Frozen' product. If the temperature of fish/fishery product is reduced from 0 ^{0} C to -5^{0}C in 2 hours or less, then it can be termed as a quick frozen product. During freezing process, the temperature of the fish should be lowered to -30^{0}C before it is transferred to the cold store. Most of the commercial freezers operate at temperatures of -40 ^{0} C to -35 ^{0} C. The thermal centre of the fish should attain -20 ^{0} C prior to its removal from the freezer. The time taken to lower the temperature of the thermal centre to -20 ^{0} C is termed as the freezing time.

Freezing systems

There are three basic methods for freezing fish. These are:

Air blast freezing: Where a continuous stream of cold air is passed over the product.

Plate or contact freezing: where the product is placed in direct contact with hollow, metal, freezer plates, through which a cold fluid is passed.

Spray or Immersion freezing: where the product is placed in direct contact with fluid refrigerant.

Air blast freezing

Circulating cold air at high speed enables freezing to proceed at a moderately rapid rate and this method is referred to as air-blast freezing. Air-blast freezing is usually accomplished by placing the products on a mesh belt and passing it slowly through an insulated tunnel containing air at-18 to -34°C or lower, moving counter current to the product at a speed of I to 20 meter/sec. Air at -29°C and at a speed of 10-12 meter/sec, is often satisfactory, although lower temperatures are preferred. Air blast freezing is economical and is capable of accommodating products of different sizes and shapes. It can result in (1) excessive dehydration of unpackaged products if conditions are not carefully controlled, and this in turn necessitates frequent defrosting of equipment and (2) undesirable bulging of packaged products which are not confined between flat rigid plates during freezing.

Spiral Belt Freezer

Modern designs of belt freezers are mostly based in the spiral belt freezer concept. In these freezers a conveyor belt that can be bent laterally is used. The present design consists of a self-staking and self-enclosing belt for compactness and improved air flow control. The

number of tiers in the belt stack can be varied to accommodate different capacities and line layouts. The belt is continuous. The products are placed on the belt outside the freezer where it can be supervised. As the belt is continuous it is easy for proper cleaning. Both unpacked and packed products are frozen and the freezer gives a large flexibility both with regard to product and freezing time. Both horizontal and vertical air flow can be used. Vertical airflow is more efficient.

Carton freezer

This freezer consists of a number of carrier shelves which are automatically moved through the section of the unit. The operations are carried out hydraulic power with mechanical linkage to coordinate different movements. The boxes are fed automatically into the freezer on a feeding conveyor.

Fluidized Bed Freezing

Marine products of small size like prawns can be fluidized by forming a bed of prawns on a mesh belt and then forcing air upward through the bed at a rate sufficient to partially lift or suspend the particles. If the air used for fluidization is sufficiently cooled, freezing can be achieved at a rapid rate. An air velocity of at least 2 meter/sec. or more is necessary to fluidize the particles and an air temperature of - 35°C is common. The bed depth depends on ease of fluidization and this in turn depends on size, shape and uniformity of the particles. A bed depth of slightly more than 3 cm is suitable for small prawns where as a depth of 20 to 25 cm can be used for non-fluidizable products such as fillets. Fluidized bed freezing has proven successful for many kinds and sizes of products. The best results are obtained with products that are relatively small and uniform in size. Some fluidized-bed freezers involve a two stage freezing technique wherein the first stage consists of an ordinary air-blast freezing to set the surface of the product and the second stage consists of fluidized bed freezing.

The advantages of fluidized bed freezing are (1) more efficient heat transfer and more rapid rates of freezing and (2) less product dehydration and less frequent defrosting of the equipment. Dehydration loses of about 1% have been reported during fluidized bed freezing of prawns. The short freezing time is apparently responsible for the small loss of moisture. The major disadvantage of fluidized-bed freezing is that large or non-uniform products cannot be fluidized at reasonable air velocities.

Contact Plate Freezing

Fish products can be frozen by placing them in contact with a metal surface cooled by expanding refrigerants. Double contact plate freezers are commonly used for freezing fish/prawn blocks. This equipment consists of a stack of horizontal cold plates with intervening spaces to accommodate single layers of packaged product. The filled unit appears like a multi layered sandwich containing cold plates and products in alternating layers. When closed, the plates make firm contact with the two major surfaces of the packages, thereby facilitating heat transfer and assuring that the major surfaces of the packages do not bulge during freezing. Vertical plate freezers are also in use especially onboard fishing vessels. Contact plate freezing is an economical method that minimises problems of product dehydration, defrosting of equipment and package bulging. In this method the packages must be of uniform thickness. A packaged product of 3 to 4 cm thickness can be frozen in I to 1.5 hour when cooled by plates at -35°C. Freezing times are extended considerably when the package contains a significant volume of void spaces.

Liquid Immersion Freezing

Liquid immersion freezing or direct immersion freezing is accomplished when a product is frozen by immersing or by spraying with a freezant that remains liquid throughout the process. This technique is occasionally used for fish and prawns. Liquid immersion freezing can result in moderately rapid freezing. Freezants used for liquid immersion freezing should be non-toxic, inexpensive, stable, reasonably inert, and should have a low viscosity, low vapour pressure and freezing point and reasonably high values for thermal conductivity. Freezants should have a low tendency to penetrate the product, little or no undesirable effects on organoleptic properties and require little effort to maintain desired standards for sanitation and composition. Aqueous solutions of propylene glycol, glycerol, sodium chloride, calcium chloride and mixtures of sugars and salt have been used as freezant.

Cryogenic Freezing

Cryogenic freezing refers to very rapid freezing by exposing food products to an extremely cold freezant undergoing change of state. The fact that heat removal is accomplished during a change of state by the freezant is used to distinguish cryogenic freezing from liquid immersion freezing. The most common food grade cryogenic freezants are boiling nitrogen and boiling or subliming carbon dioxide. Boiling nitrous oxide also has been considered, but at present it is not being used commercially. The rate of freezing obtained with cryogenic methods is much greater than that obtained with conventional air-blast freezing or plate freezing, but is only moderately greater than that obtained with fluidized bed or liquid immersion freezing. For example, shrimp freeze in about 9 min in a commercial liquid nitrogen freezer and in about 12 min in a fluidized bed freezer. Currently liquid nitrogen is used in most of the cryogenic food freezers. Usually liquid nitrogen is sprayed or dribbled on the product or alternatively very cold gaseous nitrogen is brought into contact with the product. Freezing with carbon dioxide usually involves tumbling the product in the presence of powdered or liquid carbon dioxide. Carbon dioxide is absorbed or entrained by the product in this method. This entrapped CO_2 should be removed before it is packaged in an impervious material.

Crusto Freezer

This is a combination of cryogenic freezing system and air blast freezing system. The equipment utilizes the possibility of a fast and efficient crust freezing of extremely wet, sticky products which can then be easily handled in a spiral belt freezer or a fluidized bed freezer without deformation or breakage.

Individually Quick-Frozen Products (IQF)

Lobster, squid, cuttlefish, different varieties of finfish etc. are processed in the individually quick-frozen style. IQF products fetch better price than conventional block frozen products. However, for the production of IQF products raw-materials of very high quality need to be used, as also the processing has to be carried out under strict hygienic conditions. The products have to be packed in attractive moisture-proof containers and stored at –30°C or below without fluctuation in storage temperature. Thermoform moulded trays have become accepted containers for IQF products in western countries. Utmost care is needed during the transportation of IQF products, as rise in temperature may cause surface melting of the individual pieces causing them to stick together forming lumps. Desiccation leading to weight loss and surface dehydration is other serious problem met with during storage of IQF products.

Some of the IQF products in demand are prawn in different forms such as whole, peeled and de-veined, cooked, headless shell-on, butterfly fan tail and round tail-on, whole cooked lobster, lobster tails, lobster meat, cuttlefish fillets, squid tubes, squid rings, boiled clam meat and skinless and boneless fillets of white lean fish. IQF products can be easily marketed as consumer packs, which is not possible with block frozen products. This is a distinct advantage in marketing.

Pre-freezing and Freezing Considerations

The quality of frozen-thawed cooked fish is influenced by a number of factors including species, composition, size, how and where caught, elapsed time between harvest and freezing, the state of rigor and quality when frozen and the details of freezing process and frozen storage.

The major problems encountered during the freeze-processing of fish are oxidative deterioration, dehydration, toughening, loss of juiciness, and excessive drip. Effective pre-freezing and freezing techniques are available for controlling many of these problems except toughening and loss of juiciness. Reasonable control of toughening and loss of juiciness can be accomplished only by storing fish for a minimal time and / or at temperatures at -18°C or lower. Undesirable oxidative changes in fish can be minimized by (1) eliminating oxygen (2) avoiding contamination with heavy metals (oxidative catalysts) (3) adding antioxidants and (4) by using low storage temperature. Dehydration can be avoided by applying glaze and suitable protective coatings. Most foods expand on freezing but to a lesser extent than pure water. The various factors that contribute to volume change upon freezing of food are:

- Cooling of specimen prior to freezing causes contraction
- Ice formation during freezing causes expansion
- Cooling of ice crystals causes contraction
- Solute crystallization causes contraction or expansion depending on the type of solutes.
- Cooling of solute crystals present in eutectics causes contraction.
- Solidification and cooling of non-solutes such as fat causes contraction.

The effect of ice formation predominates during freezing. A consequence of the increase in volume during freezing of food is the development of mechanical stress and hence freezing damage to food. The dislocation of water that accompanies slow freezing and re-crystallization may also cause mechanical stress. Mechanical damage to the texture of tissues during freezing is marginal in muscles because of its pliable consistency and parallel arrangement of cells. Sample size, freezing rate and final temperature of the tissue appear to influence the intensity of stress. In large tissues, outer surface freezes to solid before freezing commences in inner areas. On further freezing, the inner areas get frozen leading to considerable internal stress. The rate of freezing also influences the severity of stress. Slow freezing results in unusually great damage due to detrimental size and location of ice crystals. Rapid freezing coupled with low temperature will result in severe cracking of tissues containing large percentage of water.

During freezing of tissues, nearly all the non-aqueous constituents concentrate in a diminished quantity of unfrozen water. The extent of concentration is influenced

mainly by the final temperature, and to a lesser extent by the eutectic temperatures of the solutes present, agitation and rate of cooling. Agitation of the fluid phase during freezing aids in the formation of pure ice crystals by minimizing accumulation of solutes at the solid liquid interface. Slow removal of heat results in a smooth, continuous solid liquid interface, maximum crystal purity and concentration of solutes in the unfrozen phase. Rapid freezing results in an irregular and discontinuous interface, considerable entrapment of solutes by growing crystals and less than maximum concentration of solutes in the unfrozen phase. During freezing, the unfrozen phase changes significantly in properties such as pH, acidity, ionic strength, viscosity, freezing point, surface tension, interfacial tension, and oxidation reduction potential. Freezing forces the macromolecules like proteins to come closer making interactions between molecules more probable. The pH changes occur because of increasing concentration of solutes in the unfrozen phase during freezing. The effect of eutectics on pH is governed by the type of solutes that crystallize during freezing.

The freezing process is considered complete when most of the water at the center of the food product has been converted into ice. At -15°C, more than 80% of total water is transformed into ice. The system is segregated into a crystalline phase of pure water and an amorphous domain, which contains solutes and residual water. As the temperature decreases, the viscosity of the interstitial fluid increases rapidly as a result of both increase in concentration and decrease in temperature. When the viscosity reaches a very high value (~1011 – 1012 PaS), solidification (vitrification) occurs, and the concentrated phase surrounding the ice crystals becomes a glass. The temperature at which this transition takes place is called the glass transition temperature of the maximally freeze concentrated system. The freezing of water is stopped at this temperature; water still unfrozen is often called “un-freezable water”.

Physical changes during frozen storage

The major physical changes during frozen storage of fish are freezer burn and re-crystallization. Freezer burn is a surface phenomenon which occurs in improperly packed products. Freezer burn appears as an opaque dehydrated surface. It is caused by the sublimation of ice on the surface of the muscle. The sublimation takes place when the vapour pressure of ice on the surface of fish muscle is higher than the vapour pressure of the cold store. Other factors contributing to freezer burn are air velocity in the cold store, cold storage temperature and post mortem condition of the muscle. It can be prevented or reduced by glazing the product in chilled water and air tight packaging with water impermeable packaging materials.

The ice crystals in the frozen muscle undergo transformations during frozen storage causing changes in number, size and shape. This phenomenon is called re-crystallization. During frozen storage, the ice crystals in rapidly frozen samples are found to grow slowly. The sizes of the ice crystals between rapidly frozen and slow frozen samples have almost the same size after a long storage. There are many reasons for the changes in size and shape. During storage, the reorientation of the ice crystals takes place to give a stable shape with a compact structure having smaller surface to volume ratio and lower surface energy. In frozen products, the large ice crystals may grow at the expense of small crystals. This may be caused by melting-diffusion-refreezing or sublimation-diffusion- refreezing. The net result is an increase in average crystal size, decrease in the number of crystals and decrease

in surface energy of the crystalline phase. Fluctuating temperature and associated vapour pressure gradients enhance this type of re-crystallization. Also contacting crystals fuse together resulting in an increasing crystal size, decrease in number of crystals and decrease in surface energy. Each frozen product exhibits a critical temperature below which re-crystallization does not occur at a significant rate. Low and uniform temperature of frozen storage can minimize re-crystallization.

Drip

Drip is the exudates coming out from a frozen product on thawing. Fish after freezing, frozen storage and thawing often exudates a considerable amount of drip. Drip may amount to 1 to 5% or much more. Drip loss may cause sizable financial loss. On thawing, if the drip loss is high, the frozen products appear somewhat dry and stringy. However, the relationship between texture and drip loss need not be linear up to moderate drip loss, but at high drip loss, the loss of texture is directly related. Though factors like internal pressure developed during freezing, freezing rate, size and location of ice crystals may influence thaw drip, the major factors are the quality of the raw material, abuse of frozen storage and the extent of resultant denaturation. When the quality is poor and the frozen product is stored especially at a higher frozen storage temperature for a long duration the amount of drip is found high and is almost proportional to the storage period. Very slow freezing and the development of large extracellular ice crystals also have some influence. In quick freezing the cell dehydration during freezing is minimum due to the formation of uniform intracellular and extracellular ice crystals. This causes minimum damage to the cell and consequently expects a low drip.

Temperature Fluctuation

In good cold storage it is rare that temperature fluctuation in storage rooms exceed more than ± 2°C. Temperature fluctuation has little effect on quality when the storage temperature is below -18°C. Very high temperature fluctuation may have an adverse effect on product quality.

Quality Changes

Most of the quality changes normally attributed to the freezing process are indeed unrelated to that process. In fact, except for cases where texture is adversely affected by freezing, the frozen product is often practically indistinguishable from the fresh product when thawed immediately. However, after few months of storage, depending on product, process, packaging and storage temperature, changes are noticed. These changes are due to changes during frozen storage. The drip is very much increased by warm freezer storage temperatures. The explanation generally offered is that the high ionic strength of the solution causes rapid denaturation of proteins with poor binding of water as a consequence. This effect is not pronounced at colder freezer storage temperature because of reduced reaction rates. The most important adverse effect on freezing and frozen storage on nutritive value may be a loss of vitamins, mostly the more labile ones such as ascorbic acid, thiamin and riboflavin vitamins are water soluble and hence some losses occur in the drip.

Time Temperature Tolerance

Longer keeping times are recorded at colder temperatures in frozen storage shelf life studies. Many chemical reactions such as lipid oxidation, lipid hydrolysis and

protein denaturation and the resultant sensory changes in texture and flavor are temperature dependent. Time temperature tolerance studies for quality changes during frozen storage showed a logarithmic relationship of storage time vs. temperature of the storage. Various studies indicated that the frozen storage temperature has pronounced influence on quality and shelf life. In general, the retention of the qualities will be better at lower temperatures and an inversely proportional shelf life.

Freeze/Thaw Stability

Most frozen food will suffer some physical deterioration if they are subjected to thawing and refreezing. There are often textural changes brought about by the formation and reformation of ice crystals. Fish and meat both suffer under these circumstances and cause protein denaturation. It is possible to give some protection against damage from freeze/thaw cycles by using certain stabilizers. Polysaccharides such as sucrose, sorbitol, carrageenan and modified starches exhibit such cryoprotective properties.

References

- Anon. (2012) The State of World Fisheries and Aquaculture 2012 Part I World Review of Fisheries and Aquaculture pp 63.
- Bandhopadhyay,J.K, Chattopadhyay,A.K and Bhattacharya, S.K (1985) Studies on the ice storage characteristics of commercially important freshwater fishes In: Harvest and Post –harvest Technology of Fish , Society of Fisheries Technologists (India), Cochin, pp 381-385.
- Bhattacharya, S.K and Choudhuri, D.R (1990) Studies on Storage Characteristics of Clarias batrachus at Different Temperatures. Fish Technol. 27, pp 127-129.
- Bremner,H.A (2000) *A critical look at whether "freshness" can be determined*. J.Aquat.Food Prod. Technol., 9 , pp 5-25.
- Connel, J.J (1995) *Control of Fish Quality*. Fishing News Books, London, England p 245.
- Daun,H.(1993) Introduction, In *Shelf Life Studies of Foods and Beverages – Chemical, Biological, Physical and Nutritional Aspects*, Charalambous, G., Ed. Elsevier Science Amsterdam, pp ix-x.
- Garthwaite G.A(1997)Chilling and Freezing of Fish. In: *Fish Processing Technology* 2 nd Edition (Ed.Hall G.M) , Springer (India) Pvt.Ltd, New Delhi , pp 98-108.
- Hardy, R (1986) *Fish processing*, Proc. R. Soc. Edinburg, 87B, 201.
- Hultin, H.O (1992) Control of lipid oxidation processes in minced fatty fish In Seafood Science and Technology, Bligh, E.G., Ed. Fishing News Books, Oxford, England p 93.
- Huss, H.H **(**1995) *Quality and quality changes in fresh fish*, FAO Fisheries Technical Paper No. 348. Rome. 195 p.
- Joseph J, Perigreen,P.A, Surendran,P.K and Gopakumar,K (1990) Iced storage characteristics of cultured major carps of India. I.I.F, I.I.R, Commission C2, Aberdeen (UK) pp 117 -121
- Ninan, G., Bindu,J, Ashok Kumar,K and Jose Joseph (2003) Biochemical changes during chilled storage of M.rosenbergii (De man,1879) In: Freshwater Prawns – Advances , Biology, Aquaculture and marketing (C.M Nair & D.D Namboodiri Eds.), Allied Publishers, New Delhi, pp 625-632.

- Olssen,G.B (2003) *Changes in water holding capacity of halibut muscle during cold storage*, Lebensm.Wiss.Technol., 36, p 771.
- Perigreen,P.A, Jose Joseph, Surendran,P.K and Gopakumar,K (1987) Studies on Iced Storage of Common Murrel (Channa striatus), Fish Technol. 24(2), pp 99-102.
- Robb, D.H.F (2001) The relationship between killing methods and quality, In Farmed Fish Quality, Kestin, S.C and Warris, P.D., Eds. Fishing News Books, Oxford, England p 220.
- Santos Lima Dos, C.A.M (1981) The storage of tropical fish in ice- A review.Trop. Sci. 23,pp 97-127
- Subsinghe,S (1996) *Handling and marketing of aquacultured fish*, Infofish Int.,3,p 44.
- Venugopal, V. and Shahidi,F (1998) Food Rev. Int. 14.p 35.
- Venugopal, V.(2006) Bulk handling and Chilling, In *Seafood Processing: Adding value through quick freezing, retortable packaging and quick chilling*, CRC Press , Taylor & Francis Group, Boca Raton, FL., p 485
- Zugarramurdi,A., Parin,M.A., and Lupin,H.M(1995) Economic engineering applied to the fishery industry. FAO Fisheries Technical Paper No.351, FAO,Rome,Italy.

Annexure 1

Context	Meaning	Measurement	Product	References
Commercial shelf life	Period fish can be offered for sale	Sensory (Consumer acceptability)	Whole and gutted fish, cooked fillets,	Gelman(1990)
Maximum shelf life	Up to inedibility of fish	Sensory	Whole and gutted fish, cooked fillets,	Gelman(1990)
Predict shelf life	Based on microbial count	*Pseudomonas*, *Schewanella* and *Photobacterium* counts.	Lightly preserved fish products	Gram, and Huss (1996)
Remaining shelf life	Sensory properties	Quality Index Method	Whole fish	Branch and Vail (1985)
Total shelf life	Until sensory rejection for any food use	Sensory evaluation	Fish	Gelman(1990)
True shelf life	Microbial rejection	Microbial count, mathematical prediction	Fish and other foods	Fu and Labuzza (1997)
Maximum storage time	Sensory (whole and cooked), chemical, scoring texture, odour and flavour	Freshness score, K-value, TVB, TMA	Albacore	Perez-Villarreal and Pozo (1990)
Keeping quality, storage life	Rejection mainly by sensory characteristics.	Water binding capacity, texture measure, sensory tables, sensory panel (for raw and cooked)	Fish in general	Santos Lima Dos (1981)

Chapter 6

Machinery and equipment involved in unit operation of fish and marine food processing

Mr. Sreejith S. and Dr. Bindu. J.
Fish Processing Division, ICAR-CIFT
Email: ssreejith1985@gmail.com

Equipment and machinery are inevitable for the large-scale processing and manufacturing of fishery products. Manually it is not easy to process fish that are landed in bulk quantities. Machinery help to maximize production with minimum human handling and reduce the wastage of fishes, which is otherwise a highly perishable commodity. For the mass production of fishery products, machinery is needed for fish pre-processing operations (i.e. to remove unwanted parts of the fish, shape the fish flesh into required sizes etc.), for suitable preservation techniques to be applied (i.e. chilling, drying, freezing, retorting etc.), for value addition and pack it in appropriate containers and store it till it reaches the consumer in a good form. Use of appropriate equipment and machines along the fish value chain will help in producing better quality products and fetch higher price.

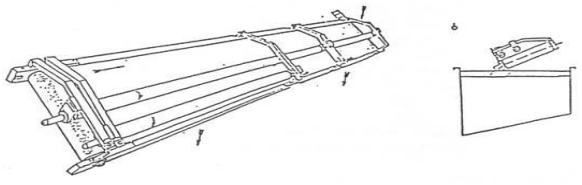
1) Machinery for pre-processing of fish

Preliminary processing of fish usually consists of the following steps or unit processes: size grading and washing, evisceration, deheading, scaling, cutting of fins and belly flaps, slicing of whole fish into steaks, filleting, skinning, grinding of skinned fillets etc. A variety of equipment and machinery are employed to facilitate these tasks.

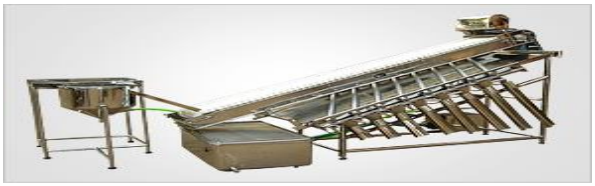
a) Size grading and washing machine

The processing sequence starts from grading the fish by species and size. Sorting by species or on the basis of freshness and physical damage are still manual processes, but grading of fish by size is easily done with mechanical equipment. Mechanical graders yield better sorting precision for fish. Generally size graders work on two smooth rotating rollers that are installed above the surface of the conveyor belt and the distance between the rollers and belt can be adjusted according to the maximum thickness of the sorted fish. Thinner animals fall off the belt while the thick ones are retained on it until the end of line. The device serves simultaneously as a grading machine and a conveyor. For shrimps, the equipment mainly consists of a driving device, a transmission drum, a conveyer belt, a groove type upper

supporting roller, a lower supporting roller, a rack, a sweeper, a tension device, a turnabout drum, a guide chute, an electric control device, etc.



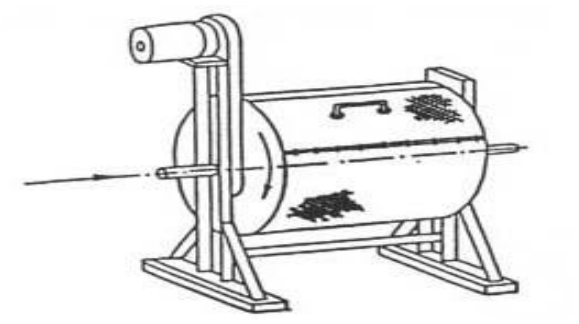
Fish size grader



Shrimp size grader

b) De-scaling machine

Most common type of descaling machine is a cylindrical de-scaler with a horizontal rotation axis that can be periodically tilted during a scaling cycle which causes fish to tumble inside the drum, and consequently scales more efficiently. In some fish species, the scales can be removed from fish with a pressurized stream of water while fish is placed inside the scaler drum. The drums of such devices are made either of stainless mesh with rough edges or of stainless sheets perforated with contoured slits which detach the scales. Water has to be injected into the drum for the machine to operate. Another type is the vertical cylindrical scaler with rotating bottom and fixed side wall is widely used in small fish processing plants. Fish is loaded from the top and unloaded through the door in the side wall. Scales catch on small contoured slits cut in the bottom and side wall of the device, and are thus pulled out of the skin. The same machines can be used for slime removal.



Cylindrical de-scaler with a horizontal rotation axis

Yet another type is mechanized and power-assisted hand-held scalers commonly used in small processing plants. Electrical hand-held scalers simplify and speed up the scaling procedure. They are most commonly used for secondary scaling of fish which has left the automated scaling device 80-90% free of scales. Use of electrical hand-held scalers reduces labour intensity and assures complete elimination of scales. The power-assisted tool consists of a cylindrical rotating scraper powered by an electric motor and connected to it with a flexible rod.

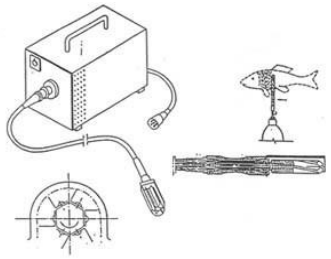
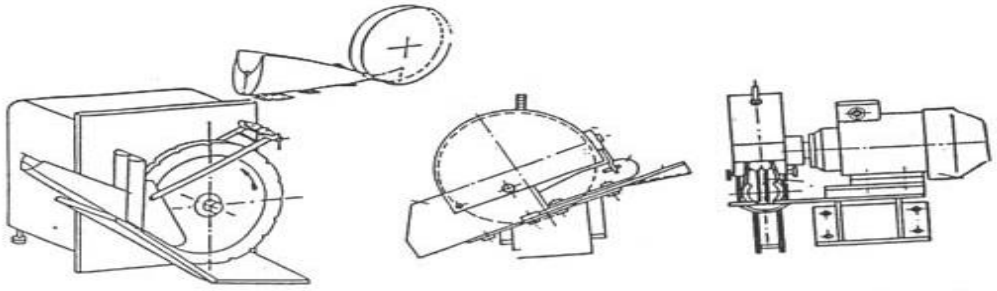


Figure 3.7 Electrical scaler

Power-assisted hand-held scalers

c) Filleting machine

The simplest filleting machine for gutted and deheaded fish has two disc knives set from each other at a distance equal to the thickness of the fish's backbone. Filleting speed of these devices is usually 30-40 fishes/minute: they are efficient and the quality of the final product is good. However, manual processing yields better results. The size range of the processed fish is usually 20-45 cm. Machines of different design and with bigger knives are used for processing larger fish. Filleting devices are produced in several countries and are increasingly used in small processing plants. Meat left on the fish's backbone after filleting can be recovered to a high degree using a meat-bone separator. Up to 50% of the total mass of processed backbones can be recovered as meat.

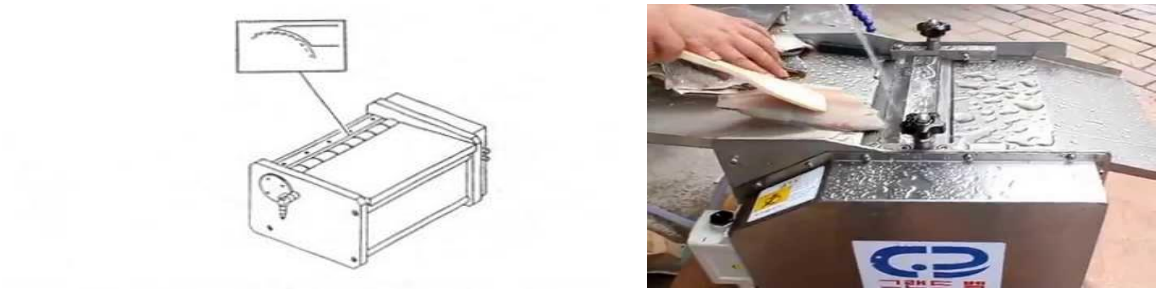


Filleting machine in operation

d) Fish skinner

The simplest and most inexpensive automated tool for skinning of fillet with or without scales can be attached to the processing table. It consists of an oscillating knife powered with a small electric motor and a system of compression springs operated with a foot pedal. Water

is not needed to operate this device. One end of the fillet is placed in a slit between the knife and compression element and the tip grasped manually in a wrench which allows the skin to be pulled off the meat from under the oscillating knife. Some devices are small and can be placed directly on the processing table; running water and electricity are necessary for their operation. Efficiency varies depending upon the fish species. Some are quite expensive and their use is profitable only when a certain level of production is maintained.



Fish skinner

2) Machinery for coated products

Coated product is one, which is coated with another foodstuff. They are an important item among the group of value added fish products and are processed out of a variety of fish and shell fish. Coated fishery products include fish cutlets, fish balls, fish fingers etc. Depending on the scale of operation, industrial and bench-top model machinery is employed for manufacturing coated products.

a) Meat-bone separator

This equipment is used to separate meat from fish. The principle is forcing the fish against a screened or slotted surface when the flesh passes through the openings as finely ground paste. A common type of machine is the belt and drum type. In the separator machine, meat is squeezed through holes into the cylinder under pressure applied by a conveyor belt partially encircling the cylinder. The cylinder rotates slightly faster than the conveyor. The openings in the cylinder are usually 3-7 mm in diameter. For processing of freshwater fish, the holes are 4 and 5 mm in diameter. The smaller the holes is, the stronger the grinding action. Pressure applied by the conveyor to the cylinder can be regulated depending on the type and size of the raw product and on the hole diameter.

Belt and drum type meat-bone separator

b) Fish Meat Strainer

Fish mince produced using the meat bone separator is refined further by passingit through a strainer, which will remove bone fragments and small pieces of bellylining etc. The Fish meat strainer mainly consists of strainer drum withperforations less than 1 to 2 mm in diameter and a screw conveyer to push the mince through the strainer drum and a valve opening at the endof the drum. When the equipment is operated, bone free mince is forced throughthe perforations and the fin, bones and other wastes are pushed to the end portionof the drum from there they are periodically removed by opening the valve.

Meat strainer

c) Forming machine

When a uniform shape is needed for the coated products like fish fingers, it is easy to cut the blocks into suitable sizes. But when there is demand for different shapes like round, oval, star and other forms a forming machine is required. Dyes with different shapes that can form desired shapes can be designed and fabricated. Depending on the market preference, the product can be framed into any shape. A forming machine does the job of shaping the product to the required shape.

d) Pre-dusting machine

To remove the greasiness or wetness and increase the batter pick up, the substrate to be coated are passed through the pre-dust or the dry batter itself before the application of batter. This process is called as pre-dusting. Predusts are usually applied by a breading machine suitable for handling flour. A special sprinkler conveyor may be added for applying a thin, even layer to the top of the product.

e) Battering and breading machine

The basic purpose of a coating machine is to achieve uniform coating. Also, it is necessary to make all the operations in a uniform style till the product is packed. Battering and Breading Machine is a conventional machine where the two applications viz. battering and breading can be carried out continuously. This equipment is a combination of one battering unit and a breading unit coupled together so that after the application of batter, the fish portions are transferred to the breading unit by the conveyer system.

Battering and breading machine with integrated forming unit

f) Fryers

Frying is one of the fastest heat transfer methods available for cooking. It is a simple and commonly used technique for developing flavour, colour and unique product characteristics that cannot be duplicated by any other methods. Frying can be accomplished in a batch or continuous system. Batch system is recommended for small-scale production and continuous system for large-scale commercial production. The type of product and its sensory qualities and physical dimensions all have to be considered while selecting a frying system.

Fryer

3) Freezers

For freezing whole fish and processed fish products, different types of freezers are available. The freezers selected for freezing depends on the type of products, quality requirements of the products and type of packaging. The common freezers used are plate freezers, air blast freezers, and cryogenic freezers.

a) Plate freezers

In a contact freezer or plate freezer the fish is frozen by direct contact with a refrigerated surface, typically between two hollow metal plates cooled by a refrigerant, such that the distance between the plates can be varied up to 100 mm or more. Horizontal and Vertical types of plate freezers are available. Horizontal freezers are generally used in processing plants in which fish, especially in flat packs such as laminated blocks, is frozen between two or more hollow, horizontal, parallel plates through which refrigerant passes. In a vertical plate freezer, the refrigerated, parallel plates are vertical and it is used mainly at sea or onshore for freezing large 25 or 50 kg blocks of whole, gutted, or headed and gutted fish.

Horizontal plate freezers

Vertical plate freezer

b) Air Blast Freezers

In an air blast freezer, fish is frozen in a stream of high velocity cold air either in a batch or continuously, typically in a duct or tunnel in which a stream of cold air is guided over the product on shelves (batch) or on a conveyor (continuous air blast freezer); also called blast freezer, freezing tunnel, tunnel freezer. The advantage of the blast freezer is its versatility. It can cope with a variety of irregularly shaped products and whenever there is a wide range of shapes and sizes can be frozen. Continuous air blast freezers and batch air blast freezers are used.

Air blast freezer

c) Tunnel Freezer

The equipment has a food grade conveyor belt passing through an insulated chamber. It has an air-cooling system and an air blower to blow the air through the tunnel. Cold air is blown to the tunnel counter to the movement of the belt. The product to be frozen is passed through the belt. Circulating cold air at high speed enables the product to be frozen at a moderately rapid rate. Usually, the air temperature is between-18 and -34°C or lower. The moving of the product counter current to the cold air at a speed of 1 to 20 meter/second enables freezing to take place at a rapid rate. It is the popular method to prepare frozen fish products as IQF(Individually Quick Frozen).

Marine products of small size like prawns in different forms and style can be fluidized by forming a bed of the products on a perforated mesh belt and then forcing cold air upwards through the bed at a rate sufficient to partially lift or suspend the particles. The air used for fluidization should be sufficiently cooled; freezing can be achieved at a rapid rate. An air velocity of at least 2 meter/sec. or more is necessary to fluidize the particles and an air temperature of - 35°C is common.

Tunnel Freezer

d) Spiral belt freezer

Modern designs of belt freezers are mostly based on the spiral belt freezer concept. In these freezers, a product belt that can be bent laterally is used. It usually consists of a self-stacking and self-enclosing belt for compactness and improved airflow control. The number of tiers in the belt stack can be varied to accommodate different capacities and line layouts. The belt is continuous. The products are placed on the belt outside the freezer where it can be supervised. As the belt is continuous, it is easy for proper cleaning. Both unpacked and packed products are frozen and the freezer gives a large flexibility both with regard to product and freezing time. Both horizontal and vertical air flow can be used.

Spiral belt freezer

e) Cryogenic Freezer

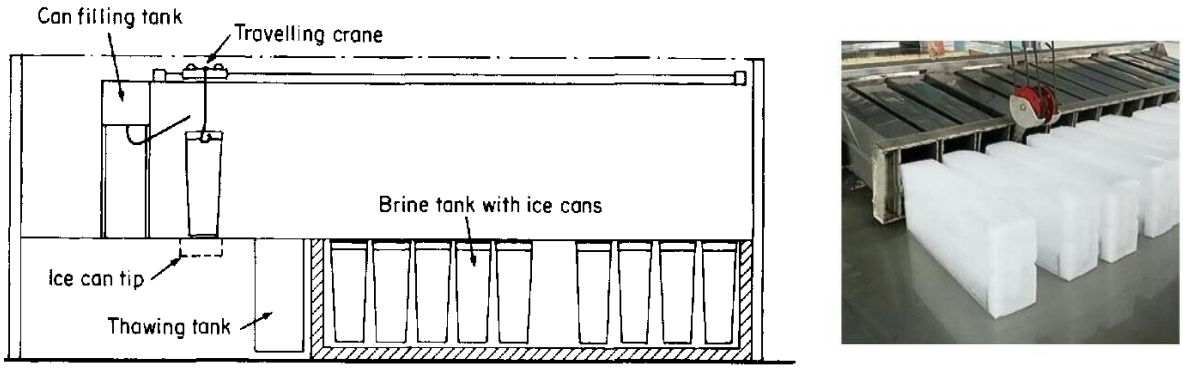
Cryogenic freezing refers to very rapid freezing by exposing food products to an extremely cold freezant undergoing change of state. The fact that heat removal is accomplished during a change of state by the freezant is used to distinguish cryogenic freezing from liquid immersion freezing. The most common food grade cryogenic freezants are boiling nitrogen and boiling or subliming carbon dioxide. Liquid nitrogen is used in most of the cryogenic food freezers. Usually, liquid nitrogen is sprayed or dribbled on the product or alternatively very cold gaseous nitrogen is brought into contact with the product.

4) Equipments for manufacturing ice

Cold preserves and maintains the quality of fish and fishery products and protects them against premature spoilage. Ice is a reliable coolant that has been put to good use for cooling fish both on and off shore. Ice can be produced in different shapes; the most commonly utilized in fish utilization are flake, plate, tube and block.

a) Block ice maker

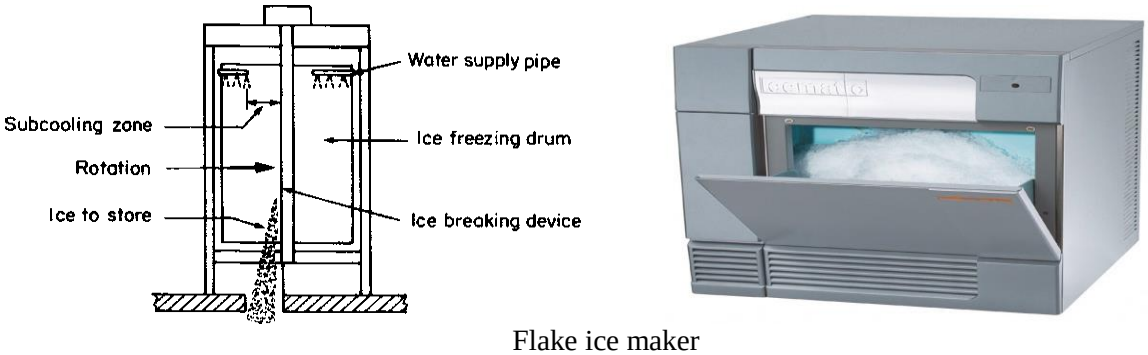
The traditional block ice maker forms the ice in cans which are submerged in a tank containing circulating sodium or calcium chloride brine. The block weight can vary from 12 to 150 kg, depending on requirements. A travelling crane lifts a row of cans and transports them to a thawing tank at the end of the freezing tank, where they are submerged in water to release the ice from the moulds. The cans are tipped to remove the blocks, refilled with fresh water and replaced in the brine tank for a further cycle. With an appropriate ice crushing machine, block ice can be reduced to any particle size but the uniformity of size will not be as good as that achieved with some other forms of ice. In some situations, block ice may also be reduced in size by a manual crushing method.



Block ice maker

b) Flake ice maker

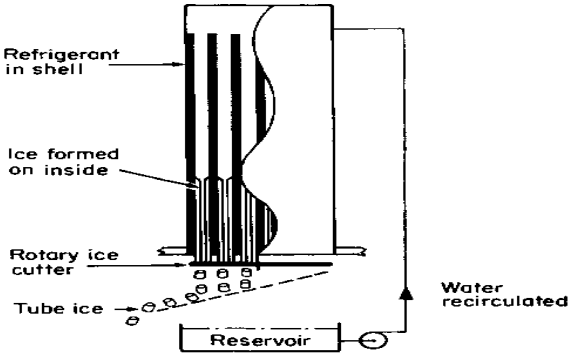
This type of machine forms ice 2 to 3 mm thick on the surface of a cooled cylinder and the ice is harvested as dry sub-cooled flakes usually 100 to 1,000 mm² in area. In some models, the cylinder or drum rotates and the scraper on the outer surface remains stationary. In others, the scraper rotates and removes the ice from the surface of a stationary drum, in this case, built in the form of a double-wailed cylinder. It is usual for the drum to rotate in a vertical plane but in some models the drum rotates in a horizontal plane. The refrigerant temperature, degree of sub-cooling and speed of rotation of the drum are all variable with this type of machine and they affect both the capacity of the machine and the thickness of the ice produced.



Flake ice maker

c) Tube ice maker

Tube ice is formed on the inner surface of vertical tubes and is produced in the form of small hollow cylinders of about 50 x 50 mm with a wall thickness of 10 to 12 mm. The tube ice plant arrangement is similar to a shell and tube condenser with the water on the inside of the tubes and the refrigerant filling the space between the tubes. The machine is operated automatically on a time cycle and the tubes of ice are released by a hot gas defrost process. As the ice drops from the tubes a cutter chops the ice into suitable lengths, usually 50 mm.



Tube ice maker

d) Plate ice maker

Plate ice is formed on one face of a refrigerated vertical plate and released by running water on the other face to defrost it. Other types form ice on both surfaces and use an internal defrost procedure. Multiple plate units are arranged to form the ice-making machine and often these are self contained units incorporating the refrigeration machinery in the space below the ice-maker. The optimum ice thickness is usually 10 to 12 mm and the particle size is variable. An ice breaker is required to break the ice into a suitable size for storage and use.

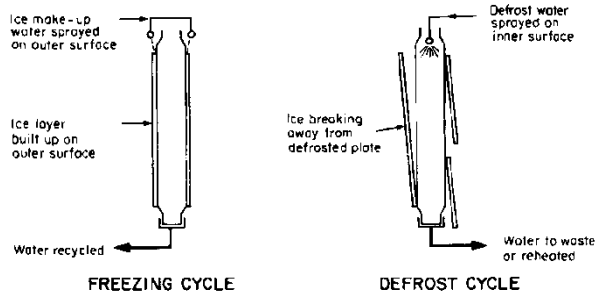


Plate ice maker

5) Fish dryers

Fish smoking and drying are preservation techniques that are widely used in small-scale fisheries communities in developing coastal regions.This is advantageous compared to fresh or frozen fish which requires cold storage that is largely inaccessible due to electricity scarcity in rural areas.

a) Mechanical dryers

In mechanical dryers, removal of water from the fish is achieved by an external input of thermal energy. This is an expensive method since there is need of fuel for heating and

maintenance of the temperature. The drying chamber consists of a long tunnel in which the washed and cleaned fish is placed on trays or racks. A blast of hot air is passed over the material to be dried. After the required degree of drying the product is removed from the drier and packed. In mechanical dryers usually the heat is transferred into the product through a hot gas.eg. Kiln dryers, cabinet dryers, tunnel dryers and fluidized bed dryers.

b) Solar Dryers

In solar dryers during sunny days fish will be dried using solar energy and when solar radiation is not sufficient during cloudy/ rainy days, other back up heating system will be automatically actuated to supplement the heat requirement. Thus continuous drying is possible in this system without spoilage of the highly perishable commodity to obtain a good quality dried product. Designs of solar dryer vary from very simple direct dryers to more complex hybrid designs. The hybrid model Solar Dryers are having LPG, Biogas, Biomass or Electricity as alternate back up heating source for continuous hygienic drying of fish even under unfavourable weather conditions. The capacity of these hybrid solar dryers varies from 6 sq.m to 110 sq.m tray spreading area for drying fish (capacity 10kg to 500kg).CIFT has developed different models and capacities of solar dryers for hygienic dying of fish

CIFT developed hybrid solar dryer

.

6) Machinery for thermal processing of fish

Thermal processing of fish by canning or retorting is a method of food preservation in which food is packed in metal or glass or plastic containers, sealed air tight and heated sufficiently to destroy the spoilage, pathogenic and food poisoning organisms making the food safe for consumption. The process involves a lot of machinery and the important ones are mentioned below.

a) Pre-cookers

Larger sized fishes like Tuna are given a pre-cook by heating at a temperature range of 100 ºC. This operation is necessary to make it possible to hand pick the light meat from the carcass and also to remove some of the oil from oily fish.The most common pre-cookers are live-steam cookers fitted with condensate drains, vents and safety valves. The fish is placed in baskets which are placed on racks. The racks of butchered fish are rolled into the cookers which are usually of rectangular cross section and made of reinforced steel plate with a door, or doors, at one or both ends. The pre-cooking is a batch type operation.Steam is admitted through a steam spreader on the floor of the cooker. Steam vent and drain valves are provided to permit removal of air and condensate. Pre-cooking may also be carried out in boiling brine.

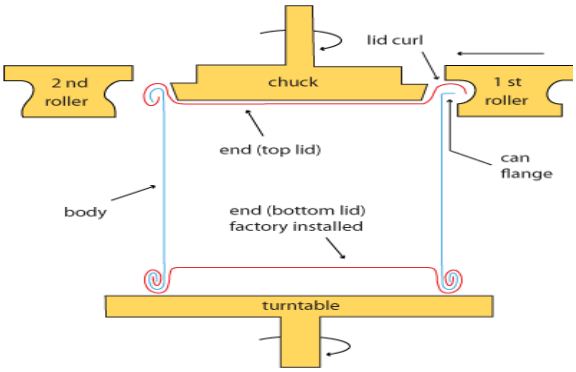
b) Exhaust boxes

The exhaust box is used to heat the contents of cans, so that they may be sealed hot, thus ensuring that, after cooling, a vacuum has formed in the container. Exhausting also drives entrapped air from the pack. Exhaust boxes may take many shapes and forms, depending on the requirements of the cannery; basically they consist of a tunnel through which the open and filled cans pass while being exposed to atmospheric steam.

Exhaust box

c) Sealing machines or can seamers

It is a machine used to seal the lid to the can body. The simplest of machines are hand operated or semi-automatic single-head equipment with motorized drives. For those with a low output, hand operated models are ideal.The sealing operation is initiated by depressing a foot pedal which lifts the can up to the chuck on the sealing head and into position for double seam rolling. The first and second action rollers are sequentially brought into action while the can is rotated by the spinning seaming head. At the completion of the seaming operation the sealing chamber is opened to the atmosphere and the hermetically sealed container is removed. Machines of the type described can frequently have the facility for steam flow closing, in which case steam is injected across the headspace of the container immediately prior to double seaming.

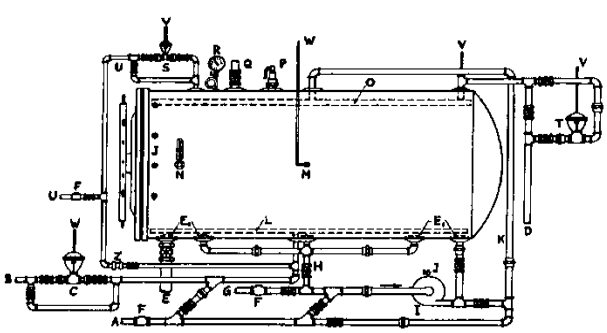


Can seamer

d) Retorts

All canned fish products are sterilized at temperatures above 100 ºC. Thermal process sterilization takes place in retorts, with or without water. Overpressure is between 2-3 kg/cm². The simplest and most common retorts today are horizontal, or vertical, batch retorts. The most frequently used style of retort found in commercial fish canneries today, is the static batch system for processing cans in saturated steam. The most significant difference between static retorts and continuous systems is that the latter must have container transfer mechanisms to regulate the movement of cans at a predetermined rate through the heating and cooling sections. Batch retorts heated with water under pressure are vertical or horizontal

and are most frequently used for sterilization of products packed in aluminium cans with score-line easy open ends.



Horizontal retort

7) Machinery for packaging

Packaging is a crucial element in the safety and protection of processed fishery products during its shelf life. It uses a variety of different materials to protect food and provide surfaces for labelling. Important machinery used for common packaging applications are discussed.

a) Sealers

Sealers are used in multiple forms of flexible packaging applications. A heat sealer uses heat to melt plastic or adhesive together to seal off a package. Heat sealers are used for many different products to help protect from product tampering and contamination. They can be used in small operations and fully automatic operations. Heat sealing systems use a combination of heat, time and pressure to create a seal with a set of crimp seal heating bars. When the jaws come together, this melts a layer of plastic and bonds the two layers of film together. Different types of sealers are:

Band sealers are used to seal pouches and can be horizontal or vertical. In the typical embodiment, a moving pair of band grasps the top of the package and moves it past the heating elements. Packages can be supported from beneath by a moving conveyor or in the case of lightweight packages, held by the sealing bands themselves.

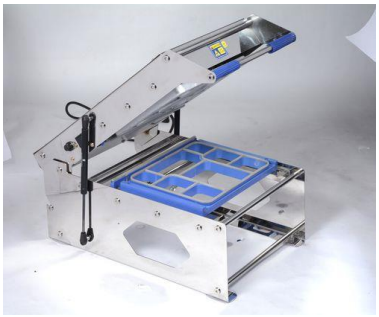
Blister sealers and tray sealers are used to attach thermoformed blisters to paperboard or film backings and can range from single package per cycle manual shuttle units to automated rotary type machines. In case of tray sealers, plastic films are sealed over open ends of thermoformed plastic trays.

Vacuum packaging involves the removal of air from the package and the application of a hermetic seal. **Vacuum sealers** are used primarily for packaging owing to the benefit of low oxygen levels for retarding spoilage. Vacuum machines often incorporate a chamber for evacuating the package or tray prior to sealing the top layer or cover into place. They can be manual, semi-automatic, or automatic machines.

A **vertical form fill sealing machine** is a type of automated assembly-line product packaging system. The machine constructs plastic bags and stand-up pouches out of a flat roll of film, while simultaneously filling the bags with product and sealing the filled bags. Both solids and liquids can be bagged using this packaging system.

Hand sealer

Band sealer



Tray sealer

b) Labelling and coding machines

Labelling and coding machines are used for industrial and retail packaging applications. Most packaged products use some form of labelling or coding. Labelling machines are used for applying branded labels for advertising and/or bar codes for inventory and batch management.

Labelling and coding machines

c) Strapping and bundling machines

The most popular use for strapping machines is a reinforcement of heavy boxes during shipping and retail sales. Polypropylene strapping is commonly used. Strapping machines use heat to mend ends together for durable reinforcement. Another use for a strapping machine is bundling applications. Strapping can help unitize multiple products together and secure products for transport.

Strapping and bundling machine

References

V.Claude(2010) Retorting Machinery for the Manufacture of Heat-Sterilised Fish Products. In:Fish Canning Handbook, L. Bratt (ed), Blackwell Publishing Ltd. pp. 179-209

Bykowski, P. and Dutkiewicz, D.Freshwater fish processing and equipment in small plants.FAO Fisheries Circular.No. 905. Rome, FAO. 1996. 59p.

A. A.Gonçalves and F. Blaha (2010) Cold chain in seafood industry. In: Refrigeration: Theory, Technology and Applications, M. E. Larsen (ed), Nova Science Publishers. pp.287-367

Graham, J., Johnston, W.A., Nicholson, F.J.Ice in Fisheries. FAO Fisheries Technical Paper.No. 331. Rome, FAO. 1992. 75p.

Chapter 7

Salt curing, smoking and drying of fishery products

Mr. K. Sathish Kumar
Scientist, Fish Processing Division, ICAR-CIFT
Email: sathishcife@gmail.com

Introduction

There are various methods of preserving fish by curing, including drying, salting, smoking, marinating, combinations of these methods, and fermentation (FAO, 1983). Curing is an ancient preservation technique. Despite the fact that curing has undergone changes in the course of history, in principle, it remains fundamentally the same. White fish species are traditionally preserved by salting because they contain fewer lipids, while fatty pelagic species are generally preserved by smoking and marinating due to their high fat content. There have been changes in the methodology and/or the equipment used in salting and smoking, but marinating and fermentation processes follow the traditional practices, which are very closely tied to certain geographical regions.

Salting

Salting is one of the oldest methods of preservation of fish. Salting is usually done as such or in combination with drying or as a pre-treatment to smoking. The presence of sufficient quantities of common salt (sodium chloride) in fish can prevent or drastically reduce bacterial action. Salting amounts to a process of salt penetration into the fish flesh when fish is placed in a strong solution of salt (brine) which is stronger than the solution of salt in the fish tissue. Penetration ends when the salt concentration of the fish equals that of the surrounding medium. This phenomenon is known as osmosis. It is based on different factors like diffusion and biochemical changes in various constituents of the fish. This process facilitates preservation of fish by reducing the water activity. A concentration of between 6–10 % salt in the tissue together with the removal of some water from the tissue during the salting process will prevent the activity of most spoilage bacteria. If fish are salted before drying, less water needs to be removed to achieve preservation. A water content of 35–45%, depending on the amount of salt present, will often prevent, or drastically reduce, the action of bacteria.

Salt: Source and properties

Common salt, in its purest form consists of sodium chloride (NaCl). However almost all commercial salts contain varying levels of impurities depending on the source and method of production.

Based on the source as well as method of manufacture, common salt can be grouped as:

Solar salt: prepared by the evaporation of sea or Salt Lake waters by the action of sun and wind.

Brine evaporated salts: produced from underground salt deposits which are brought to the surface in solution form and is heat evaporated.

Rock salt: obtained as natural deposits from interior rock mines which are ground to varying degrees of fineness without any purification.

Chemical composition

Commercial salts vary widely in their composition with best quality salt containing up to 99.9 % sodium chloride, whereas low quality salt may only contain 80 % sodium chloride. The main chemical impurities of commercial salts include calcium and magnesium chlorides and sulphates, sodium sulphate and carbonate, and traces of copper and iron. Apart from these, contaminants such as dust, sand and water may also be present in salt. Presence of calcium and magnesium chlorides even in small quantities tends to slow down the penetration of salt into the flesh and hence their presence may lead to increase in the rate of spoilage. Further magnesium chloride is hygroscopic and tends to absorb water, making the fish more difficult to dry and to keep dry. Calcium and magnesium salts give a whiter colour but tend to impart a bitter taste. Very often the consumer demands a whitish colour in salted fish products and small quantities of calcium and magnesium compounds in the salt are usually considered desirable. Excessive quantities, however lead to a bitter flavour and the dried product tends to be brittle which can cause problems during packaging and distribution. Trace quantities of copper in salt can cause the surface of salted fish to turn brown affecting the appeal of dried fish.

Microbiological purity

Many commercial salts, particularly solar salts, contain large numbers of salt tolerant bacteria (halophiles) and counts of up to 105/g have been recorded. A group of halophiles, also referred to as the red or pink bacteria, can be a problem in commercial fish curing operations as they cause a reddening of wet or partly dried salt fish. Halophilic moulds tend to grow on dried fish under favourable conditions causing the formation of dark patches called 'dun'. They tend to occur more frequently in rock salt.

Physical properties

Fine grain salt dissolves more rapidly in water and is preferred for making brines. However, on direct application of fine grain salt on fish causes a rapid removal of water from the surface which becomes hard and prevents the penetration of salt to the inside of the fish, a condition referred to as 'salt burn'. Hence for dry salting, a mixture of large and small grain sizes of salt is recommended.

Types of Salting

Dry salting: This is the most widely used method of fish curing. Dry salting is advisable for fishes of any size, except fatty fishes. The fish is gutted, beheaded or ventrally split open and the viscera removed followed by washing. Scoring is also practiced if the flesh portion is thick for facilitating better salt penetration. Salt is then applied in the ratio 1:3 to 1: 10 (salt to fish) depending upon the size of the fish. The fish is then stacked in clean cement tanks or other good containers layered with salt and weight is applied from top for better salt penetration. The fish is kept in this condition for 24-48 hours. After salting period, the fish is

taken out, washed in brine to remove adhering salt and drained. It is then hygienically dried to a moisture content of about 25%. Yield of the product by this method is about 35-40% with a storage stability of up to three months under ambient conditions.

Wet salting: The initial stages of processing and salting are the same as for dry curing. However, the fish kept in tank is allowed to remain in self-brine till marketing without further drying. For marketing, as per the demand the wet salted fish is drained and packed in palmyrah leaf baskets or coconut leaf baskets. This method is particularly suitable for fatty fishes like oil sardine, mackerel etc. Wet salted fishes have short shelf stability with moisture content of 50-55% and a salt content of around 25%.

Pickle salting: Pickle curing is a type of wet salting where the fish is layered by granular salt which, dissolves in the surface moisture of the fish forming solution which penetrates into the fish removing moisture from the fish. The fish is allowed to remain in this self-brine. If the self-brine is not sufficient, saturated brine is added to immerse the fish.

Kench salting: In this method, salt is rubbed on to the surface of the fish and stacked in layers of salt and fish. The self-brine formed is allowed to drain away. This method cannot be recommended for general use in the tropics as the fish are not covered by the brine or pickle and are therefore more susceptible to spoilage and insect attack. Exposure to the air and the presence of salt also encourages the rate of fat oxidation which gives rise to discoloration and the characteristic rancid flavours.

Mona curing: Mona curing is mainly adopted for medium to small size fishes. Before salting, the intestine and entrails are removed by pulling out through the gill region without split opening the fish. The flesh is not exposed during salting thereby causing less contamination and the product has a shelf stability of about two months. The yield obtained by this method is about 70%.

Pit curing: In this method, fish is mixed with salt (4:1) and placed in pits dug on beaches. The pits may be lined with palymrah / coconut leaves. After 2-3 days of maturation, the fish is taken out for marketing in wet condition and packed in bamboo baskets and transported to markets without drying. The quality of fish cured by this technique is poor with a shelf stability of upto three weeks only.

Colombo Curing: Colombo curing is similar to pickling process which is widely practiced in Sri Lanka. A piece of dried Malabar tamarind (*Garginia cambogea*) is kept in the abdomen portion of the gutted and cleaned fish which is further stacked in airtight wooden barrels filled with brine. Fishes cured by this method has a shelf life for upto 6 months.

Quality issues in dried and salted fish

Pink/Red: Salt content prevents the growth of normal spoilage micro-flora in the fish but halophiles, which can survive at 12-15% of salt concentration, will survive. Halophilic bacteria are present in most of the commercial salt. A particular group of halophiles called Red / Pink cause reddening of wet or partially dried salted fish. These do not grow in brine or in fully dried fish. They are aerobic and proteolytic in nature, grows best at 36ºC by decomposing protein and giving out an ammoniacal odour. Spoilage appears on the surface as slimy pink patches. However, these bacteria are not harmful in nature. Usage of good quality salt is recommended to avoid this condition. This spoilage is mostly found in heavily salted fish and absent in unsalted fish.

Dun: In salted fish, brownish black or yellow brown spots are seen on the fleshy parts, referred to as "dun". This is mainly caused by growth of halophilic mould called *Sporendonema epizoum*. This gives the fish a very bad appearance. Moulds usually grow at relative humidity above 75%. The optimum temperature for growth is 30-35 ºC. During the initial stages of appearance of moulds on the fish, it is possible to remove them manually. In advanced stages it penetrates into the flesh. To avoid the mould growth it is necessary that the fish be dried, packed and stored properly to avoid uptake of moisture. Chemical method of prevention includes dipping the fish in a 5% solution of calcium propionate in saturated brine for 3-5 minutes depending upon the size of the fish.

Salt Burn: A mixture of large and small grain sizes is recommended for dry salting of fish. If fine grain is used directly on the fish, salt burn may occur due to the rapid removal of water from the surface with no penetration of salt to the interior of the fish.

Case hardening: Under certain conditions, where the constant rate drying is very rapid due to high temperature and low relative humidity, the surface of the fish can become 'case hardened' and the movement of moisture from the deeper layers to the surface is prevented. This can result in a fish which is dry at surface. However, the centre remains wet and hence spoils quickly.

Rancidity: This is caused by the oxidation of fat, which is more pronounced in oil rich fishes like mackerel, sardine etc. The unsaturated fat in the fish reacts with the oxygen in the atmosphere forming peroxides, which are further broken down into simple and odoriferous compounds like aldehydes, ketones and hydroxyl acids, which impart the characteristic odors. At this stage the colour of the fish changes from yellowish to brown referred to as rust. This change results in an unpleasant flavour and odour to the product, leading to consumer rejection.

Insect Infestation: Spoilage due to insect infestation occurs during initial drying stages as well as during storage of the dried samples. The flies which attack the fish during the initial drying stage are mainly blowflies belonging to the family Calliphoridae and Sarcophagidae. These flies are attracted by the smell of decaying matter and odours emitted from the deteriorating fishes. During the glut season when the fish is in plenty and some are left to rot, these flies come and lay their eggs. These eggs develop into maggots, which bury within the gill region and sand for protection from extreme heat. and develop mainly when conditions are favourable. The most commonly found pests during storage are beetles belonging to the family Dermestidae. Beetles attack when the moisture content is low and especially when the storage is for a long time. The commonly found beetles are *Dermestes ater*, *D frischii*, *D maculates*, *D carnivorous* and *Necrobia rufipes*. The larva does most of the damage by consuming dried flesh until the bones only remain. Mites are also an important pest, which are found infesting dried and smoked products. *Lardoglyphus konoi* is the commonly found mite in fish products. Infestation can be reduced by proper hygiene and sanitation, disposal of wastes and decaying matter, use of physical barriers like screens, covers for curing tanks etc, and use of heat to physically drive away the insects and kill them at 45 º C.

Fragmentation: Denaturation and excess drying of fish results in breaking down of the fish during handling. Fish can become brittle and liable to physical damage when handled roughly. Insect infestation is also a reason behind fragmentation in dried samples. It is necessary that fresh fish be used as raw material to ensure a good finished product.

Smoking

Smoking is an ancient method of food preservation, which is also known as smoke curing, produces products with very high salt content (>10%) and low water activity (~0.85). Smoking is a process of treating fish by exposing it to smoke from smouldering wood or plant materials to introduce flavour, taste, and preservative ingredients into the fish. This process is usually characterised by an integrated combination of salting, drying, heating and smoking steps in a smoking chamber. The drying effects during smoking, together with the antioxidant and bacteriostatic effects of the smoke, allow smoked products to have extended shelf-life. Smoked seafood includes different varieties like, smoked finfish and smoked bivalves. Many of the smoked products are in the form of ready-to-eat.

Developments of modern food preservation technology, such as pasteurization, cooling/refrigeration, deep-freezing, and vacuum packaging, have eclipsed the preserving functions of many traditional methods including smoking. Nowadays, the main purpose of smoking has been shifted for sensory quality rather than for its preservative effect.

Depending upon how the smoke is delivered into the food and smoking temperature, four basic types of smoking can be defined: hot smoking, cold smoking, liquid smoking, and electrostatic smoking. Hot smoking is the traditional smoking method using both heat and smoke, which usually occurs at temperatures above 70 °C. For smoked fish and fisheries products, a minimum thermal process of 30 min at or above 145 °F (62.8 °C) is required by FDA (2001). Therefore, after hot smoking, products are fully cooked and ready for consumption.

Hot smoking

Torry smoking kiln was introduced in the early 1960s by United Kingdom's Torry Research Station. The Torry smoking kiln is considered as a model for the modern smokers/smokehouses by enabling the precise controls of the heating temperature, air ventilation, and smoke density. Some recently designed smokehouse may also be equipped with more precise time and temperature controls, humidity control, and product internal temperature monitor probes. Thus, the products produced by the modern smokehouses are much more uniform than those produced with traditional smokers. Hot smoking is typically not a single process. Several other steps such as brining, drying and smoking are also involved to produce a product of good quality.

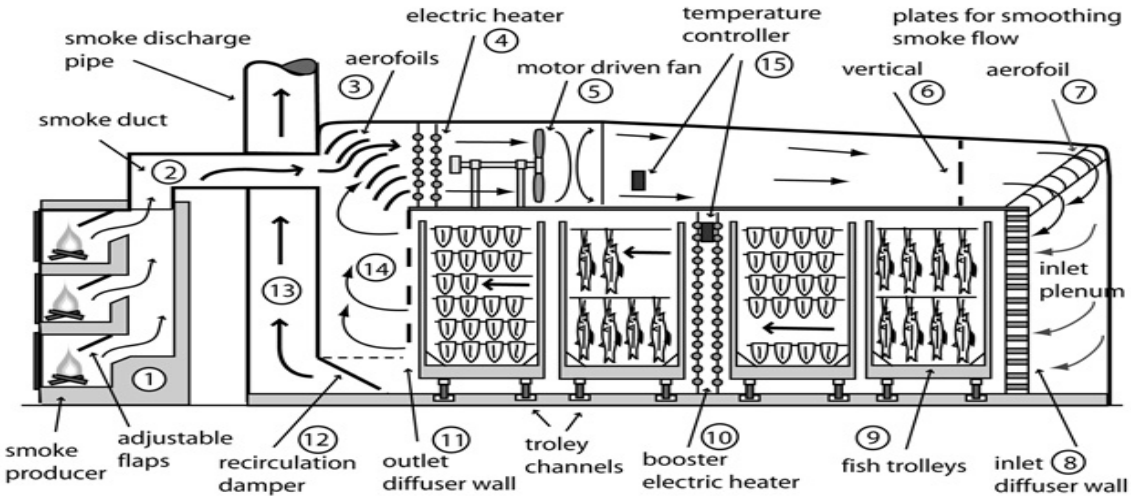


Fig. Illustration of the hot smoke airflow in the Torry smoking kiln

Cold smoking

Fish can also be subjected to cold smoking. Temperatures of cold smoking typically do not exceed 30 °C. Thus, cold smoked products are not cooked and typically heavily salted. Compared to the traditional hot smoking, cold smoking runs longer, has a higher yield and retains the original textural properties much better than the hot-smoked ones. Cold smoking of varied fish species has been reported, including rainbow trout.

Liquid smoking

Liquid smoke is smoke condensate that is dissolved in a solvent, such as water or oil (Maga, 1988). Liquid smoke can be used directly on products by dipping or spraying. It is rapid and much easier to achieve a uniform smoke flavour than traditional cold and hot smoking processes, although the flavour and colour from the traditional smoking cannot be exactly duplicated (Varlet et al., 2007). Some potential harmful ingredients (e.g. polycyclic aromatic hydrocarbons, PAHs) in the nature smoke can be separated out and excluded from the liquid smoke (Chen & Lin, 1997). Other advantages of liquid smoke include easy modification, application to food items that traditionally are not smoked, lower operation cost, and less environmental pollution (Abu-Ali & Barringer, 2007). However, the application of liquid smoking may be expensive compared to other methods. Liquid smoking of fish species had been reported on swordfish, salmon and rainbow trout.

Electrostatic smoking

Electrostatic smoking is another rapid way to smoke. In the electrostatic smoking, fish are sent into a tunnel where an electrostatic field is created. Smoke particles are given a positive charge and deposit onto the surface of the fish which are negative charged. Although this procedure will change the composition of the smoke, the efficiency of smoking is still higher than that of the traditional smoking. It can also be operated continuously. The smoke compound ratio in the vapour phase may be modified by the electrostatic field, which results in increased level of carbonyl compounds (Ruiter, 1979). Factors that may influence the electrostatic smoking operation include the skin thickness, presence of scales, and subcutaneous fat amount (Maga, 1988). This operation may present safety problems to employees. Applications of electrostatic smoking have been reported mainly in salmon and herring.

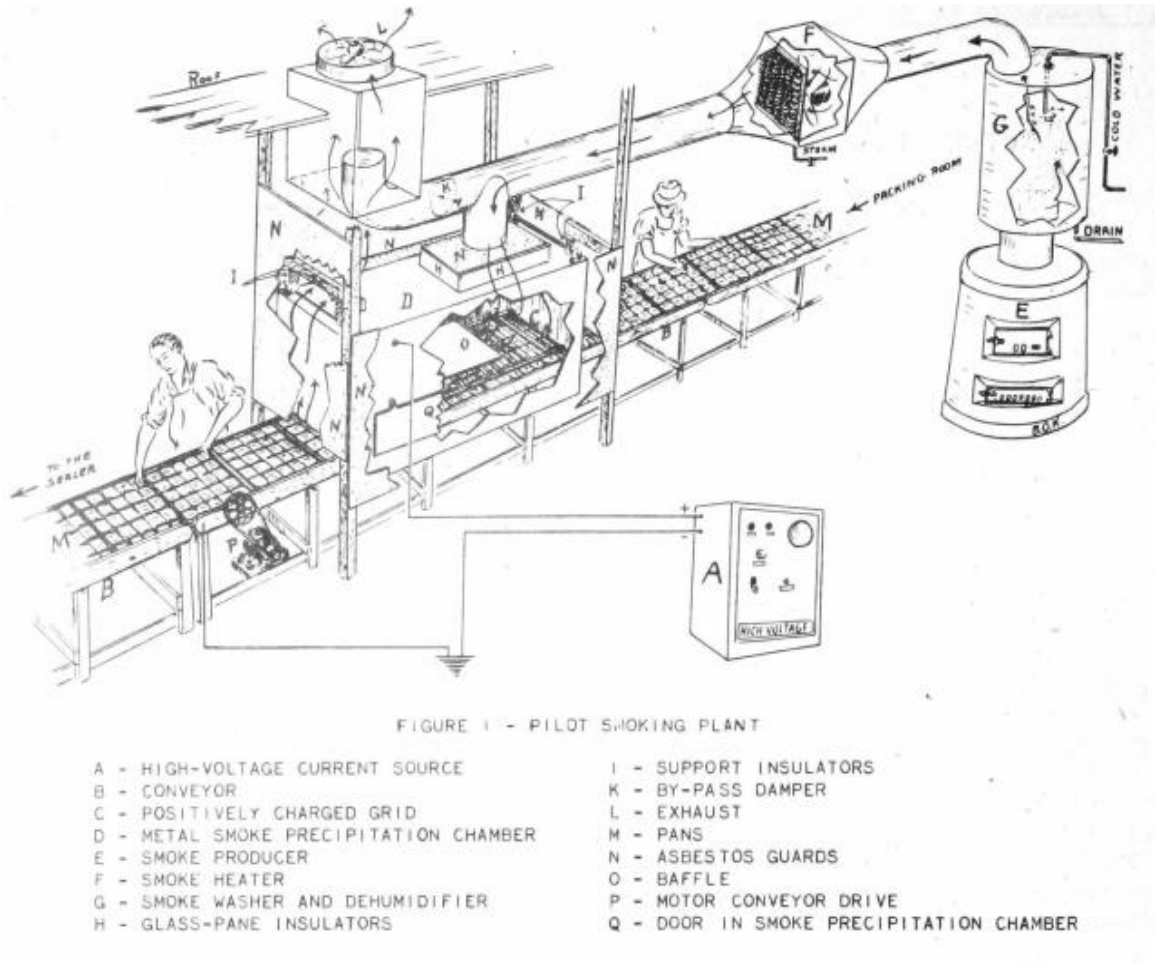


Fig. Schematic diagram of Electrostatic smoking with basic components.

Hot smoking of fish

Good smoked products can only be obtained from good raw material (Dore, 1993). In addition, control of the smoking procedures plays an equal importance in the production of good products. From raw material preparation to final product storage, smoking includes several operations, such as brining, drying, smoking, packaging and storage.

Brining

This is the stage when the flavours and spices are introduced into the fish. Cleaned fish are submerged under a prepared brine solution for a certain amount of time. A brine time less than 12 hours at 3.3 °C (38 °F) is recommended to minimize the possible spoilage in the fish (Lee, 1977). Salt is an important ingredient to be delivered into the fish tissue at this stage as well as a key hazard analysis and critical control point (HACCP) preventive measure for smoked fish. Not only does it bring the taste but also reduces the water activity (a_w) in the product, so that bacterial growth can be inhibited in the smoked fish.

Of all the bacteria that can exist in fish products, *Clostridium botulinum* is a major concern for vacuum or reduced packaged fish products. *C. botulinum* is a strictly anaerobic, gram positive bacillus bacterium. The vegetative cells and their neurotoxins can be easily destroyed by heat (less than five minutes) at 85 °C. However, their spores are very resistant to heat and can survive for up to 2 hours at 100 °C (Caya, 2001). Thus, prevention of

botulism from hot smoked fish products depends on the destruction of all *C. botulinum* spores or inhibition germination of the spores that may be present in the products.

Water phase salt (WPS) is used to measure the amount of salt in the fish products.

The WPS is calculated as (FDA, 2001):

$$WPS = \frac{\%Salt}{\%Salt + \%Moisture} \times 100$$

The higher the WPS value, the less the availability of the water. When sodium chloride is the only major humectant in the cured food, the relationship between the aw and WPS can be express as (Ross & Dalgaard, 2004):

$$a_w = 1 - 0.0052471 \cdot WPS\% - 0.00012206 \cdot (WPS\%)^2$$

or

$$WPS\% = 8 - 140.07 \cdot (a_w - 0.95) - 405.12 \cdot (a_w - 0.95)^2$$

Current regulations require at least 3.5% WPS in the loin muscle of the vacuum packaged smoke products; at least 3.0% WPS if at least an additional 100 ppm nitrite exists in the vacuum packaged product; air packaged smoked fish products must contain at least 2.5% WPS (FDA, 2001).

Several salting methods are available to deliver the salt into the fish. The most common techniques used by the industry are dry and brine salting. Dry salting is widely used in low fat fish. Basically, fish are put into layers with dry salt separating each layer. Water removed by salt is allowed to drain away. Periodical reshuffling of the layers may be necessary to make sure all the fish get uniform salting and pressure. Muscle fiber shrinks more during dry salting than brine salting (Sigurgisladottir et al., 2000b). Thus, dry salting of fish typically results in over-dried fish and low yield. A better quality and higher yield is usually obtained from brine salting.

Fish are brine salted by completely being covered in a prepared brine solution for a certain time period. The brine solution can have a salt concentration from relatively low to saturated levels. Brine salting is also used widely for most fatty fish since oxygen cannot oxidize the fish fat easily. Some modern processors inject the brine to speed up the process, therefore lowering the cost and minimizing the chance of fish deterioration. Salt is distributed evenly in the fish when injection brine is used. A higher brine yield can be obtained through injection brine as compared to brine or dry salting. Flavour ingredients can also be incorporated into the injection solution. However, the injecting brine operation has to be carefully controlled to avoid contamination delivered by the needles into the previously sterile flesh. Brine salting is still one of the most widely used salting methods for smoked fish. Efficiency of salt penetration into the fish tissue is affected by several factors, such as species, physiological state of fish (rigor), fish quality (fresh/frozen) fish dimension (thickness), brine concentration, brine time, brine to fish ratio, brine temperature, fat content, texture, etc.

After brining, fish have to be rinsed with clean water to remove the brine solution on its surface because a harsh, salty flavour can develop due to residues of brine solution.

Drying

It is widely known that reducing the water activity (a_w) will result in a reduction of microbial activity. The a_w is defined as:

$$a_w = p / p_0$$

where p is the vapour pressure of the product, and p_0 is the vapour pressure of pure water at the same temperature (Olley, Doe, & Heruwati, 1989).

For ideal solutions (real solutions at low concentrations), water activity can be calculated from the formula:

$$a_w = n_1 / (n_1+n_2)$$

where n_1 is the number of moles of solvent, and n_2 is the number of moles of the solute.

This relationship may become complex due to the interactions between moisture and the fish tissue and also the relatively high solute concentration involved in cured fish. Drying of the fish can still be simulated with the formula in a way that drying the fish will cause a decrease in n_1 and an increase in n_2, which finally decreases the a_w.

A certain amount of moisture has to be lost from fish after brining; so that water activity (a_w) can be decreased and a good texture can be obtained at the end of the smoking process. Drying of fish occurs at the early stage of smoking process. An air flow is applied on the fish; so that moisture in the fish tissue can migrate to the surface and leave the fish by evaporation. The temperature, relative humidity and velocity of the air flow are keys to the rate of drying. Drying with a low relative humidity air at high velocity may not drive the moisture out of the fish fast. If the temperature is too high fish surface may be hardened at the beginning of drying resulting in a blocking layer to the inside moisture migration. The hardened surface may also prevent smoke penetrating into the tissue, which decreases the preservative effects of the smoke. Tissues under the hardened surface will tend to spoil from inside.

Drying at temperatures below 70 to 80 °C was recommended to minimize the damage to protein quality in fish (Opstvedt, 1989). Drying also influences the quality of finished smoked fish product.

Smoking

Smoke is generated from the incomplete combustion of wood at certain temperatures followed by thermal disintegration or pyrolysis of high molecular organic compounds into volatile lower molecular mass (Eyo, 2001). Smoke is composed of two phases: a particulate or dispersed phase and a gaseous or dispersing phase. The major parts of dispersed phase are particles in the droplet form having an average diameter of 0.196 to 0.346 µm (Maga, 1988; Wheaton & Lawson, 1985). These particles are mainly tars, wood resins, and compounds with high or low boiling points. The dispersed phase is the visible part of the smoke. The dispersing phase is responsible for flavouring, colouring, antioxidative, and bacteriostatic roles of the smoke (Hall, 1997). The composition of the dispersing smoke phase is

complicated, many of which have yet been identified. More than 200 components have been identified. The most abundant chemicals found in smoke are carbonyls, organic acids, phenols, alcohols, and hydrocarbons.

Quality and composition of the smoke are affected by several factors, such as combustion temperature, wood type, moisture content of wood, air ventilation rate, and wood size.

Cellulose, hemicellulose and lignin are three main components in wood and their contents and compositions vary in different types of wood. Cellulose levels are fairly consistent among different species. Softwoods have higher lignin content than hardwoods. Hardwoods typically contain more hemicellulose than softwoods. Decomposition of hemicellulose happens at the early stage of smoking and produces furan and its derivatives as well as aliphatic carboxylic acids, which drops the pH in the smoked product. Softwoods also contain more resin acids than hardwoods, which typically introduces unpleasant flavor to the fish. Hardwoods, such as hickory, oak, cherry, apple and beech, are preferred in most situations over the softwoods for smoke generation. This is because hardwoods tend to produce more phenols and organic acids which contribute to the flavor and preservation effect of smoking (Hall, 1997).

The amount of air present during the production of smoke also influences the results of wood pyrolysis. Lower temperature and less air produce a smoke with more flavoring and preserving substances. While a higher temperature and more air burn the woods into carbon dioxide and water. Smoke production can be influenced by the size of wood. Wood can be used as chunks, chips or sawdust forms. However, their combustion rates will vary if same ventilation rate is used. Sawdust produces more smoke than chunks or chips due to its self-smoldering effect, which blocks the access of oxygen. Fish is also more likely to be charred with less smoke when chunks or chips are used. Most modern smokers use continuously fed sawdust to maintain a consistent production of smoke.

Although people like the flavour and taste of the smoked product, there are concerns about the negative side of smoked products, which are mainly focused on the carcinogenic substances found in the smoke: the polynuclear aromatic hydrocarbons (PAHs). PAHs are composed of multiple fused benzene rings. It can be thermally produced by either high temperature pyrolysis or from the incomplete combustion of materials containing carbon and hydrogen. Up to 100 PAHs compounds have been either identified or detected (Maga, 1988). The level of PAHs can be reduced by decreasing the combustion temperature since the PAHs content was found to change linearly from 5 to 20 µg/100g in temperature range 400 to 1000 °C (Eyo, 2001). Indirect smoking like liquid and electrostatic smoking also significantly reduces the PAHs amount.

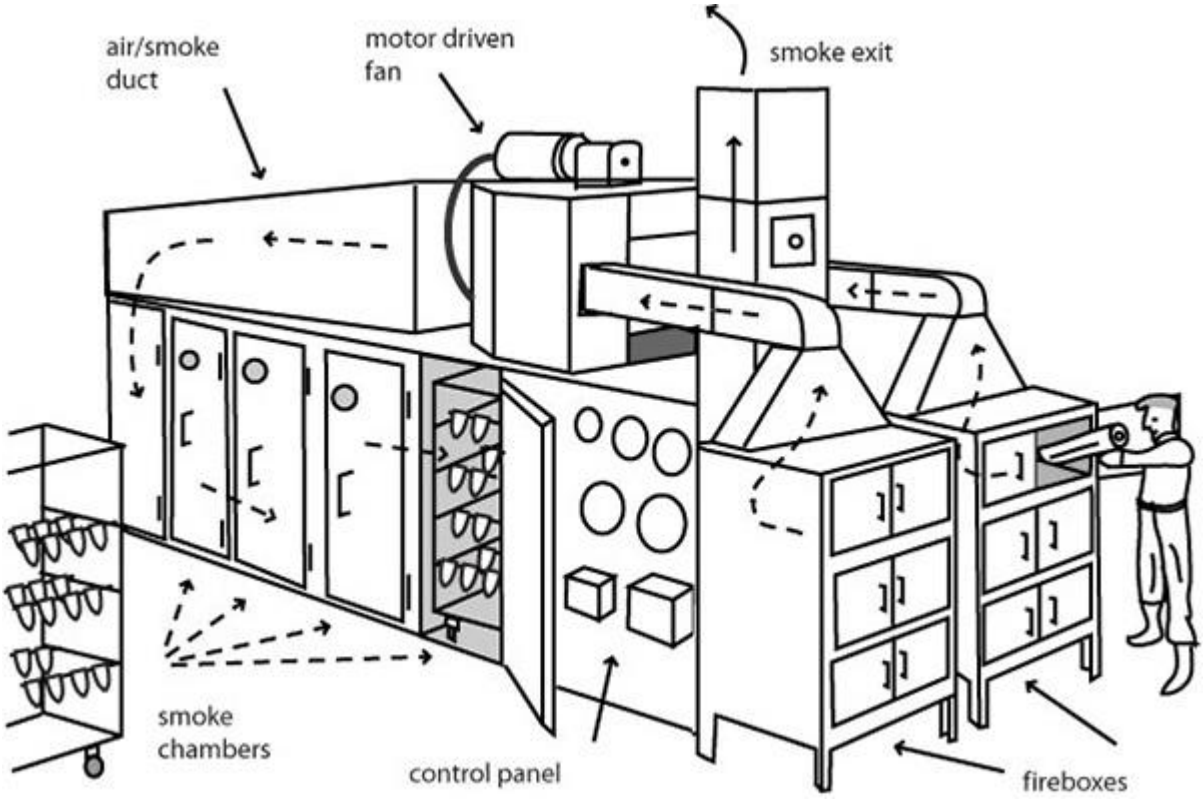


Fig. Smoking kiln

Potential hazards associated with smoking of fish

I. Biological hazards

Generally, Cold smoking will typically reduce the level of microorganism by 90 to 99%. But after the cold smoking there is no such steps to eliminate or reduce the level of microorganisms. Typical temperature used for cold smoking is 22-28º C. However, this temperature is not sufficient to eliminate the risk from *Listeria monocytogens*, a gram positive, facultative anaerobic, psychrotropic bacteria causing deadly septicaemia, meningitis, spontaneous abortion, and foetal death in adult human beings. Specific high risk categories like persons with altered immune system, pregnant ladies, old aged persons etc. will be more susceptible to listeriosis followed by accidental inclusion. Comparatively high temperature used in hot-smoking process and long-time of exposure to that temperature (60-70˚C for 2-3 h) can inactivate the *L. monocytogens* effectively, provided the raw material is not extra-ordinarily contaminated with the bacteria prior to processing. At the same time listericidal process should be validated to ensure that the treatments are effective and can be applied continuously. But the hot smoked products are susceptible to post-process contaminations from many of the micro-organisms due to improper handling and storage of the products. Sufficient heat treatment, proper hygienic handling and cold chain maintenance during distribution can reduce the risk of biological hazards in smoked fish and fishery products.

Another important biological hazard associated with storage of smoked fish is *Clostridium botulinum.* The toxin produced by *C. botulinum* can lead to botulism, serious illness and death to the consumer. Even a few micrograms of intoxication can lead to ill-health with symptoms like weakness, vertigo, double vision, difficulty in speaking,

swallowing and breathing, abdominal swelling, constipation, paralysis and death. The symptoms will start within 18-36 h after consumption of the infected product. By achieving proper salt concentration in processed fish, proper refrigeration during storage and reduced oxygen packaging like Modified Atmosphere Packaging (MAP) and vacuum packaging of the products can prevent the occurrence of *C. botulinum* in smoked fish and fishery products, especially type E and non-proteolytic types B and F. Salt along with smoke effectively prevents the toxin formation from type E, B and F.

In cold smoked fish and fishery products, which undergoes mild heat processing, the presence of spoilage organisms prevents the growth of *C. botulinum* and toxin production. Whereas in hot-smoked products, high temperature application causes damages to spores of *C. botulinum* thus prevents the toxin formation. Same process also prevents the prevalence of spoilage organisms and thus extends the shelf life of the product. Thus, the time- temperature combination for smoking, along with salt concentration plays critical roles in safety and quality aspects of the smoked fish and fishery products.

II. Chemical hazards

1. Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are large class of organic compounds containing two or more fused aromatic rings made up of carbon and hydrogen atoms. Incomplete combustion (pyrolysis), during smoking can lead to formation and release of PAHs into the smoked product. Some of them are carcinogenic and mutagenic substances causing serious health issues to the consumers. Processing procedures such as smoking, drying, roasting, baking, frying and barbecuing/grilling can lead to formation of PAHs in food items. Many reports indicate that individual PAHs in smoked fish can go up to a level of 200µg/Kg. Among the 33 PAHs evaluated by the scientific committee on Food (SCF, 2002) of EU, 15 were found to be having mutagenicity/Geno toxicity in somatic cells of experimental animal in-vivo. They are benzo[a] anthracene, benzo[b]-, benzo[j]- and benzo[k] fluoranthene, benzo[ghi] perylene, benzo[a] pyrene, chrysene, cyclopenta[cd] pyrene, dibenz[a,h] anthracene, dibenzo[a,e]-, dibenzo[a,h]-, dibenzo[a,i]-, dibenzo[a,l] pyrene, indeno[1,2,3-cd]pyrene and 5-methylchrysene. The carcinogenic and genotoxic potentials of PAH are largest among the high molecular weight PAH, i.e. compounds with 4 rings or more. Among that benzo[a]pyrene regarded as potentially genotoxic and carcinogenic to humans. They can cause long-term adverse health effects following dietary intake of PAH.

The PAH contamination in smoked products can be significantly reduced by using indirect smoking process instead of direct smoking of the fish. In indirect smoking, the smoke generated in an external smoking kiln, under controlled conditions, is used for smoking process. The smoke produced can be even, washed before coming into contact with the food material processed. In addition to that, use of lean fish for smoking, and cooking at lower temperature for longer time can also reduce the PAH contamination significantly. If the smoke condensate is used for smoking, usage of smoke condensate from reputed reliable resources approved by competent authority can effectively reduce the occurrence of PAH contamination in the final product. The formation of PAH in smoked fish can be minimised by following Code of Practice for the Reduction of Contamination of Food with Polycyclic Hydrocarbons (PAH) from Smoking and Direct Drying Processes (CAC/RCP 68-2009) given by Codex Alimentarius Commission. EU No.835/2011 specifies that maximum level of benzopyrene, and PAH4 (benzo[a]pyrene + chrysene+ benz[a] anthracene+benzo[b] fluoranthene) should be 2µg/Kg wet weight and 12µg/Kg in meat of smoked fish and fishery

products, 5µg/Kg and 30µg/Kg in smoked sprats and 6µg/Kg and 35µg/Kg in smoked bivalve mollusc respectively.

2. Histamine:

Histamine poisoning is associated with Scombroid fishes and other dark meat fishes. The fishes showing potential treats of histamine poisoning are tunas, bonitos, mackerel, mahi mahi, carangids, herring etc. These fishes having high content of free histidine, which during spoilage are converted to histamine by bacteria like *Morganella morgani, Klebsiella pnuemoniae* and *Hafnia alvei*. Histamine is heat stable, even cooking or canning cannot destroy it. Presence of other biogenic amines like cadaverine and putrescine will act as potentiators for histamine production. As per Codex standards, the maximum allowable histamine content in smoked fishes is 200 mg/Kg for species like *Scombridae, Clupeidae, Engraulidae, Coryphaenidae, Pomatomidae,* and *Scomberesocidae.* Low temperature storage of fishes right from catch can effectively reduce the production of histamine in fishes.

3.Biotoxins:

Biotoxins causing a number of food borne diseases. The poisoning due to biotoxins are caused by consuming finfish/shell fish containing poisonous tissues with accumulated toxins from plankton they consumed. Paralytic shellfish poisoning (PSP), diarrheic shellfish poisoning (DSP), amnesic shellfish poisoning (ASP), and neurotoxic shellfish poisoning (NSP) are mostly associated with shellfish species such as oysters, clam and mussels. The control of biotoxin is very difficult. They cannot be destroyed by any of the processing methods like cooking, smoking, drying or salting. Environmental monitoring of plankton and proper depuration process of the bivalves only can reduce the occurrence significantly.

III. Physical Hazards

Presence of parasites like nematodes, cestodes, trematodes and any other extraneous matter can be considered as physical hazards. Particular attention needs to be paid to cold smoked or smoke-flavoured products, which should be frozen before or after smoking if a parasite hazard is present.

IV. Other potential hazards associated with smoking of fish

If wood or plant material is using for smoking of fish, there is a chance of presence of natural toxins, chemicals, paint, or impregnating material in plant or wood used which may result in imparting undesirable odour in processed products. This can be prevented by using sufficiently dried wood or plant material for smoke generation, judicious selection of the species of wood or plant and not using woods having mould or fungus growth for smoking process. Moreover, the material for smoking should be kept in a clean dry place during storage to prevent any kind of contamination, till the usage.

Drying

In general, the term ‘drying' implies the removal of water by evaporation. In fish, water constitutes about 70-80% and since water is essential for the activity of all living organisms, its removal will facilitate retardation of microbial and autolytic activity as well as oxidative changes and hence can be used as a method of preservation. In any process of drying, the removal of water requires an input of thermal energy. The thermal energy required to drive off the water can be obtained from a variety of sources, e.g., the sun or the controlled burning of oil, gas or wood, electrical heating etc. The thermal energy can also be

supplied directly to the fish tissue by microwave electromagnetic radiation or ultrasonic heating.

Drying Phases

During air drying, water is removed from the surface of the fish and water moves from the deeper layers to the surface. Drying takes place in two distinct phases. In the first phase, whilst the surface of the fish is wet, the rate of drying depends on the condition (velocity, relative humidity etc.) of the air around the fish. If the surrounding air conditions remain constant, the rate of drying will remain constant; this phase is called the 'constant rate period'. Once all the surface moisture has been carried away, the second phase of drying begins and this depends on the rate at which moisture can be brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower; this phase is called the 'falling rate period'.

Constant rate drying phase

During this period the rate of drying is dependent on several factors:

Air temperature: At the beginning of drying, the heat energy required for evaporation is balanced by the heat supplied by the surrounding air. Warm air can provide more heat energy and, provided that the air speed and relative humidity will allow a high rate of water movement, the rate of drying will be increased.

Relative humidity of the air: The lower the relative humidity of air surrounding the drying area, the greater the ability to absorb water and the faster the rate of drying.

Air velocity: Air velocity has a positive relation with rate of drying. Better the speed of the air over the fish, the greater will be the drying rate. The air around fish consists of an immediate stationary layer above the fish, a slowly moving middle layer and an outer turbulent layer. On saturation of the immediate stationary air layer, the moisture passes into the slowly moving middle layer. The higher the air speed in the outer layer is, the thinner the slow moving layer, allowing more rapid movement of water away from the fish.

Surface area of the fish: the larger the surface area, the faster the rate of drying. By scoring and splitting the fish, the surface area increases relative to the weight/thickness resulting in the rate of drying to be faster.

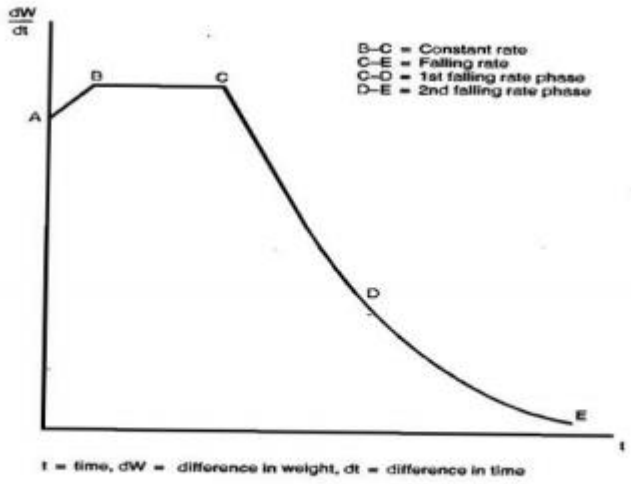
Falling rate drying phase

Once the free surface moisture has been removed, the rate of drying depends on the movement of moisture from interior to the surface of the fish. Several factors influence the rate of drying:

Nature of the fish: a high fat content in the fish retards the rate of drying. Thickness of the fish: the thicker the fish, the further the water in the middle layers has to travel to reach the surface, slowing down the drying rate.

Temperature of the fish: diffusion of water from the deeper layers to the surface is greater at higher temperatures.

Water content: as the water content falls, the rate of movement to the surface layers is reduced.



Drying rate curve.
Source: Redrawn from *FAO Fisheries Report*, No. 279. Food and Agriculture Organization of the United Nations, Rome. 1983.

Methods of Drying

There are basically two methods of drying fish. The common and traditional method of drying is sun drying which is done by utilizing the atmospheric conditions viz., temperature, humidity and airflow. In recent times, the controlled artificial dehydration of fish has been developed so that fish drying can be carried out under controlled conditions, regardless of weather conditions.

Natural or sun drying:

In this type solar and wind energies are utilized as the source of energy.

- Drying on the ground
- Rack Drying
- Solar drying using Solar tent dryers, Solar cabinet dryers

Artificial / Mechanical Dryers

- Hot air dryers
  - Cabinet dryer
  - Tunnel dryer
  - Multi deck tunnel
- Contact Dryers
  - Vacuum dryers
  - Rotary dryers
  - Drum dryers

Sun drying on racks

Solar driers

Cabinet driers

Conclusion

Curing is one of the oldest and traditional methods of fish preservation. These are cost effective technologies, which can be opted for a wide range of communities. However, a major drawback with this traditional processing is the lack of standard operating procedures being followed which affects the quality of cured products. Moreover, there is a general conception that drying/salting is a secondary method for preservation applicable for low value as well as inferior quality varieties. Efforts towards effective and hygienic handling practices in the process chain, popularization of improved drying and packaging practices, and adequate extension services can facilitate better adoption of cured fishery products in the seafood sector.

References:

1. Daniela Borda, Anca I. Nicolau and Peter Raspor, (2017). Trends in Fish Processing Technologies, CRC Press, Taylor & Francis Group, Boca Raton, FL
2. G. M. HALL, (1997). Fish Processing Technology (Second edition), Published by Blackie Academic and Professional, an imprint of Chapman & Hall, 2-6 Boundary Row, London, UK

3. J. Clucas, ‘’Fish Handling, Preservation and Processing in the Tropics’’. Part 2. Report of The Tropical Development and Research Institute (TDRI). 45-50. 1982
4. FAO, ‘’Handling of Fish and Fish Products. Fisheries and Aquaculture Department’’. Rome. Updated 31st October, 2001. Retrieved 9th, January, 2012. 2005

Chapter 8

Thermal processing of fish

Dr. C.O. Mohan
Senior Scientist, Fish Processing Division
ICAR-Central Institute of Fisheries Technology
Email: comohan@gmail.com

Preservation is the process achieved to store food for storing longer duration. Human beings are dependent on products of plant and animal origin for food. As most of these products are readily available only during certain seasons of the year and fresh food spoils quickly, methods have been developed to preserve foods. Preserved foods can be eaten long after the fresh products would normally have spoiled. Preservation must be seen as a way of storing excess foods that are abundantly available at certain times of the year, so that they can be consumed in times when food is scarce.

Fish and shellfishes pass through a number of processing stages immediately after catch before it is consumed or sold for consumption. These processes can be divided into primary processing and secondary processing. Primary processing includes the steps that enable fish to be stored or sold for further processing, packaging and distribution. Examples include washing, cleaning, heading, gilling, scaling, gutting, grading, filleting, de-boning, skinning, chilling and freezing. Secondary processing includes the production of 'value-added products'. Examples are salting, drying, smoking, canning, marinating and packaged ready to eat foods. There are number of reasons for processing fish and shellfish which are given below.

1. To supply safe food
2. To minimize loss/waste of valuable food commodity
3. To meet consumer preference and specified quality standards
4. To extend the shelf life of food for longer duration
5. To make profit by adding value and increasing convenience to the consumer

Fresh fish will spoil very quickly due to its internal and external factors. Once the fish has been caught, spoilage progresses rapidly. In the high ambient temperatures of the tropics, fish will spoil within few hours. The storage life of fishery products can be increased by adopting good fishing techniques (to minimize fish damage) and cooling the fish immediately to minimize the spoilage caused by enzymatic, bacterial action and oxidation process. Fish spoilage can be effectively minimized if the effects of enzymes, bacteria and oxidation are controlled properly. This can be achieved by understanding the optimum conditions that enzymes, bacteria and oxidation processes prefer and modifying these conditions. Many processing techniques aim to alter these conditions to achieve preservation. Some of the approaches are given in Table 1.

Table 1. Possible preservation approaches

Approaches	*Examples of process*
Low temperature	Chilling, Refrigeration, Freezing
High temperature	Pasteurization, Thermal processing, smoking
Reduced water availability	Drying, salt curing, spray drying, freeze drying
Chemical based preservation	Organic acids, natural extracts from plants
Microbial product based	Bacteriocins
Radiation	Ionizing (Gamma rays) and non-ionizing (UV rays) radiation
Hurdle technology	Altered atmosphere (vacuum and modified atmosphere with CO_2, O_2, N_2 and other gases); active packaging; high pressure treatment; smoking etc

The demand for better quality processed food is ever increasing. This led to the development of a large food preservation industry aiming to supply food that is sterile, nutritious and economical. Thermal sterilization of foods is the most significant part of this industry and is one of the most effective means of preserving our food supply. Thermal processing, which is commonly referred as heat processing or canning is a means of achieving long-term microbiological stability for non-dried foods without the use of refrigeration, by prolonged heating in hermetically sealed containers, such as cans or retortable pouches, to render the contents of the container sterile. The concept of thermal processing has come a long way since the invention of the process by French confectioner, Nicholas Appert. Later on Bigelow and Ball developed the scientific basis for calculating the sterilization process for producing safe foods. Today, thermal processing forms one of the most widely used method of preserving and extending shelf life of food products including seafood's. Thermal processing involves application of high temperature treatment for sufficient time to destroy all the microorganisms of public health and spoilage concerns. Normally, thermal processing is not designed to destroy all microorganisms in a packaged product, which may result in low quality product which destroys important nutrients. Instead of this, the pathogenic microorganisms in a hermetically sealed container are destroyed by heating and a suitable environment is created inside the container which does not support the growth of spoilage type microorganisms. Several factors must be considered for deciding the extent of heat processing which include,

a) type and heat resistance of the target microorganism, spore, or enzyme present in the food

b) pH of the food

c) heating conditions

d) thermo-physical properties of the food and the container shape and size

e) storage conditions

Thermal processing is designed to destroy different microorganisms and enzymes present in the food. Normally in thermal processing, exhausting step is carried out to before sealing the containers. In some cases, food is vacuum packed in hermetically sealed

containers. In such cases very low levels of oxygen is intentionally achieved. Hence, the prevailing conditions are not favorable for the growth of microorganisms that require oxygen (obligate aerobes) to create food spoilage or public-health problems. Further, the spores of obligate aerobes are less heat resistant than the microbial spores that grow under anaerobic conditions (facultative or obligate anaerobes). The growth and activity of these anaerobic microorganisms are largely pH dependent. From a thermal-processing standpoint, foods are divided into three distinct pH groups which are given below. Changes in the intrinsic properties of food, mainly salt, water activity and pH are known to affect the ability of microorganisms to survive thermal processes in addition to their genotype. Due to health related concerns on the use of salt, there is increased demand to reduce salt levels in foods. The United States Food and Drug Administration (FDA) have classified foods in the federal register (21 CFR Part 114) as follows (Table 2):

1. high-acid foods (pH < 3.7; e.g., apple, apple juice, apple cider, apple sauce, berries, cherry (red sour), cranberry juice, cranberry sauce, fruit jellies, grapefruit juice, grapefruit pulp, lemon juice, lime juice, orange juice, pineapple juice, sour pickles, vinegar)
2. acid or medium-acid foods (pH 3.7 - 4.5; e.g., fruit jams, frit cocktail, grapes, tomato, tomato juice, peaches, piento, pineapple slices, potato salad, prune juice, vegetable juice)
3. low-acid foods (pH > 4.5; e.g., all meats, fish and shellfishes, vegetables, mixed entries, and most soups).

Table 2. Approximate pH range of different food

Food	pH	Food	pH
Lemon juice	2.0 - 2.6	Sweet potato	5.3 – 5.6
Apples	3.1 - 4.0	Onion	5.3 – 5.8
Blueberries	3.1 – 3.3	Spinach	5.5 – 6.8
Sauerkraut	3.3 – 3.6	Beans	5.6 – 6.5
Orange juice	3.3 – 4.2	Soybeans	6.0 – 6.6
Apricot	3.3 – 4.0	Mushroom	6.0 – 6.7
Bananas	4.5 – 5.2	Clams	6.0 – 7.1
Beef	5.1 – 7.0	Salmon	6.1 – 6.3
Carrot	4.9 – 5.2	Coconut milk	6.1 – 7.0
Green pepper	5.2 – 5.9	Milk	6.4 – 6.8
Papaya	5.2 – 6.0	Chicken	6.5 – 6.7
Tuna	5.2 – 6.1	Whole egg	7.1 – 7.9

The acidity of the substrate or medium in which micro-organisms are present is an important factor in determining the extent of heat treatment required. With reference to thermal processing of food products, special attention should be devoted to *Clostridium botulinum* which is a highly heat resistant mesophilic gram positive, rod shaped spore-forming anaerobic pathogen that produces the toxin *botulin*. It has been generally accepted that *C. botulinum* and other spore forming, human pathogens does not grow and produce toxins below a pH of 4.6. The organisms that can grow in such acid conditions are destroyed by relatively mild heat treatments. For food with pH values greater than 4.5, which are known as low-acid products which includes fishery products, it is necessary to apply a time–temperature regime sufficient to inactivate spores of *C. botulinum* which is commonly referred to as a *botulinum cook* in the industry. Thermal processes are calibrated in terms of the equivalent time the thermal centre of the product, i.e. the point of the product in the container most distant from the heat source or cold spot, spends at 121.1°C, and this thermal

process lethality time is termed the F_0 value. Although there are other microorganisms, for example *Bacillus stearothermophilus*, *B. thermoacidurans*,and *C. thermosaccolyaticum*, which are *thermophilic* in nature (optimal growth temperature ~ 50–55°C) and are more heat resistant than *C. botulinum* *a* compromise on the practical impossibility of achieving full sterility in the contents of a hermetically sealed container during commercial heat processing, whereby the initial bacterial load is destroyed through sufficient decimal reductions to reduce the possibility of a single organism surviving to an acceptably low level. This level depends on the organism, usually *Clostridium botulinum*, which the process is designed to destroy. The time required to reduce the number of spores of this organism (or any other micro-organism) by a factor of 10 at a specific reference temperature (121.1°C) is the decimal reduction time, or *D* value, denoted D_0. The D_0 value for *Clostridium botulinum* spores can be taken as 0.25 minutes. To achieve a reduction by a factor of 10^{12}, regarded as an acceptably low level, requires 3 minutes at 121.1°C, and is known as the process value, or *F* value, designated F_0 so, in this case, $F_0 = 3$, which is known as a botulinum cook which is the basis of commercial sterility.

Thermal resistance of microorganisms

For establishing a safe thermal processing, knowledge on the target microorganism or enzyme, its thermal resistance, microbiological history of the product, composition of the product and storage conditions are essential. After identifying the target microorganism, thermal resistance of the microorganism must be determined under conditions similar to the container. Thermal destruction of microorganism generally follow a first-order reaction indicating a logarithmic order of death i.e., the logarithm of the number of microorganisms surviving a given heat treatment at a particular temperature plotted against heating time (survivor curve) will give a straight line (Figure 1). The microbial destruction rate is generally defined in terms of a decimal reduction time (D value) which represents a heating time that results in 90% destruction of the existing microbial population or one decimal reduction in the surviving microbial population. Graphically, this represents the time between which the survival curve passes through one logarithmic cycle (Fig. 1). Mathematically,

$$D = (t_2 - t_1) / (\log a - \log b)$$

where, *a* and *b* are the survivor counts following heating for t_1 and t_2 min, respectively. As the survivor or destruction curve follows the logarithmic nature, the complete destruction of the microorganisms is theoretically not possible.

From the survivor curve, as the graph is known, it can be seen that the time interval required to bring about one decimal reduction, i.e. 90% reduction in the number of survivors is constant. This means that the time to reduce the spore population from 10,000 to 1000 is the same as the time required to reduce the spore population from 1000 to 100. This time interval is known as the decimal reduction time or the ‘D’ value. The D value for bacterial spores is independent of initial numbers, but it is affected by the temperature of the heating medium. The higher the temperature, faster the rate of thermal destruction and lower the D value. The unit of measurement for D is ‘minute’. An important feature of the survivor curve is that no matter how many decimal reductions in spore numbers are brought about by a thermal process, there will always be some probability of spore survival. Different micro-organisms and their spores have different D values as shown in Table–3.

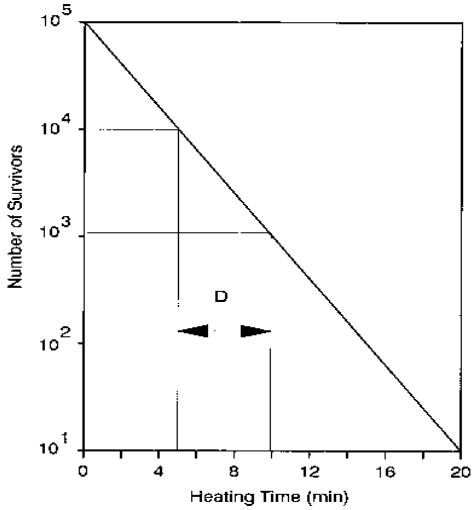


Fig 1. Survivor curve

Table-3. D value (at 121.1°C) of some bacterial spores

Microorganism	Optimum growth temperature (°C)	D value (min)
Bacillus stearothermophilus	55	4 to 5
Clostridium thermosaccharolyticum	55	3 to 4
Clostridium nigrificans	55	2 to 3
Clostridium botulinum types A & B	37	0.1 to 0.25
Clostridium sporogenes (PA 3679)	37	0.1 to 1.5
Bacillus coagulans	37	0.01 to 0.07
Non spore forming mesophilic bacterial yeasts and moulds	30 - 35	0.5 to 1.0

The thermal death time may be defined as the time required at any specified temperature to inactivate an arbitrarily chosen proportion of the spores, the higher the proportion the greater will be the margin of safety. TDT is the heating time required to cause complete destruction of a microbial population. Such data are obtained by subjecting a microbial population to a series of heat treatments at a given temperature and testing for survivors. The thermal death time curve is obtained by plotting the thermal death time on logarithmic scale against temperature of heating on linear scale on a semi-logarithmic graph paper (Fig. 2). Comparing TDT approach with the decimal reduction approach, one can easily recognize that the TDT value depends on the initial microbial load (while D value does not). Further, if TDT is always measured with reference to a standard initial load or load reduction, it simply represents a certain multiple of D value. For example, if TDT represents the time to reduce the population from 10^0 to 10^{-12}, then TDT is a measure of 12 D values. i.e., TDT = nD, where n is the number of decimal reductions. The extent of inactivation in the case of pathogenic microorganisms (*C. botulinum*) is equivalent to a 12 D process. The slope of the TDT curve is defined as 'z' value, which is the number of degrees for the TDT curve to traverse one log cycle. The temperature sensitivity indicator is defined as z, a value which represents a temperature range which results in a ten-fold change in D values or, on a semi-

log graph, it represents the temperature range between which the D value curve passes through one logarithmic cycle. The 'z' value which is also known as the temperature sensitivity indicator is usually taken as 10°C in the case of *C.botulinum.*

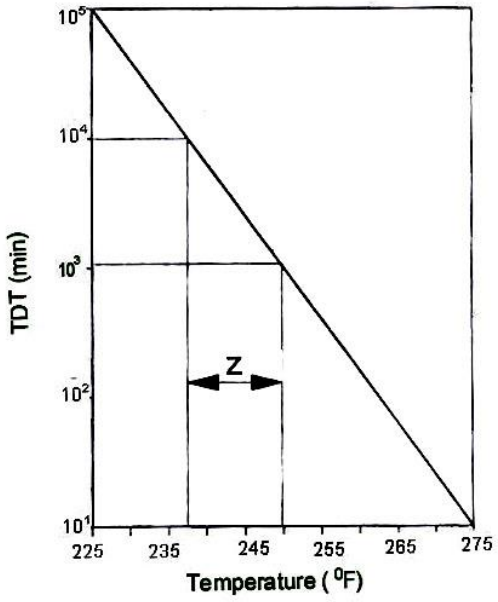


Fig. 2 TDT Curve

For the purpose of heat process determination with respect to their lethality towards specific micro-organisms, the reciprocal of the thermal death time (TDT value) called the lethal rate, L is used. So, instead of temperatures, the corresponding lethal rates are plotted against time, the area enclosed by the graph and the ordinate represent the F value for the process. i.e.,

$$L = \frac{1}{TDT}, \quad \text{and}$$

$$F = \int_0^t L \, dt$$

Thermal Process Severity or F_0 value

From D value and the initial number of spores inside the sealed container (N_o), an idea of the severity of heat process required to reduce the spore population to a predetermined level, N_t, can be calculated from the equation:

$t = D (\log No - \log N_t)$ or $t = D \log (No/N_t)$

where, t = time required to achieve commercial sterility

This $\log No/N_t$ is sometimes referred to as the 'order of process', factor 'm' and the value of the product of m and D is called the 'process value' or 'F value'. That is:

$$F_0 = mD_{121.1°C}$$

For example, considering the generally accepted minimum process for prevention of botulism through under processing of canned fishery products preserved by heat alone, assuming that the initial loads are of the order of 1 spore/g and in line with good manufacturing practice guidelines, the final loads shall be no more than $\log 10^{-12}$ spores/g. That is 12 decimal reductions are required. It is also known as 12 D process. The minimum time required to achieve commercial sterility can be calculated from

$$t = 0.25 (\log 1 - \log 10^{-12}),$$

$$\text{i.e., } t = 0.25 \times 12 = 3.00 \text{ min}$$

Thus an F_0 value of 3.00 minutes at 121.1°C at the slowest heating point (SHP) of the container is sufficient for providing safety from pathogenic organism *C. botulinum*.

Commercial sterility

If the thermal process is sufficient to fulfill the criteria of safety and prevention of non-pathogenic spoilage under normal conditions of transport and storage, the product is said to be 'commercially sterile'. In relation to canned foods, the FAO/WHO Codex Alimentarius Commission (1983) defines, commercial sterility as the condition achieved by the application of heat, sufficient alone or in combination with other appropriate treatments, to render the food free from microorganisms capable of growing in the food at normal non-refrigerated conditions at which the food is likely to be held during distribution and storage. Apart from this concept there are circumstances where a canner will select a process which is more severe than that required for commercial sterility as in the case of mackerel and sardine where bone softening is considered desirable.

Mechanism of heat transfer

Understanding the mechanism of heat transfer is very important for thermal processing. Normally, there are three different modes of heat transfer: conduction, convection and radiation. Conduction is the transfer of heat by molecular motion in solid bodies. Convection is the transfer of heat by fluid flow, created by density differences and buoyancy effects, in fluid products. Radiation is the transfer of electromagnetic energy between two bodies at different temperatures. In thermal processed foods, the mechanism of heat transfer is either by conduction, convection or by broken heating (combination of conduction and convection). The factors which determine the mode of heat transfer are nature or consistency of a food product, the presence of particles, and the use of thickening agents and sugars. The heating modes in the thermal processing are first by heat transfer to the container or packaging material from heating and cooling media, second through the container wall and third is into the product from container wall. Convective-heat transfer rates depend largely on the velocity of flow of the media over the container, and this is an important factor to be controlled in all processing operations. In conduction heading method, energy transfer takes place when different parts of a solid body are at different temperatures. The slowest heating point or cold point in cylindrical metal containers is at its geometric centre for food products heated by conduction method. Convection heat transfer involves the transfer of heat from one location to the other through the actual movement or flow of a fluid. The slowest heating point for convection heated products in cylindrical metal container is approximately $1/10^{th}$ up from the base of the container. Packaging material forms the most important component of thermal processed foods. It should be able to withstand the severe process conditions and should prevent recontamination of the product.

Containers for thermal processing

Containers used for thermal processing should have special properties like it should withstand high temperature and pressure. Tin cans are commonly used in the canning industry and cans are denoted by trade name. First digit represents diameter of can (in inches) and next two digits represent measurement in sixteenth of inches. Apart from Open-Top-Sanitary (OTS) cans, other container used in canning are: aluminium cans, tin free steel (TFS) cans, glass containers, retort pouches and semi-rigid containers.

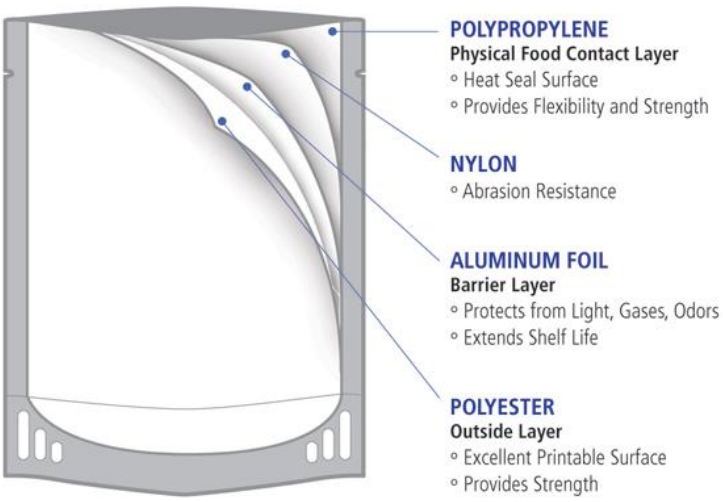
Table 4. Cans used in fish canning industry

Trade Name	Dimension	Over-seam dimension
41/2 OZ prawn cans	301 x 203	77 x 56
8 oz prawn cans	301 x 206	77 x 60
1 lb. jam can	301 x 309	77 x 90
No.1 tall can	301 x 409	77 x 116
8 oz. tuna can	307 x 113	87 x 43

Nowadays, retort pouch processing is very popular. The retort pouches are flexible in nature and they easily withstand high temperatures used during thermal processing. They also provide good barrier against moisture and gases. The most common retort pouch is 3 layered laminate. The 3 layers are joined with adhesive lamination. These three layers are:

- Polyester layer which helps in providing strength and abrasion resistance
- Aluminium foil for providing barrier against moisture, gases and light
- Polypropylene/ polyethylene for heat sealing properties.

Containers used for thermal processing



Composition of retortable pouch

Ideally, the container used for thermal processing should fulfil following characteristics:

- Should withstand the sterilisation pressure and temperature
- Should be impervious to air, moisture, dust and disease germs once the can is sealed air tight
- Internal lacquer should not impart toxicity to the contents
- Strong enough to protect the contents during transportation and handling
- Inexpensive, preferably cheap enough to discard after use
- Capable of sealing at high speed
- Pleasing and sanitary appearance

Thermal processing of fishery products

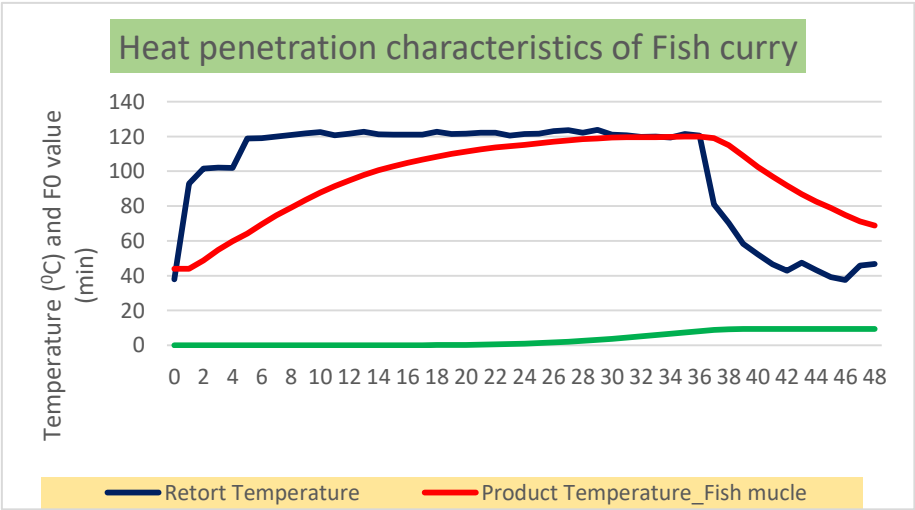
The thermal processing is carried out for achieving two objectives; the first is consumer safety from botulism and the second is non-pathogenic spoilage which is deemed commercially acceptable to a certain extent. If heat processing is inadequate the possibility of spoilage due to C. *botulinum* is more and will endanger the health of the consumer. Safety from botulism is made possible by making the probability of *C. botulinum* spores surviving the heat process sufficiently remote and presents no significant health risk to the consumer. An acceptable low level in the context of this dangerously pathogenic organism means less than one in a billion (10^{-12}) chance of survival. Such a low probability of spore survival is commercially acceptable as it does not represent a significant health risk. The excellent safety record of the canning industry with respect to the incidence of botulism through under processing, confirms the validity of this judgment. An acceptable low level in the case of thermophilic non-pathogenic organisms should be arrived at judiciously considering the factors like very high D value, risk of flat sour spoilage, commercial viability and profitability etc. Since non-pathogenic organisms do not endanger the health of the consumer process adequacy is generally assessed in terms of the probability of spore survival which is judged commercially acceptable. Considering all these facts, it is generally found acceptable if thermophilic spore levels are reduced to around 10^{-2} to 10^{-3} per g. Another reason for this acceptance is that the survivors will not germinate if the storage temperature is kept below the thermophilic optimum growth temperature i.e. below 35°C.

Fishery products, being categorized as low acid foods require heat processing severity with respect to *C botulinum* and F_0 value recommended is 5-20 min. Thermal processing of fishery products include various steps. These steps include, preparations like washing, beheading, gutting, removing scales / fins, cutting into required size, blanching (hot / cold), pre-cooking, filling fish pieces into containers, filling content or medium, exhausting to remove air, sealing, loading into the retort or autoclave, sterilization, washing and storing. Various packaging materials have been used from historically starting from glass container to metal container, flexible retortable pouches and rigid plastic containers. The sterilization process in the canned product can be subdivided into three phases. First one is heating phase, in which the product temperature is increased from ambient to the required sterilization temperature by means of a heating medium (water or steam). This temperature is maintained for a defined time (phase 2 = holding phasing). In (phase 3 = cooling phase) the temperature in the container is decreased by introduction of cold water into the autoclave. In order to reach temperatures above 100°C (sterilization), the thermal treatment has to be performed under pressure in pressure cookers, also called autoclaves or retorts. Simple autoclaves are generally vertical ones with the lid on top. Through the opened lid, the goods to be sterilized are loaded into the autoclave. The cans are normally placed in metal baskets. The autoclave and lid are designed to withstand higher pressures up to 5.0 bar. These types of autoclaves are best suited for smaller operations as they do not require complicated supply lines and should be available at affordable prices. Larger autoclaves are usually horizontal and loaded through a front lid. Horizontal autoclaves can be built as single or double vessel system. The double vessel systems have the advantage that the water is heated up in the upper vessel to the sterilization temperature and released into the lower (processing) vessel, when it is loaded and hermetically closed. Using the two–vessel system, the heat treatment can begin immediately without lengthy heating up of the processing vessel and the hot water can be recycled afterwards for immediate use in the following sterilization cycle. In rotary autoclaves, the basket containing the cans rotates during sterilization which enhances the heat penetration resulting in reduced process time. This technique is useful for cans with liquid or semi-liquid content as it achieves a mixing effect of the liquid/semi-liquid goods. Water immersion retorts are also used in the industry for thermal processing which is advantageous over steam retorts due to its uniform temperature distribution as there is no possibility of forming air pockets in the retort which limits the heat transfer in steam retorts. At the final stage of the sterilization process the products must be cooled as quickly as possible by introducing cold water. The contact of cold water with steam causes the latter to condense with a rapid pressure drop in the retort. However, the overpressure built up during thermal treatment within the cans, jars or pouches remain for a certain period. During this phase, when the outside pressure is low but the pressure inside the containers is still high due to high temperatures there, the pressure difference may induce permanent deformation of the containers. Therefore, high pressure difference between the autoclave and the thermal pressure in the containers must be avoided. This is generally achieved by a blast of compressed air into the autoclave at the initial phase of the cooling. Sufficient hydrostatic pressure of the introduced cooling water can also build up counter pressure so that in specific cases, in particular where strong resistant metallic cans are used, the water pressure can be sufficient and compressed air may not be needed unlike in flexible retortable pouches. After thermal processing, the containers are washed with chlorinated potable water and stored for conditioning for 2 – 4 weeks. Conditioning helps in proper mixing of the ingredients with the fish products and helps in assessing the extent of thermal process severity. If the containers do not show any deformation, it indicates the effectiveness of the thermal processing.

The important steps in canning process are:

1. Raw material preparation
2. Blanching/ Precooking
3. Filling into containers
4. Addition of fill (brine/ oil/ gravy)
5. Exhausting
6. Seaming/ sealing
7. Retorting (heat processing)
8. Cooling
9. Drying
10. Labelling and storage

Steam retort and water immersion retort



Typical heat penetration curve of fish curry in retortable pouches

References:

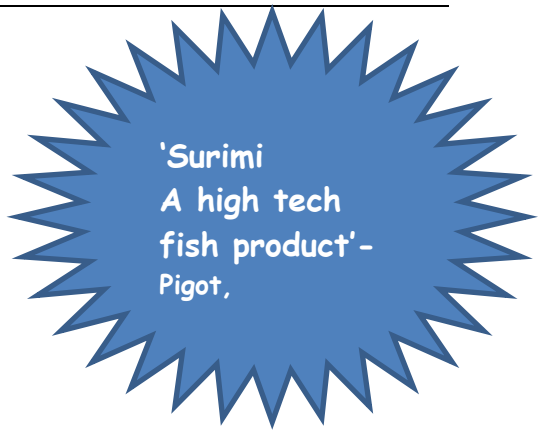
1. Stumbo CR. 1973. Thermo bacteriology in food processing. 2nd ed. New York: Academic Press. p 236.
2. Balachandran, K.K. (2003). Fish Canning – Principles and Practices, 180 Pp. Cochin: Central Institute of Fisheries Technology.
3. Ranganna S. 2000.Handbook of canning and aseptic packaging.NewDelhi, India: Tata McGraw-Hill Publishing Co. Ltd. p 507–8.
4. Ball, C. O., 1923. Thermal process times for canned foods. Bull. No. 37. National Research Council, Washington.
5. Ball, C. O. and Olson, F. C. W., 1957. Sterilization in Food Technology. Mc Graw-Hill Book Co., New York, 654pp.

Chapter 9

Surimi and other mince based fishery products

Dr. K. Elavarasan
Scientist, Fish Processing Division, ICAR-CIFT
Email: elafishes@gmail.com

Contents



Introduction

Fish as a food has gained a greater attention in the recent past due to the awareness about the nutritional and health beneficial aspects of fish consumption. World per capita apparent fish consumption per capita for the year 2015 has been estimated to be 20 kg (FAO 2016). Fish is good source of easily digestible proteins blended with all the essential amino acids at appropriate proportion. FAO stated that the global population has obtained 17 % of animal protein and 6.7 % of total protein in the form of fish proteins. Fish lipids are known for their polyunsaturated fatty acids content and their therapeutic properties against heart related problems. From health point of view, the focus on dietary macronutrients are shifting towards the importance of micronutrients like minerals and vitamins, which are essential in the diet for the better physiological functional and normal well-being. These micronutrients are presented in fish in easily absorbable and biologically available form. In spite of this, fish is highly perishable. Its perish ability nature is due to near neutral post mortem pH, low content of connective tissue, higher water activity, highly unsaturated lipids and nutritional richness. Hence, processing of fish is essential to make it available (preservation) in one or another form for human consumption. The processing of fish leads to diversification in products based on the consumer need. Surimi is one such intermediate product. Surimi, truly

the "high tech" product can enable the human population to realize the utilization of fish as the most important source of protein.

What is surimi?

The term 'surimi referred to minced and water-washed fish muscle tissue (Ohshima et al., 1993). The word ‘surimi’ comes from the Japanese words ‘suru’ meaning ‘to process’ and ‘mash/mi’ meaning ‘meat’.

Advantages / Why should we go for surimi? / importance of surimi manufacturing

- Helps in utilization of underutilized fishery resources
- Efficient utilization of edible parts of fish
- Cuts down the cost of transport
- Frozen surimi has longer shelf life with reference to functionality
- Variety of products formulation using available process technology and ingredient technology
- Current technology employed in surimi production allows manufacturing of surimi with uniform quality

Disadvantages of surimi production

- Huge quantity of water requirement
- Nutritional loss
- Loss of taste/ flavor
- Pollution problem

History of Surimi and Milestones in Development of Surimi Industry

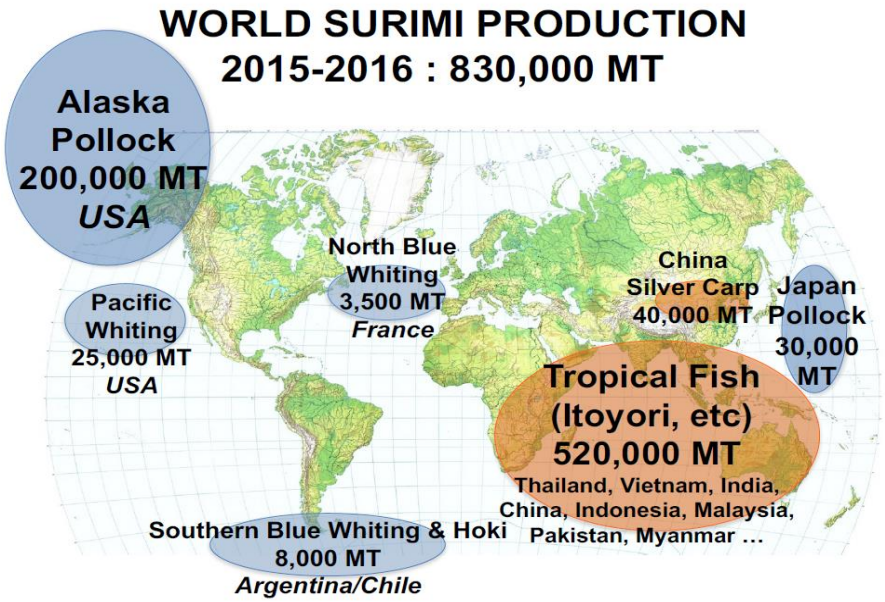
Surimi is a Japanese term meant for minced and washed fish meat. Surimi seafood was initially created by Japanese chefs hundreds of years ago, who saved any extra fish they couldn't use by salting and grinding it into a gel. The Japanese have considered it a delicacy for 900 years. The record for earlier surimi processing has been found in Japanese cookbook written in the year of 1528. Till, 1603 it was family based production and used as a major ingredient in Kamoboko-type products. The pioneering work by the scientists **‘Nishiya Kyosuke’** and ‘**Takeda Fumio’** revealed the use of sugar as cryoprotectants in surimi which protect/minimize the structural changes in fish myosin, thus preserve the gel forming capacity of fish meat. This invention shifted the fresh surimi to frozen surimi. Later, the innovation of the surimi product called crabstick in Japan during 1970s played a major role in globalizing surimi and expanding surimi seafood consumption to the United States, Europe, and Russia. Commercial surimi production process has witnessed dramatic changes due to developments and innovations in machineries and ingredients. These developments have eased the production process and enhanced the gel strength of fish meat from various species. The following are the major milestones in the surimi industry.

Years	Major Inventions	Contribution
1960	Cryoprotectants	Fresh surimi to Frozen surimi
1970	Crab stick	Expansion of Surimi market to USA
1987	Microbial Transglutaminase enzyme	Gel strength improvement
1990	Decanter	3-5 % increase in yield of surimi

Surimi- a look at world market

According to Pascal Guenneugues from Future Seafood, France, global production of surimi is almost stagnant for last five years with little fluctuation. The surimi production has been projected to be at the same level for the year 2017. The global surimi production has witnessed a sharp increase from the year 2009 to 2012. In the year 2013, the surimi

production was leveled to 80,000t. By 2014, surimi production raised back hitting to 820,000t in 2015 and 830,000t in 2016. (Figure 2). Overall production of tropical fish surimi in 2016 was stable, with a decrease in Thai and Chinese production and an increase in Indian and Indonesian production, and about the same levels in Vietnam, Malaysia, Pakistan and Myanmar.



(**The information was obtained from Pascal Guenneugues from Future Seafood, France**)

Despite investment in technology and improvement in processing conditions, the quality of surimi is decreasing due to lower supply of good quality fish, a result of overfishing, reduced access to good fishing grounds and more fish directed to direct consumption and freezing for export.

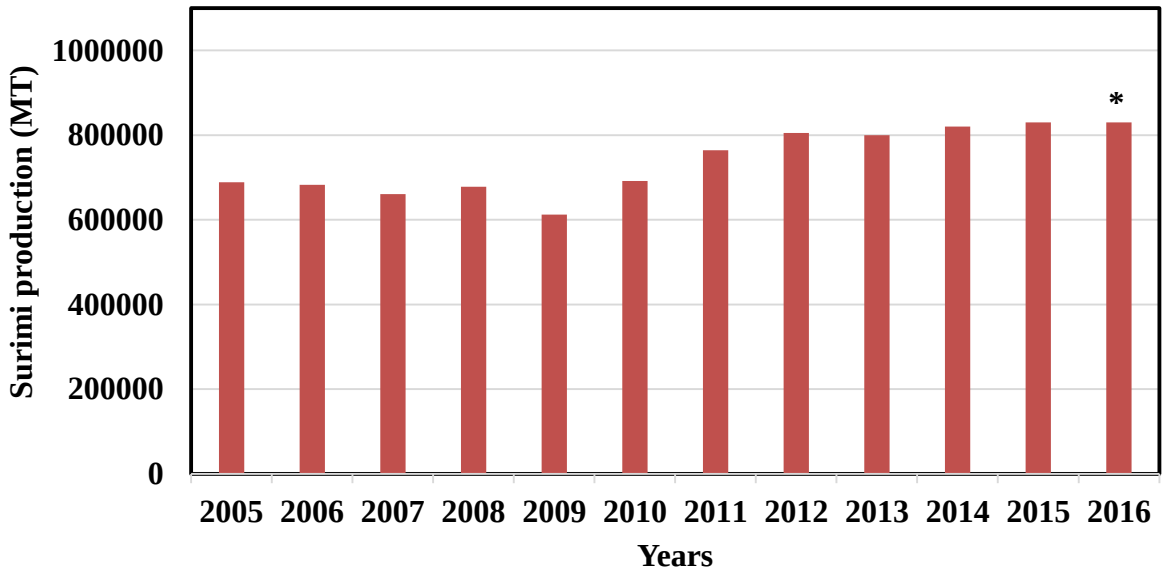


Figure 2. The world surimi production (2005-2016; *Estimated)

Indian Surimi Industry-An Overview

The Indian surimi industry developed in the 1990s on the west coast of India under the influence and support of Japanese importers as well as with Korean and Thai assistance. Production rapidly grew to reach around 20,000 MT by the year 2000, 40,000 MT by 2005, and 65,000 MT by 2010. Over the past years the industry has consolidated as some factories closed down mostly due to issues with wastewater disposal. However, new factories keep developing, which results in a strong competition for raw material. Threadfin bream is the main species (70%) used for surimi production and various other species include lizard fish, croaker, big eye snapper, goat fish, ribbon fish, and sardine. The average fish size is bigger than in Thailand and the freshness of fish is usually good since the fishing fleet is constituted of small vessels (10–12 m) operating on short trips of 3–5 days. Indian surimi production is mostly exported to Japan where it competes with Thai surimi and to East Europe. India utilizes a small portion of its production to process crabsticks for export to Europe and the United States (around 10,000 MT in 2010).

Unit operations in surimi production

The process flow involved in surimi preparation is given in Figure 1. It mainly involves separation of meat and repeated washing to obtain the refined fish meat which is a wet concentrate of myofibrillar protein.

Unit operations in Surimi production

1. Raw material
2. Dressing
3. Meat separation
4. Water washing (Leaching/bleaching)
5. Dehydration
6. Refining/straining
7. Mixing with additives (0.2% Sodium tri-poly phosphate + 4% sucrose + 4% sorbitol)
8. Panning
9. Freezing
10. Frozen storage

Note: all unit operations should be carried below the temperature of 5 ^{o}C

Raw material

The first and foremost thing to remember is ‘only some fishes have the suitability to be raw material for surimi production process’. The suitability is determined by the functionality of fish myofibrillar protein called ‘gelation’. Gelation is the ordered aggregation of fish myosin with the entrapment of water and other added ingredients upon extraction with salt and heating. The gel forming capacity of fish meat is expressed in terms of gel strength (g.cm). In general, gel-strength is higher in the salt-water fish than in fresh-water fish, and greater in white-fleshed fish than in dark fleshed fish. The high quality surimi production is possible only through using the superior quality raw material. Before choosing the raw material, the following criteria should be considered.

- Strong gel-forming capability
- White flesh
- Less fat
- Year-round availability
- Abundance
- Reasonable price

Dressing

As soon as receiving the raw material, it has to be washed using chlorinated (less than 2 ppm) chilled water. The next step is dressing of fish. Dressing include removal of head, entrails, scales and fins. At most care has to be taken not to disturb the visceral mass as it includes the stomach and intestines which are in turn rich source of proteolytic enzymes. Damaging the stomach and intestines likely to contaminate the muscle with proteolytic enzymes which act on the protein and degrade them. The degradation of protein will have drastic effect on the gel forming capacity of fish meat. Pyloric caeca contain large amount of proteases. Upon releasing, they break the proteins into peptides. Particularly, the myofibrillar protein, myosin, has to be protected from degradation and denaturation to have the better gelation. A thorough washing of belly cavity has to be exercised to remove the peritoneal membrane which is black in color and gives negative perception on the appearance of surimi and surimi based products. If kidney is disturbed, then TMAO oxidase is liberated which acts on TMA-O and convert into TMA, DMA, MMA and formaldehyde. Formaldehyde is a potent cross linker. It cross links two proteins and reduce the gel forming ability. Pancreas and liver contain lots of enzymes. If it is disturbed it also affects the quality of surimi.

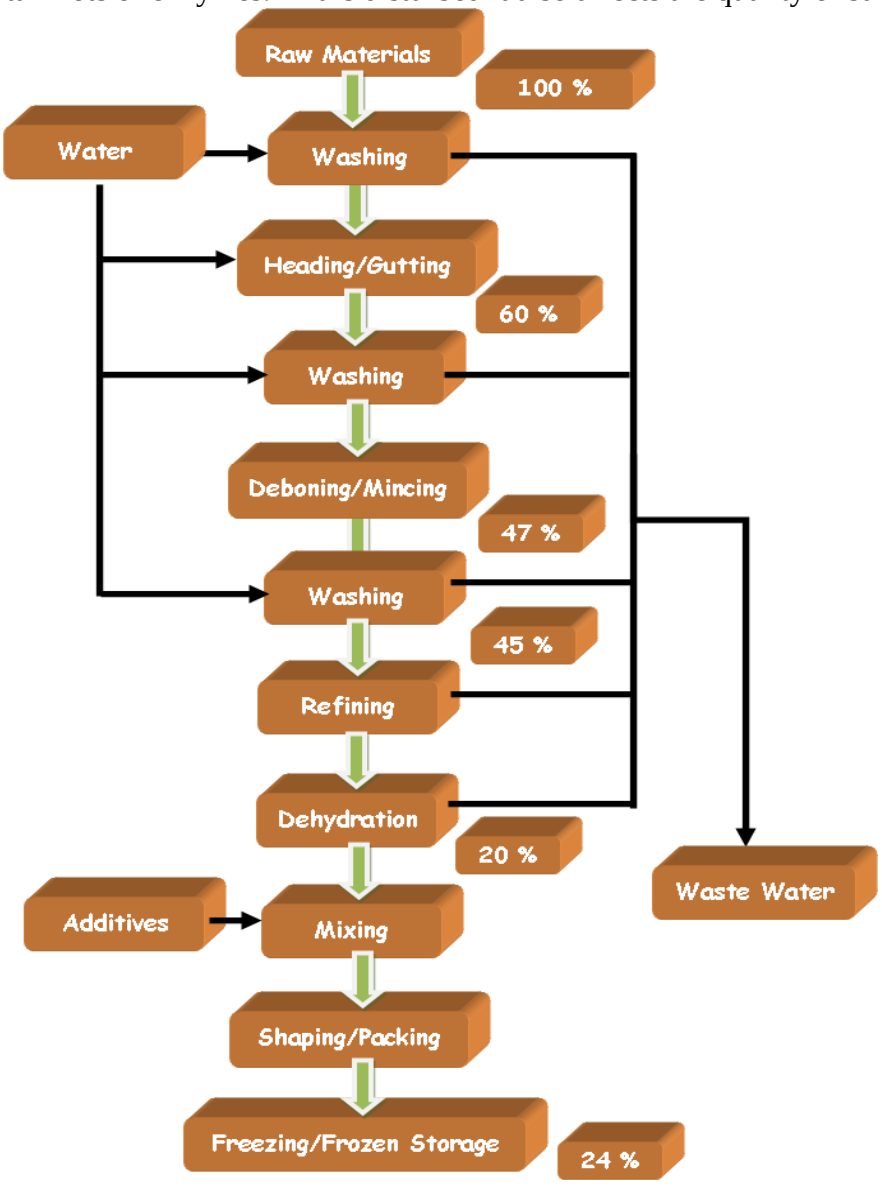


Figure. 1 The process flow for surimi production

Meat Separation

Meat separation is carried out mechanically. Commercially used meat separator is drum type separator / reciprocator type. Size of the meat particle obtained after meat separation is 2-5mm. If the meat size is 2 mm then the mincing operation can be omitted. The yield from whole fish to separated meat is 55-70%. The separated meat is referred as otoshimi in Japanese. Even today, the presence of some small fins or pin bones and scales are the technological issues remains to be addressed.

Water washing

Washing the minced meat is a critical step in the production of surimi, which not only removes fat, pigments, amines and sarcoplasmic proteins but also concentrates myofibrillar proteins. Washing also reduce the microbial load and remove the cathepsins (proteases). The water used for washing should be potable, chilled and soft water (chlorine 0.5-1ppm). Two types of washing operations are practiced in Industries. One is batch type and another one is continuous type. Batch type requires water in minimum quantity and is generally carried out using agitators. Whereas in continuous washing operation, a series of tanks are arranged.

Lean fish varieties require 3-4 times of water on the basis meat weight for water washing. Fatty fish varieties require 4-5 fold of water. The rate at which these undesirable soluble components are removed from the minced meat is a function of several factors, including water, temperature, the degree of agitation and the contact time between water and meat particle. The number of washing cycles and water/meat ratios used for washing vary among surimi processors. A water/meat ratio of 3:1 to 8:1 is often used by on-shore processors. This washing process is repeated three to four times to ensure sufficient removal of sarcoplasmic protein fractions. The majority of the soluble components are freely and rapidly removed in the first washing cycle primarily by dilution of the free soluble components. Long periods of washing would result in higher hydration of mince and degradation of myofibrillar proteins, making the subsequent dehydration process more difficult and could reduce gel-forming ability

It is important that the effect of the number of washings and other processing conditions on the physicochemical and functional properties of proteins from different fish suitable for surimi production should be standardized. The need for standardization of the number of washing cycles, especially in batch production of surimi from different fish species, is high, in order to minimize the consumption of water and to avoid environmental pollution.

Refining/Straining

Before the final dewatering process in a screw press or decanter, the unit operation called refining/straining is carried out to remove the impurities, such as skin, pin bones, scales, and connective tissues. It is done in equipment called refiner/strainer or specially designed screw press. Perforation in the refiner/strainer is small so that only meat comes out whereas fins and scales are retained. Straining is often done with the injection of water which helps in easy flow. It is done to get a fine grade surimi.

Dewatering/Dehydration

After repeated washing and refining, the moisture content of fish meat likely to increase from 82–85% to 90–92%. Hence, it is essential, to remove excess water prior to mix with additives like cryoprotectants and subject to freezing process. Removal of excess water after washing the meat is termed as dewatering/dehydration. The desirable moisture content

of the meat, prior to blending, typically ranges between 80% and 84%. Proteins have both polar and non-polar amino acid residues. Polar residues absorb water. Only 30% of total amino acid residues are non-polar remaining 70% are polar residues in fish meat protein. In order to facilitate the easy removal of water at the end of washing certain divalent ions and salts are added. In very small quantity divalent salts have greater affinity towards water molecules than that of polar residues present in protein, thus, facilitate the easy removal of water. As a part of evaluation, the industrial surimi making process have witnessed different methods by which the excess water is removed such as manual press, nylon mesh bag method, Centrifugation and screw press.

Nylon mesh bag

In this method small size nylon mesh is hung in chill room (4-6^{o}C). washed meat is placed in this and kept for few hours. The excess water drains due to gravity.

Centrifugation

In this method, perforated basket type centrifuge is used. Normally, it is centrifuged in the speed range of 4000-5000 x g. The water thrown during centrifugation can be collected, recycled and used. It is a batch process. So it is time consuming.

Screw press

The screw press is a compression machine with a 2:1 fixed compression ratio: two parts in, one part out. Entire barrel of screw press is provided with perforation. The desired moisture content out of the screw press is 82% moisture or 18% solids. During screw pressing meat and water get separated. During pressing temperature may increase. Refrigerant is used to keep temperature low. The effectiveness of water removal is governed by the length and speed of the screw, the volume reduction ratio, and the perforation of the screens. Of late, the screw press is replaced by decanter centrifuge.

Mixing with cryoprotectants

The term ‘Cryo’ means ‘low temperature’ and ‘protectants’ means the substance which shows protective activity. When the protein molecules present in the fish meat exposed to various environmental conditions, they become reactive (chemically they interact with each other). If any residues in the protein molecules combine and forms a bond or a sort of interaction, is referred as ‘aggregation’. The denaturation of proteins, to be more specific the myosin, causes loss of gel forming ability-an important functional property to be preserved during surimi process. Generally, minced meat attains a spongy texture and loses the ability to hold water upon poor freezing practice and thawing which results in loss of gel forming ability. In order to minimize the denaturation some substances are added to surimi which is mainly intended for freezing and frozen storage.

Cryoprotectants are normally small molecules having the functional groups like –OH, -COOH, -NH^{+}_{3}. They should able to orient appropriately towards water molecules present along with the protein in the fish tissue to exert the cryoprotective effect. Most widely used cryoprotectants are polyols, CHO, amino acids and certain salts. Sucrose (4%), sorbitol (4%), sodium tri-polyphosphates (0.2%) are commercially used in surimi. At high concentration of sucrose product is sweeter and at high concentration of sorbitol, products become more brownish. Commercially cryoprotectants is added by mixing it with meat in bowl and chopper/mixer

Panning

The washed and dewatered fish mince (surimi) is placed in trays with the thickness of the slab of not more than 60mm. This operation is termed as panning.

Freezing

The freezing of surimi slabs is done at -30 to -40 ^{o}C using either contact plate freezer or air blast freezer. The core temperature should be at least -20 ^{o}C and the freezing is usually carried out for 90 min.

Storage

Technically, -30 ^{o}C is more preferred frozen storage temperature. However, in most of the commercial establishments, it is maintained at -18 to -20 ^{o}C. The frozen surimi can be stored at the above mentioned condition for at least 6 months with minimum loss of gel forming ability.

Grading of Surimi

The quality of surimi is determined by the following main characteristics:

- Gel-forming properties (determined by texture analyzer)
- Colour (the whiter the colour, the higher the quality)
- purity (the more complete the absence of blood, skin and brown meat, the greater the purity)
- Regularity
- Bacteriological aspect

Theoretically, these characteristics are specified in a surimi grade system. In practice, these characteristics vary with raw material and supplier.

Example for grading of surimi from Threadfin bream

Grade	Moisture (%)	Gel strength		Whiteness		Impurities
		Force	Deformation	L*	b*	/40g
SSA	**76**	>1000	>1.30	>78	<6	<40
SA	**76**	>900	>1.20	>76	<6	<40
FA	**76**	>750	>1.15	>75	<6	<40
AA	**76**	>600	>1.10	>75	<8	<40
A	**76**	>400	>1. 05	>75	<8	<40
KA	**77**	>300	>1.00	>74	<10	<60

Surimi based products

As mentioned earlier, surimi is an intermediate product and many number of products can be developed from surimi depending on the creativity, innovation and knowledge of the one involved in this line. However, Kamaboko, Chikuwa, Hanpan and Satsum-age are the traditional surimi based Japanese products. Of late, the products like fish ball, fish sausage and fish ham were introduced. Today, surimi is used mainly in analogue or imitation products like crab stick, shrimp analogue, lobster analogue and scallop analogues. Generally, the surimi-based products can be divided as follows

- Satsuma-age (fried)
- Chikuwa, (baked)
- Kamaboko (steamed)

- Hanpen/naruto (boiled)
- Fish ball
- Flavored kamaboko (fish sausage/ ham)
- Analog/imitation seafood

Table 2. Common surimi based products

Surimi based product	Year of introduction	Processing method
Hanpen	1548	Boiling
Uo-Somen	1580	Boiling
Tsumire	1580	Boiling
Shinjio	1580	Boiling
Yaki Chikuwa (Chikuwa)	1674	Baking
Mushi chikuwa (Shirochikuwa)	1674	Steaming
Yaki Kamaboko (Itazuke)	1684	Baking
Kasutera Kamboko (Datemaki)	1785	Baking
Nikamboko (Suji)	1798	Boiling
Surimi kasutera	1804	Baking
Mushi kamaboko	1823	Steaming
Naoruto kamaboko	1823	Steaming
Tsukeage	1846	Deep-frying
Fish sausage	1953	Boiling
Kaniashi (Flake)/kanikama/Crabstick	1973	Steaming
Kaniashi (stick)/kanikama/Crabstick	1975	Steaming

(Adopted from Park, J.W. ed., 2013. *Surimi and surimi seafood*. CRC press.)

Kamaboko

Kamaboko is the most typical surimi based product in Japan. Traditionally, surimi paste is formed into a Quonset hut shape on a wood board before subjecting to any thermal treatment. Sometimes, the surface of shaped meat is coated with colored paste for appearance. The shape and texture of kamaboko vary from region to region. After shaping, the surimi paste is subjected to a low-temperature setting process (20 to 40^{o}C) for 30 to 60 min to enhance the gelation is carried out. This process yields a very strong and elastic gel. Cooking by either steaming or baking is practiced. The finished steamed product is called *mushi* (steaming) kamaboko. On the other hand, the baked kamaboko is called *yaki-ida* (baked on the board).

Another type of kamaboko is called molded kamaboko, which is also processed in a Quonset hut-shaped mold. The molding technique is mainly applied for the utilization of low-grade surimi which has low gelling capacity. In this process, surimi paste is poured into a plastic mold and “cooked” at 90°C (baking or steaming) after setting at 10 to 15°C for 10 h. The finished products are packed, pasteurized, and chilled before supplied to the market.

Chikuwa

Chikuwa is a pipe or tube shaped surimi product. Surimi paste is placed onto a grooved hole in a rectangle shape on the surface of a drum. The paste is then rolled onto a metal stick on the conveyor. To facilitate with gelation, the rolled paste on the stick is baked

rotationally in the oven on a screw conveyer. The finished products are packed, pasteurized, and chilled as like kamaboko before channeling to the market.

Hanpen

Hanpen is having the soft texture like a marshmallow or soft tofu. For the development of soft texture, whipping (agitation or stirring at high speed) is required. At the last step of mixing, gums or polysaccharides have been added as whipping agents or stabilizers. Vegetable oil is commonly mixed as well for the development of soft texture. The surimi paste is traditionally whipped using the pestles of the stone mixer at high speed. In recent years, however, the surimi paste is aerated compulsorily by a continuous mixer. The whipped paste is then boiled in hot water (80 to 85°C) to fix the soft gel texture.

Satsuma-age

Satsuma-age is a fried kamaboko product has various shapes and characteristics.

Fish Ball

Typical ingredients used for fish ball, in addition to surimi, are salt, sugar, monosodium glutamate (MSG), starch, and water. No flavors or protein additives are added to the formulations. Once the paste is prepared, it is extruded or formed into a ball shape and dropped into warm water (20 to 40°C) for 30 to 60 min. Keeping a uniform shape of fish ball, in a mass production, is critical. Thereafter, fish balls are placed in hot water (95 to 98°C) for 10 to 30 min (the core temperature should reach 80°C), followed by chilling under running tap water. The fish ball, after draining water, is then packed in a poly bag.

Fish sausage

Fish sausage is an emulsion based fish product. For the preparation of fish sausage, the thawed surimi is mixed with salt, sugar, STPP, starch, spice mixes (coriander, chilli powder, ginger garlic paste, pepper), vegetable oil and water in a bowl chopper to get a homogeneous paste. The mixing process should be ideally completed within 12-15 min. The paste is then stuffed into synthetic casings preferably PVDC and heat processed for 45 min at 90 °C followed by cooling for 15 min in chilled water and re-boiling for 1 min. Fish sausage is one of the surimi seafood products originally produced in Japan, but different from other surimi seafood based on the added ingredients (i.e., edible fat and spices). The sausage is consumed primarily as a snack and as an appetizer or used as an ingredient for salad and stir-fried food.

Fish ham

Fish ham is prepared by mixing of fish paste with cured meat made from a red fish such as tuna or marlin followed by addition of pork fat, stuffing into a large sausage-type casing in. The curing is usually carried out using salt and nitrite. The fish paste and cured meat ratio is 2:1. The heat processing is similar to sausage processing. The casing used for ham preparation is larger in dia compared to sausage casing and most of the time colored casing are used.

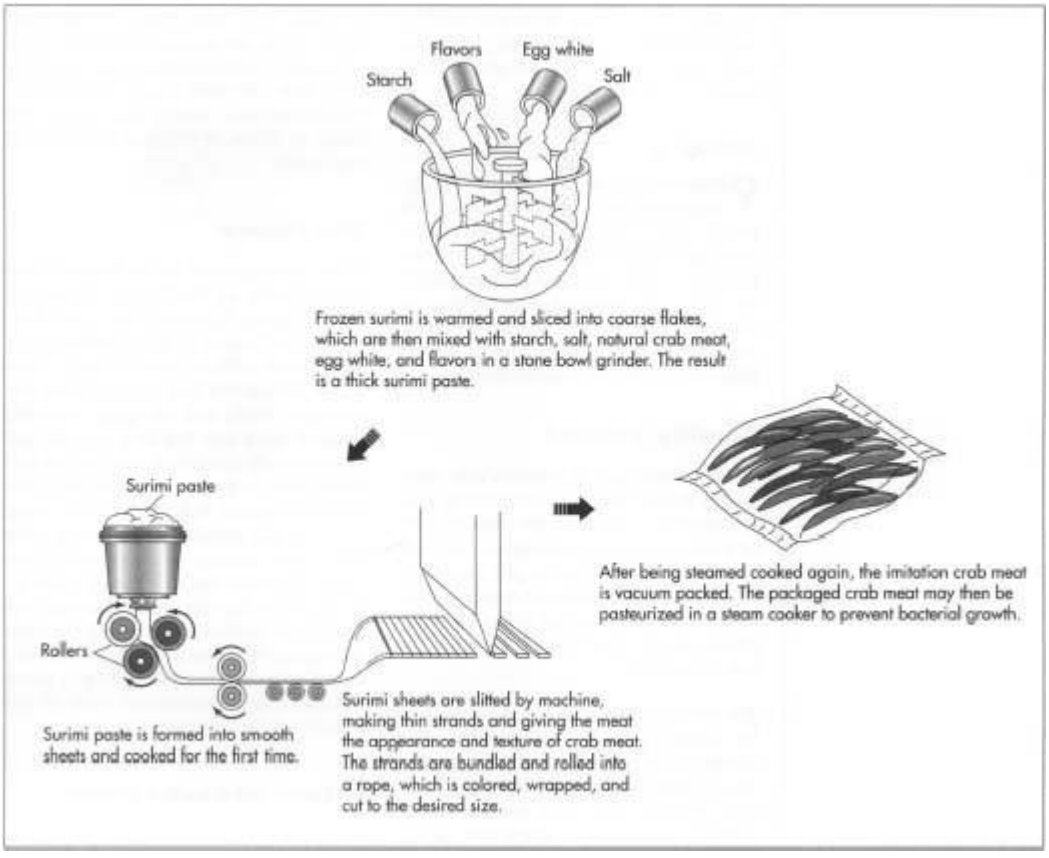
Imitation products

As surimi is bland in taste and have the gel forming property, it is used as a major ingredient to develop the imitation products with resemblance in the texture and taste. The

imitation products include shrimp analog, lobster analog, scallop analog, carb leg and crab stick.

Crab analogue

The frozen surimi is converted to imitation crab meat through various steps. First, it is tempered at -4°C, then shredded into coarse flakes and subjected to comminution during which, the surimi flakes are mixed with other ingredients include starch, salt, natural crab meat, egg white, and flavours in a bowl chopper. Comminution results in the formation of thick surimi paste, which is then transferred to a hoper (holding tank). The paste is conveyed from the hoper to the sheet-forming machine. Continuous sheets of surimi, about 10 inches (25 cm) wide and 0.05 inch (1.2 mm) thick are extruded. Due to the functional nature of surimi protein, the extruded sheets are very smooth in texture. After the sheets are formed, they are passed to machines and subjected to initial cooking. This cooking meditates the setting of the sheets and prepares them to be suitable for the further slitting process. Slitting gives the appearance and texture of crab meat. The slitting is done by a machine which is composed of two steel rollers that cut the thin sheets into strands having 1.5 mm wide. These thin strands are pulled, bundled and rolled into a rope. This rope is colour, wrapped, and cut to the appropriate size. It is then steam cooked, forming a product that imitates in texture and tastes very much like the crab meat.

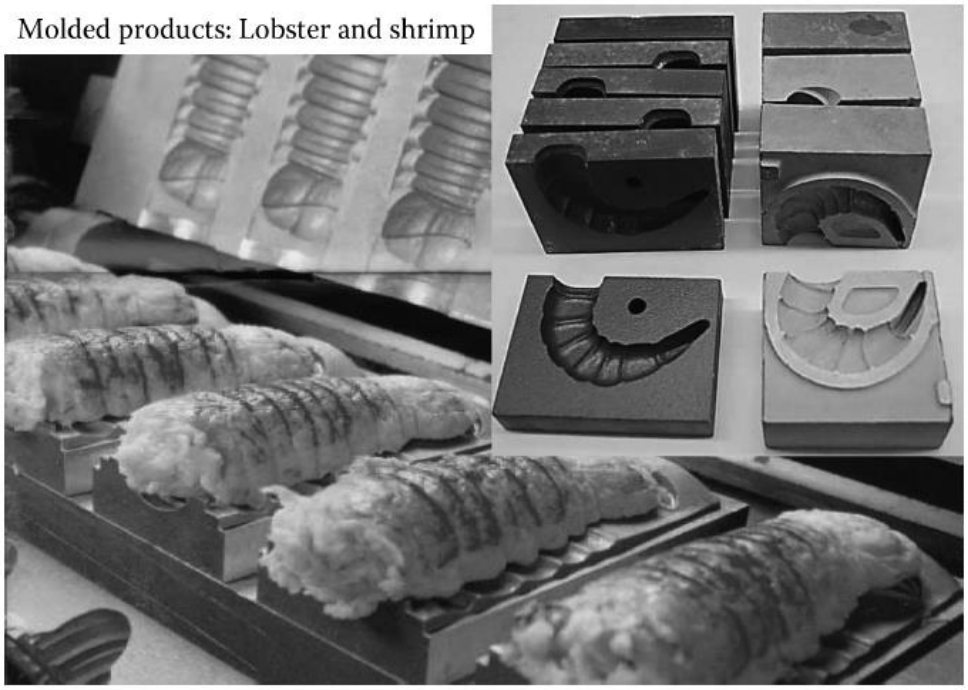


(Adopted from http://www.madehow.com/Volume-3/Imitation-Crab-Meat.html)

Shrimp and lobster analogue

For the preparation of shrimp and lobster style products, the surimi paste is commonly mixed with pre-prepared surimi meat fibers and transferred to a molding machine or cold-extruded in a three-dimensional shape. For imparting the color, a color solution is sprayed

inside the mould before stuffing. Another way to impart the colour is directly using the colored paste (brushed) on the surface of cooked moulded products. In the later method an additional, additional heating is needed to set the colour.



Molding for shrimp-flavored or lobster-flavored surimi seafood.

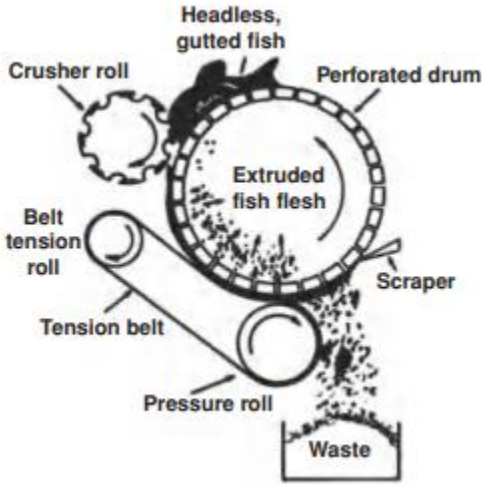
(Adopted from Park, J.W. ed., 2013. *Surimi and surimi seafood*. CRC press.)

Scallop Analogues

The plant set up for the production of scallop analogue is similar to crab analogue. For the preparation of scallop analogue, a wider and thicker surimi sheet is extruded compared to the surimi sheet extruded in crab analogue preparation. After sheet formation, surimi sheet subjected to partial cooking for facilitating the gelation and subsequently subjected to slitting. After slitting, an uncooked layer of surimi paste is added on top of the gelled surimi sheet immediately. This additional layer of surimi paste is to enhance the binding of fibres. The gelled fibres are wrapped and cut into 2-foot lengths and heat processed. The cooked fibre bundles are cut into to the desired dimension of scallops shapes using flaking machine.

Mince

Minced fish is the flesh separated in the form of reduced particle size from the skin, bones, scales, and fins. Mince could be the intermediate product for versatile product development for example, sausages, frozen battered and breaded products, and dried fish flesh flakes. It is also a starting material for surimi processing. Mince technology can also be used to recover meat from the filleting process waste. This technology is well adoptable for underutilized species including pelagic fish. Mince is preserved and marketed often in the form of frozen blocks.



Mechanical fish separator (Adopted from Marsh and Flick, 2012)

Points to be considered for fish mince processing

- Raw materials and sources
- Separation processes
- Anatomy and biochemistry consideration
- Mince stabilization (Fat, Protein, colour, bacteriological stability)

Mince based products

- Fish Wafers
- Fish Fingers
- Fish Cutlets
- Fish Cakes
- Fish Balls
- Fish Noodles
- Fish Sausages
- Fish Patties

Acknowledgement

Authors are grateful to Dr. Pascal Guenneugues, Chairman, Future Seafood, France for sharing the updated data on world surimi market.

References

1. HE, Y.C. and HONG, Y.P., 2004. A Review: Surimi Product Elasticity and Fish Flesh Gel Characteristics [J]. *Fisheries Science*, *6*, p.015.
2. Lanier, T.C. and Lee, C.M. eds., 1992. *Surimi technology*. New York: Marcel Dekker.
3. Martin, T., 1992. Surimi products. A review. *Advances in Seafood Biochemistry. Composition and Quality*, pp.377-391.
4. Martín-Sánchez, A.M., Navarro, C., Pérez-Álvarez, J.A. and Kuri, V., 2009. Alternatives for efficient and sustainable production of surimi: a review. *Comprehensive Reviews in Food Science and Food Safety*, *8*(4), pp.359-374.
5. Ohshima, T., Suzuki, T. and Koizumi, C., 1993. New developments in surimi technology. *Trends in Food Science & Technology*, *4*(6), pp.157-163
6. Park, J.W. ed., 2013. *Surimi and surimi seafood*. CRC press.

7. Pigott, G.M., 1986. Surimi: the “high tech” raw materials from minced fish flesh. *Food Reviews International*, *2*(2), pp.213-246.
8. Sonu, S.C., 1986. *Surimi*. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region.

Website

1. http://www.madehow.com/Volume-3/Imitation-Crab-Meat.html#ixzz4qDC9b531
2. http://surimischool.org/

Chapter 10

Coated fish products

Smt. Sreelakshmi. K.R and Dr. George Ninan
Fish Processing Division, ICAR- CIFT
Email: sreelakshmi.k.ramanathan@gmail.com

Battering and breading enhances the consumer satisfaction by improving the nutritional value, organoleptic characteristics and appearance of the products and makes them popular among other consumer items. The soft and moist interior with porous outer crispy crust increases the palatability and makes these products an integral part of human foods. Consumers are looking for better alternative for conventional fresh food that offers time-saving preparation. Hence there exists an increased global demand for ready-to-heat frozen foods, especially breaded and battered products with high standards of quality. The most important advantage of coating is value addition as it increases the bulk of the product. Also this paves way for better utilisation of low cost or underutilised fishes. Coating is referred as the batter and/or breading adhering to a food product. Each ingredient in coating offers unique role in development of functionality and characteristics of the product. Polysaccharides, proteins, fat, seasonings and water are the commonly used ingredients. The method of product development differs with the type of product. Mostly this includes seven major steps.

1. Portioning / forming

A perfectly portioned product is the right starting point. Mechanically deboned fish meat is formed to different shapes and sizes after mixing with ingredients, if needed. The product should keep its consistency with proper weight and shape. The key factor in this production step is speed and accuracy of processing the frozen fish block at minimum costs without any compromise to the product quality.

2. Predusting

Predusting is usually done with very fine raw flour type material or dry batter itself, sprinkled on the surface of food substrate before coating. This helps to reduce the moisture on the surface of the product so that the batter can adhere uniformly. Flavourings such as salt and spices can be added in minimum amounts.

3. Battering

Batter is defined as the liquid mixture composed of water, flour, starch, and seasonings into which the fish products are dipped prior to breading. Two types of batter are there- adhesive batter and tempura batter. The adhesive batter is a fluid, consisting of flour and water. Tempura batter is the puff-type batter containing raising/leavening agents. This forms a crisp, continuous, uniform layer over the food. The predusted portions are applied with wet batter and excess batter can be blown off by a current of air. The batter mix helps in governing the amount of bread to be picked up and it contributes to flavour of the final product. Specific ingredients are used to aid viscosity, texture and adhesion.

Typical formulation of a batter system is given in Table. 1. The ingredients are classified as critical and optional based on the functions.

Table.1 Formulation of batter

Ingredients	**Addition range%**
Critical	
Wheat flour	30-50
Corn flour	30-50
Sodium bicarbonate	Upto 3
Acid phosphate	Adjust based on neutralizing value
Optional	
Flours from rice, soy, barley	0-5
Shortening oil	0-10
Dairy powders	0-3
Starches	0-5
Gums, emulsifiers, colours	Less than 1
Salt	Upto 5
Sugars, dextrins	0-3
Flavourings, seasonings etc.	As required

3.1. Ingredients of batter mix formulated at CIFT

An adhesive type quick setting batter is usually used. A typical adhesive batter formulated at CIFT, Kochi is given in Table 2.

Table 2. Batter Ingredients

Maida	:	2000 g
Corn flour	:	200 g
Bengal gram	:	200 g
Salt	:	30 g
Guar gum	:	5 g
Turmeric powder	:	5 g
Sodium tripolyphosphate (Food grade)	:	10g

a) Flour- Wheat flour provides structure to the product through gelatinisation of starch as well as through formation of gluten protein matrix. Higher protein levels in flour increases viscosity of batter and produce darker crispy coatings. Corn flour can be added to produce yellow colour and to enhance browning during frying.

b) Water- The ratio of water to dry batter mix is 1.8:1. Formation of gelatinised starch phase, hydration of flow proteins, batter viscosity etc. depends on the purity of water used.

c) Starch- Corn starch is added mainly to control batter viscosity and thus increasing the batter pickup and breading retention.

d) Flavour and flavour enhancers- salt, sugar, spices etc. can be added to improve the organoleptic characteristics of the products.

e) Sodium tripolyphosphate- This lowers the water activity of the product and has bactericidal property. It increases the hydration of proteins and reduces protein denaturation.

The ingredients are mixed evenly and one part of batter powder is mixed with two parts of water to get the required consistency.

4. Breading

Breading is defined as the application of a dry mixture of flour starch, seasonings having a coarse composition to battered food products prior to cooking. Bread crumbs, puffed grains or small potato chips can be used for coating. Normally the battered fish portions are dropped in to dried bread crumbs and are turned over to ensure complete coating with bread crumbs. A fine layer or coarse layer of bread crumbs will contribute to structure and tastiness of the product. For soft products the crumb depth should be fine so as to avoid the product damage on further processing.

Preparation of Bread Crumbs (CIFT technology)

- Remove the outer brown layer of bread
- Grind in mixer grinder
- Spread over aluminium tray
- Keep for drying for 2 ½ hrs at 70^0C in dryer (smoker)
- Store in appropriate packages

Commercial bread crumbs like planko bread crumbs (flake like), extruded bread crumbs (float in oil) etc. can also be used.

5. Pre-frying/ flash frying

Pre-frying is the process of giving a shallow fry so as to coagulate batter over the product and lock the flavour and juices to the product. The time of frying and temperature of oil are crucial factors. This could be done at 180-200°C for 40-60 sec, thus restricting the actual heat transfer to the surface of the product. The term pre-frying is used as frying will be completed only when the consumers fry the product for 4-6 minutes depending on the product size.

6. Freezing

The first step in preparing the fried fish portion for freezing is air-cooling. This is usually accomplished with the use of a fan or a series of fans. This allows the coating temperature to drop, while at the same time allowing the batter coating to recover from the frying shock and also to stabilize itself. The coated fish portions are then fed to the freezer through conveyor belts. Since the fried portions are fragile, care should be taken to avoid contact between the portions while loading in the freezer. Freezing is usually carried out in spiral freezers. Other types of IQF freezers can also be used depending on the product and convenience. Freezing is completed when the internal and external temperature of the fish portion drop to about – 40°C.

7. Packaging and storage

The common deteriorative changes taking place during frozen storage of battered and breaded fish products are desiccation, discolouration, development of rancidity etc. Application of proper packaging prevents/retards these changes to a great extent. Conventional packaging materials like flexible plastic films are not suitable for these products as they provide little mechanical protection to the products and as a result the

product gets damaged or broken during handling and transportation. Hence thermoformed containers are commonly used for this purpose. The packed coated products are usually stored at –20°C.

Coated fish fillets

Fried coated fish fillet is a prominent food item in the European markets. Along with fried potato chips it forms a substitute for lunch for majority of the floating population in Europe. Fresh water fish fillet of table size and having minimum fin bones can be used for this purpose. Various stages in the production of coated fish fillet are:

- Filleting
- Cold blanching
- Pre-dusting
- Coating with batter
- Coating with bread crumbs
- Pre-frying
- Freezing
- Packaging
- Storage

Filleting: A fish fillet is a skinless, boneless fish loin cut along the central bone frame and trimmed free of loose or hanging meat. Skinless and boneless fish fillets can be prepared manually as well as using filleting machines. While fillet yield is 30 to 40% with machine filleting, manual filleting gives better yield.

To fillet, keep the fish on the chopping board and cut from behind the pectoral fin down to the main bone and move the knife along the bone frame with minimum loss of meat. Remove the skin along with scales by passing the knife along the skin layer. Also remove the belly flaps. Trim off any hanging meat from the fillet and make it regular and uniform. Wash the fillets in chilled water and drain.

Cold Blanching: Dip the fillets in 5% brine solution containing 0.1% citric acid for 3-5 minutes depending upon the size grade and then drain off.

Pre-dusting: The fillets are then pre-dusted with a suitable pre-dust or dry batter mix itself. The excess pre-dust adhered to the substrate is then removed either by shaking or using an air blower.

Battering: The pre-dusted fillets are then coated with batter uniformly.

Breading: The batter coated fillets are further coated with bread crumbs. Generally medium size porous crumbs having a relatively large granulation are used even though the selection of the crumbs depends upon the requirement of the finished coated product. The bread crumbs are uniformly applied on the product and the excess crumbs are then removed using an air blower. The coating picks up depends on the viscosity of the batter and the type of crumbs and 30-35% is generally obtained.

Pre-frying: After the application of bread crumbs the fillets are flash fried in hot vegetable oil for 20-30 seconds depending on the size grade of the fillets. The temperature of frying is maintained at 180-200°C.

Freezing: The flash fried fillets are cooled immediately using a fan and then frozen in an

IQF freezer preferably a spiral freezer for the required time depending on the size of the fillets. The time is adjusted by regulating the conveyer speed of the freezer belt.

Packaging: The frozen coated fillets are immediately packed in thermoformed containers or pouches made of 12µm plain polyester laminated with 118µm LDPE. A specified number of such consumer packs are then packed in master cartons.

Storage: The packed cartons of frozen coated fillets are stored in a cold storage maintained at -20°C.

Fish fingers/Fish portions/fish sticks

Fish fingers are regular sized portions cut from rectangular frozen blocks of fish fillet or fish mince. A common size fish block in commercial practice in Europe is 47.9cm long, 25.4 cm wide x 6 cm thick weighing 7.5 kg. On the production line the blocks are subdivided by a series of band saws and subsequently cut into the desired width and shape. Fish fingers are made in to different shapes such as rectangular, square, wedge and french cuts. For small-scale units, frozen slabs of 1.5 cm thick may be convenient for cutting out fish fingers of uniform size. A typical British fish finger normally weighs about 28 g (1 oz) of which up to 50% of the total weight is contributed by the batter and crumbs. Accordingly, a rectangular piece of 7.5 x 2.0 x 1.5 cm weighing about 15 g may give a final weight of 28 g.

The frozen fish block is prepared by mixing fish fillet/mince with 0.6% sodium tripolyphosphate and 1% sodium chloride, placing in a frame of convenient size, pressing slightly and frozen to form a solid block of fixed dimension. (The removal of pin bones from the fillets of fresh water fish of many species is a difficult task. In such cases it will be better to prepare the fish block from the fish mince after removing the pin bones using a fish meat strainer). The frozen block is cut into suitable uniform sizes. These pieces are given a coating of pre-dust, batter and breading as in the case of coated fish fillets. The battered and breaded fish fingers are flash fried in oil at 180-200°C for 30 seconds. After cooling, the fingers are frozen preferably in an IQF machine and packed in thermoformed trays or pouches and stored at −20℃. The flow chart for production of fish finger is given in Fig.2.

The fish fingers when fried in vegetable oil develop a golden brown colour with attractive appearance and odour. It has been observed that the sensory quality of fish finger developed from the frozen block of fish fillets is superior to that developed from the block of mince.

Preparation of Fish Fingers

I. Fish Fingers from Fillet

Ingredients

Fish fillet	1 kg
Salt	3%

Procedure

Fillet the fish and cut into small pieces (about 10 cm in size) and blanch in 3% salt solution for 10-15 minutes. Drain off and pre-dust with batter powder and coat with batter and breadcrumbs and fry.

II. Fish Fingers from Mince

Ingredients

Fish fillet	1 kg
Tri-sodium polyphosphate	0.1 %
Salt	0.6 %

Procedure

Dress and fillet the fish and mince in a meat mincer. Add 0.1 % tri-sodium polyphosphate, 0.6% salt, mix, spread the mince in a tray uniformly and freeze. Cut into small pieces (about 10 cm in size) in the frozen condition itself. Pre-dust the finger with batter powder and coat with batter and breadcrumbs using a bamboo stick. The battered and breaded fish fingers are flash fried in oil at 180-200℃ for 30 seconds. After cooling, the fingers are frozen preferably in an IQF machine and packed in thermoformed trays or pouches and stored at −20℃.

The fish fingers when fried in vegetable oil develop a golden brown color with attractive appearance and odour. It has been observed that the sensory quality of fish finger developed from the frozen block of fish fillets is superior to that developed from the block of mince. The removal of fin bones from the fillets of fresh water fish of many species is a difficult task. In such cases it will be better to prepare the fish block from the fish mince after removing the fin bones using a fish meat strainer

Molded fish products

A variety of products like balls, burgers, cutlets, medallions, nuggets and surimi based products like seafood analogues come under this category. They have all the beneficial features of fish along with attributes contributed by ingredients. The molded products have good market share in the Indian snack food industry and in export market.

Fish Cutlet

Fish cutlet has become a popular snack at celebrations, household functions, tea times etc. The basic raw material required for preparation of this product is cooked fish meat generally from less costly fishes with white meat or cooked meat from skeletal frame obtained after filleting of fish.

Ingredients

Cooked fish meat	:	1000 g
Salt	:	25 g (approx.) (to taste)
Oil	:	125 ml
Green chilli	:	20 g
Ginger	:	25 g
Onion	:	250 g
Potato (cooked)	:	500 g
Curry leaves	:	20 g
Mint leaves	:	20 g
Pepper (powder)	:	3 g
Clove (powdered)	:	2 g
Cinnamon (powdered)	:	2 g
Turmeric	:	2 g

Batter mix	:	250 g
Bread crumb	:	300 g

Method of preparation

- Cook the dressed fish /skeletal frame/mince in 2% brine for 30 minutes and drain off the water
- Remove the skin, scales and bones and separate the meat
- Mix the meat well with a little salt and turmeric powder in a homogenizer
- Fry chopped onions in oil till brown. Add curry leaves, chilly and ginger in chopped form and mint in blended form and fry. Mix these with the cooked meat
- Add mashed potato and spices and mix well with the cooked meat
- Adjust the salt content to taste and shape 30 g each in round or oval form manually or using a forming machine
- Batter with batter mix dispersed in water in the ratio 1: 2 and roll in breadcrumbs
- Freeze the cutlets preferably in an IQF machine.
- Pack in thermoformed trays/pouches and store at –20 °C.

Fish Balls

There are several varieties of fish, which do not command a ready market as fresh fish, but are comparable to many table fish in nutritive value and other attributes. One of the ways of ensuring effective utilization of such fish is to process ready-to-serve or ready-to-cook value added `convenience' products, for which there already exists great demand. Fish ball is one such product prepared using fish mince and starch that can be processed as a coated product or as a heat-processed product in a suitable fluid medium. Coated fish ball is a palatable and nutritious product prepared from mince of low cost fishes. The preparation of fish ball is simple and requires only few locally available ingredients. Hence it is an ideal product for small scale units.

Ingredients

Fish mince	:	1000g Corn
starch	:	50g (5%)
Ginger	:	20g
Garlic	:	20g
Pepper	:	2g
Salt	:	10g (1%)
Batter	:	250 g
Bread crumbs	:	350 g

Process

- Allow the frozen fish mince to thaw. Wash the mince and drain.
- Add corn starch and salt to fish mince and mix thoroughly.
- Add ginger and garlic made into a paste along with pepper powder and mix thoroughly.
- Prepare balls of size 2-3 cm diameter.
- Cook in 1% boiling brine for 10 minutes.
- Take out, drain and cool.
- Pre-dust the balls with the dry batter mix

- Using a bamboo skewer dip in batter prepared in the ratio 1:2 with water
- Apply bread crumbs
- Flash fry in vegetable oil
- Pack the balls in thermoformed trays
- Freeze at -40℃ (Blast Freezer or IQF machine)
- Store at -20℃

Coated Products from Prawns

Delicious and attractive coated products can be prepared from prawns. Coated products in different forms such as butterfly, fantail round and peeled and de-veined can be prepared from prawn. The production process involves nine steps as shown below:

- Preparation of raw material: This includes the preparation of prawns in different forms such as butterfly, fantail round and peeled and de-veined and washing and draining.
- Cold Blanching: Dipped in 5% brine solution containing 0.1% citric acid for 5 minutes
  (3 minutes for butterfly)
- Pre-dusting: Coated with a thin layer of fine flour or dry batter mix itself
- Battering: Usually an adhesive type batter is used. But tempura batter can also be used as per market requirement.
- Breading: Light coloured coarse crumbs are used for Japanese markets and darker coloured crumbs (yellow-orange) for European and US markets.
- Flash frying: The coated shrimp product is flash fried for 30 seconds at 180°C in refined vegetable oil. (Optional)
- Packing: The products are packed in thermoformed containers /pouches.
- Freezing: The products are frozen in an IQF machine or in a blast freezer at -40°C
- Frozen storage: The frozen products in thermoformed containers /pouches are packed in master cartons and stored at -20°C.

Preparation of Specialty Products from Shrimp

1. Centre-peel shrimp

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water. Peel at the centre retaining the head, the last segment and the tail fans. De-vein by inserting a pointed needle or pointed bamboo stick between the segments dorsally and lifting off the vein. Remove the telson by gently raising upwards. Trim off the head and tail fans to reduce the sharpness to avoid damage of the package.

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C & storage below -18°C in master carton

2. Cooked centre peel shrimp

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water. De-vein by inserting a pointed needle or pointed bamboo stick between the segments dorsally and lifting off the vein. Remove the telson by gently raising up wards. Cook the shrimp in 1% boiling brine for 2-3 minutes depending on the size grades. Cool in chilled water. Peel at the centre retaining the head, the last segment and the tail fans. Trim off the head and tail fans to reduce the sharpness to avoid the damage of the package.

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C & storage below -18°C in master carton

3. **Easy-peel shrimp**

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. De-vein by inserting a pointed needle or pointed bamboo stick between the segments dorsally and lifting off the vein. Remove the telson by gently raising up wards. Cut the cuticle, up to end of the last segment dorsally or laterally leaving it intact, just to make the cooked shrimp easy to peel

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

4. Cooked easy-peel shrimp

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. De-vein by inserting a pointed needle or pointed bamboo stick between the segments dorsally and lifting off the vein. Remove the telson by gently raising up wards. Cook the shrimp in 1% boiling brine for 2-3 minutes depending on the size grades. Cool in chilled water. Cut the cuticle, up to the end of the last segment dorsally or laterally leaving it intact.

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

5. Shrimp skewer

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising upwards. Peel the shrimp completely, including the tail fans and de-vein. Arrange 4-5 pieces in a skewer in an inverted “U” shape.

Packaging: Arrange the skewered shrimp in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

Major Markets: Japan, US and Europe

6. Fantail round

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising up wards. Peel the shrimp leaving the shell intact on the last segment and the tail fans. De-vein the shrimp and trim the tail fans using a pair of scissors

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40°C and storage below -18°C in master carton

7. Coated fantail round

Raw Material: Fantail round shrimp pre-dust, batter and bread crumbs.

Process: Coat the Fantail round shrimp with a thin layer of pre-dust either manually or using a pre-dusting machine. Coat the pre-dusted shrimp either with a conventional (adhesive) batter or a tempura type batter, depending upon the market. Coat the battered shrimp with breading (Japanese style light coloured coarse crumbs for Japan Markets and darker coloured crumbs (yellow-orange) for European and US Markets.

Packaging: Arrange in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40°C and storage below -18°C in master carton

8. Butterfly shrimp

Raw Material: Marine prawn (*M. rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising up wards. Peel the shrimp leaving the shell intact on the last segment and the tail fans. De-vein the shrimp and trim the tail fans using a pair of scissors. Cut through the dorsal side length-wise using a sharp scalpel or knife (Butterfly cut) to partially separate the lateral muscle block. Gently open up the cut surface to reveal the butterfly shape.

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40°Cand storage below -18°C in master carton

9. Coated butterfly shrimp

Raw Material: Butterfly shrimp pre-dust, batter and bread crumbs.

Process: Coat the butterfly shrimp with a thin layer of pre-dust either manually or using a pre-dusting machine. Coat the pre-dusted shrimp either with a conventional (adhesive) batter or a tempura type batter, depending upon the market. Coat the battered shrimp with breading (Japanese style light coloured coarse crumbs for Japan Markets and darker coloured crumbs (yellow-orange) for European and US Markets.

Packaging: Arrange in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40°C and storage below -18°C in master carton

10. Butterfly "sushi" shrimp

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising upwards and de-vein. Insert bamboo skewer along the dorsal side length-wise up to the last segment so as the stretch the shrimp completely. Blanch/lightly cook in 1% boiling brine for 1-2 minutes depending on the size grades. Cool in chilled water. Peel the cooked shrimp completely, including the tail fans. Cut the gently down the ventral side length-wise up to the last segment using a sharp scalpel or knife without damaging the lateral muscle blocks on either side. Gently open up the cut surface to form the butterfly shape.

Packaging: Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40°C and storage below -18°C in master carton

11. Stretched shrimp (Nobashi)

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson and trim the tail fans. Peel the shrimp, leaving the shell intact on the last segment and the tail fans. Make three or four parallel cuts, across or diagonally on the ventral side using a sharp razor. Stretch the shrimp to the desired length by gently pressing it using a stainless steel mould

Packaging: Arrange in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

12. Breaded "Nobashi"

Raw Material: Stretched shrimp (Nobashi), pre-dust, batter and bread crumbs.

Process: Coat the stretched shrimp with a thin layer of pre-dust either manually or using a pre-dusting machine. Coat the pre-dusted shrimp either with a conventional (adhesive) batter or a tempura type batter, depending upon the market. Coat the battered shrimp with breading (Japanese style light coloured coarse crumbs for Japan Markets and darker coloured crumbs (yellow-orange) for European and US Markets.

Packaging: Arrange in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

13. Shrimp single kebab (barbecue)

Raw Material: Marine prawn (*M.rosenbergii*) / Vannamei shrimp 26/30 to 31/40 counts/kg

Process: Wash the whole shrimp in potable water and remove the head. Peel the shrimp completely and devein. Insert a bamboo skewer along the dorsal side length-wise up to the last segment so as to stretch the shrimp completely.

Packaging: Arrange the skewered shrimp in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C below -18°C in master carton

14. Shrimp vegetable kebab

Raw Material: Shrimp (any species), carrots, onion and capsicum.

Process: Wash the whole shrimp in potable water, remove the head, Peel and de-vein. Blanch in 1% boiling brine for 15-30 seconds and cool in chilled water. Wash the vegetables in potable water and dice to approximately 2 cm cubes or cut into square pieces and blanch in 1% boiling brine for 30-60 seconds and cool in chilled water. Arrange in skewer, shrimp alternating with diced vegetables

Packaging: Arrange the skewered shrimp vegetables in PVC/polystyrene trays and vacuum pack in laminated pouches.

Freezing & Storage: Blast freezing at –40^{o}C and storage below -18°C in master carton

Equipment in Battering and Breading process

Development in coating technology has been synonymous with development in machinery and equipment. Prior to the introduction of machines breading lines in food processing plants

consisted of a conveyor surrounded by personnel who battered and breaded by hand. The process was slow, tedious, low production rates and difficult to maintain the hygienic standards. Today a large number of automatic and highly sophisticated processing equipment of varying capacities are available. Commonly used equipment in the production of coated products are grading equipment, peeling and de-veining equipment, cooking equipment, meat bone separator, fish meat strainer, automatic band saw, forming machine, kneading machine, pre-duster, battering and breading machine, fryer, freezing equipment such as blast freezer, cryogenic thermal freezer, modular spiral belt freezer, fill and seal machine, vacuum packing machine with gas fleshing capability etc. The introduction of modern machines results in the growth of productivity and reduction of employment; it shortens the duration of technological processes, and makes it easier to prepare more laborious but, at the same time, more attractive products for the consumer.

References:

1. Balachandran, K. K. (2001). Post-harvest technology of fish and fish products. Daya Books
2. Ninan, G., Bindu, J., & Joseph, J. (2010). Frozen storage studies of value-added mince-based products from tilapia (*Oreochromis mossambicus*, Peters 1852). Journal of food Processing and Preservation, 34,255-271.
3. Ninan, G., & Kumar, A. (2018). Pilot scale production of battered and breaded fish products. ICAR-Central Institute of Fisheries Technology.

Chapter 11

Speciality fish products

Dr. Parvathy U.
Scientist, Fish Processing Division, ICAR-CIFT
Email: p.pillai2012@gmail.com

Seafood products are among the most important internationally traded food commodities as they satisfy the demands of the diverse global customers on account of its availability, accessibility, nutritional as well as quality and safety aspects. As the global demand for seafood continues, this sector is entering a new era of consumption and ready food formats. In this context, the industry is forced to have an outside of the box vision by taking advantage of rest raw material also and add value to them. Value addition is highly discussed in the food industry, mainly due to the increased opportunities it offers for earning foreign exchange. Value-added products are processed to create new forms, flavors and textures from a variety of raw ingredients. It is that extra feature of interest beyond the standard expectations. A speciality seafood product can be an innovative product, a new package, eco-labelling, a new cut, a ready-to-eat product, a formed product with multiple formats/ shapes/ dimensions/ flavour profiles. An array of innovative and diversified fish products for both domestic and export market based on a wide variety of seafood sources have been identified.

Chilled products

Chilled seafood commodities are an important and common value added item of domestic importance as well as in foreign trade. In the international seafood sector, the most prominent among this category is the sashimi/sushi grade tuna, which is raw fish fillets from tuna. It is a traditional delicacy in Japan with major species utilized being blue fin, big eye and yellow fin. For the best quality sashimi grade, tuna is maintained chilled throughout the food chain. Other important species like salmon, pomfret, shrimp, lobster etc are also used for raw consumption and hence requires proper chilling for maintaining the quality and safety. Further an array of marinated seafoods are also being marketed in chilled form. These ready to cook products are also gaining more popularity in the domestic market, especially among the urban entities.

Frozen products

Frozen products remains to be the prominent group that has high demand in the Industry. Various forms of IQF products from fish and shell fish viz., whole cooked lobster, lobster tails, lobster meat, cuttlefish fillets, squid tubes, squid rings, whole shrimp, peeled and de-veined shrimp, cooked butterfly shrimp, headless shell-on, butterfly, fan tail and round tail-on shrimp, stretched shrimp (Nobashi), skewered shrimp, shrimp head-on cooked (centre peeled), boiled clam meat and skinless and boneless fillets etc. are capturing the market. With the advent and spread of aquaculture for shrimp/prawn, in particular, individual quick freezing has become very popular. They have the advantage of facilitating harvesting during a predetermined period. This facility enables freezing them individually in the highest quality

possible. IQF products are packed in attractive moisture-proof thermoform moulded trays and stored at around -30°C.

Accelerated freeze dried products

Aaccelerated freeze-drying is now being increasingly used for the preservation of high value food products. It is a novel and effective approach to the food preservation and hence is fast developing into a multi-million dollar industry. Freeze drying technique involves a combination of refrigeration, vacuum and heat. In this process, the removal of water from frozen food is affected by sublimation. Initially, raw food is frozen and by employing high vacuum conditions, the ice in the food is sublimed directly into vapour. Adequate control of processing conditions contributes to satisfactory rehydration, with substantial retention of nutrient, colour, flavour, and texture characteristics. Advantages of freeze dried products are that the quality is comparable to fresh material with high retention of flavor, color, and nutritive value. Further it can be stored under ambient conditions in suitable packaging, light weight, ease of preparation as well as convenient to use. Pre-cooked ready to serve salads, instant fish soup mixes, and prawn cakes prepared using freeze drying technique were found to have good consumer acceptance. Reports suggest a storage life of more than two years for freeze dried prawns under ambient conditions. In India this technique is now applied for processing shrimp, squid rings etc. and there is immense potential for various ready-to-eat products based on fish and shellfish employing this technique.

Thermally processed ready to eat (RTE) products

Ready to eat/serve fish products are gaining wide popularity in the seafood sector on account of its delicacy as well as convenience. A broad range of products categorized under this include retorted seafood curries/masala recipes, seafood combos, seafood ethnic recipes etc. The major advantage of these speciality products is their shelf stability, which ranges from one to two years at room temperature. Retort pouches come in design variances, the most common being a 3-ply laminated material consisting of polyester/aluminium/cast polypropylene. The technology for retort pouch processing of a variety of ready to serve fish and fish products including curries from mackerel, rohu, sardine, tuna, pomfret, prawn, seer fish molly, pearl spot molly, fried mussel, fish sausage, prawn kurma, prawn manchurian, fried mussel masala etc. has been standardized and commercialized by the Institute.

Fish mince and mince-based products

Fish mince is the meat separated from fish in comminuted form and is generally free of bones, skin and other undesirable matter. When this process is encouraged in low cost, underutilized species, it adds on value to the source. Similarly processing fillets can also be effectively utilized for mince preparation. Fish mince can be used as a base material for the preparation of a an array of specialty products that have high market demand viz., fish sausage, cakes, cutlets, patties, balls, pastes etc.

Surimi and surimi based products

Surimi constitutes a wet frozen concentrate of myofibrillar proteins of fish muscle prepared by deboning, washing the fish mince and stabilizing by cryoprotectants. It serves as a convenient raw material for the preparation of various comminuted fish products like sausages, snacks, paste fishery products (kamaboko-type products) and a variety of fabricated products such as crab sticks and shrimp analogues. The purpose of using frozen surimi, rather than whole fish, is not only to cut down the processing procedure but also to ensure a standard quality supply. Surimi-based products are manufactured by grinding surimi with

salts and other ingredients followed by extrusion, fiberization or composite moulding depending upon the desired form of final product, and finally heated to get the shape, develop the texture, and pasteurize the product. The type of heat treatment used is altered to vary the flavour, texture and appearance desired in the final product. The different heat treatments include steaming, broiling, boiling, deep frying, etc.

Coated products

Coated/battered and breaded commodities are highly appreciated form of speciality products on account of their convenience, sensory appeal and nutritional attributes. The most important advantage of coating is that it increases the product bulk, thereby adding value to the finished product. On account of the increasing consumer demand, the technology has made several advancements. This technology also paves way for better utilisation of underutilized seafood resources. A wide array of seafood products can be categorized in it viz., coated fish fillet, fish portions, fish cakes, fish medallions, fish nuggets, breaded oysters and scallops, crab balls, fish balls, coated shrimp products, coated squid rings etc.

Extruded products

Extrusion processing is gaining more relevance in the food industry for restructuring starchy and proteinaceous ingredients. A wide array of extruded products can be produced by optimizing the process variables providing a great versatility for the development of cheap, high-nutritive and convenient cereal based food products. Extrusion technology provides a method to utilize fish muscle recovered from by-products, by-catch and other underutilized fish, thus adding value to the low-cost and underutilized fish and shellfish. Addition of protein rich seafoods in the extruded products fortify the commodity making them more palatable and nutritious. These products can be diversified by introducing attractive flavours and texture by optimized protocols and by innovative packages adopting advanced techniques like modified atmospheric packaging, adding to its shelf life too.

Ethnic seafood products

Ethnic seafood products are region specific ones being prepared and consumed by different people since ancient times. Most of these follow centuries-old indigenous knowledge of processing techniques like fermentation/drying/smoking etc. Globalization has boosted the demand for these traditional commodities and hence they are upgraded as speciality food products. Popularization of these ethnic foods by adopting diverse processing techniques can bring a new outlook for these commodities. A few among these include dried and cured products like dried fish, fermented seafoods, pickles, wafers/papads etc.

Fish pickle

Apart from staple foods, people like spicy adjuncts to make the food palatable and relishing. Preparation of pickles is an old art and a variety of these products are made in Indian homes. The basic principle of pickling is curing of fish by salting, acidifying by addition of vinegar and/or oil and spices. In general, pickling enhances the product shelf life to six months and more. Most of the seafoods like prawns, tuna, seer fish, etc. are ideally suitable for making pickles.

Fish wafers

Preparation of starch based dried products is an age old practice in the house holds and has wide popularity in the domestic market. These are dried, ready-to-fry-and-serve products employing carbohydrate as main base and incorporated with salt and several other

ingredients with or without spices. Being dried products, they have a shelf life of one to two years. By-catches as well as processing frame meat can be very well employed as raw material for the preparation of these dehydrated commodities.

Fermented products

Fermentation is a traditionally been used technique to preserve fresh fish, especially in tropical climates. In India, it is more common in the north eastern region. The ethnic people use their indigenous knowledge for fish preservation without using any extra chemicals. Nowadays it is used to enhance nutritive value, improve appearance and taste, destroy undesirable factors, and also to reduce the energy needed for cooking. A few among the fermented fish products include Ngari and Hentak of Manipur; Tungtap of Meghalaya; Shidal of Tripura etc.

Smoked products

Smoking is a traditional method of fish preservation which is done primarily for the unique taste and flavour. It involves a combination of drying, deposition of naturally produced chemicals resulting from thermal breakdown of wood and salting. It is also used as an intermediatee step in the preservation of canned smoked fish. In advanced process, preparation of products with typical flavour extracts may be advised to reduce the process time and better texture. Typical smoked fish products of the northeast include *Gnuchi*, *suka ko maacha* etc.

Live seafood

Indian fisheries sector especially aquaculture segment is booming on account of global seafood demand. However, the sector is facing a major issue with regard to the marketing of the harvested commodity in its best quality to the consumers. Live transportation is gaining more significance in the country that constantly endeavors to discover ways to enhance the final product value. Compared to the processed ones, the consumer demand and value realization for live ones are much higher. However, for effective live shipment, a number of factors need to be considered critically for improving the survival of fish during their transportation from the point of harvest till it reaches the customer's hands. Focused research and development in this area is expected to improve the quality of seafood supply chain, facilitating the availability of prime quality seafood commodity to the consumers.

Conclusion

Recently, the global seafood market signals diversification with increased consumer demand for convenient on-the-go products with superior nutritional value and palatability. In this line, a series of innovative products like noodles, pastas, energy bars etc as well as ethnic ones with modified protocols have occupied the domestic and export markets. Further there is more focus towards utilization of underutilized fishery resources for the formulation of such products. Innovations in this sector by adoption of novel processing and packaging techniques is an continuous process and consumers are bestowed the assurance to experiment with novel products launched in the market.

Suggested Readings

1. Balachandran.K.K. 2001. Post harvest technology of fish and fish products. Daya Publishing House.

2. Devadasan.K. 2003. Value added fish and fishery products. Fishing Chimes. Vol.23(1), P-131-136.
3. Gopakumar S. 2000. Fish Processing Technology. 2000. Daya publishing house.
4. Gonçalves, A. A. and Kaiser, C. (2011). Value-added seafood products: a challenge or a necessity?. INFOFISH International, 41.
5. Parvathy, U., Binsi, P.K., Kumar, K.S., Murali, S. and Ravishankar, C.N., 2019. Live fish transportation: Technology assuring quality.
6. Venugopal.V. 2003. Value addition to Aquacultured Fishery Products. Fishing Chimes. Vol.23 (1), P-82-84.
7. Venogopal . V. and Shahidi. F. 1995. Value added products from under-utilized fish species. Critical Review in Food Science and Nutrition. Vol. 35(5), P-431-453.

Chapter 12

Advanced fish processing technologies

Dr. Sarika K., Dr. Bindu J. and Dr. Parvathy U
ICAR-Central Institute of Fisheries Technology, Cochin
email: sarikacift@gmail.com, bindujaganath@gmail.com

In the last few decades' consumers are demanding new alternatives of foods having supreme qualities and freshness, minimally processed and packaged, easy to consume and nutritionally healthier, which have led to more value addition and introduction of novel food products. Changing life style and the awareness about the nutrition and healthy diet, led to the necessity of bringing more fresh and natural, ready to eat foods in the market. So, the focus of product development has moved from traditional ones towards market-driven, health-driven and technology-driven products, which often adds safety as well as quality characteristics. Thermal pasteurization and thermal sterilization are the most common processing operations widely employed for processing and preservation of food (Barbosa-Canovas and Bermudez-Aguirre, 2011). But these conventional operations are designed to focus on the vital thermal treatments responsible for microbial inactivation and reduction of enzyme activity, which assures consumer's required safety and shelf life of product. However, despite its benefits such processes end up with loss of natural freshness and quality and consequently affect its functional and organoleptic properties. Often thermal processing ends with the reduction of nutrient content and formation of cooked off flavours in the products. Hence, the focus of food scientists and engineers have been directed towards alternative technologies or minimal processing and preservation technologies that are environment friendly, low in cost and able to preserve fresh quality attributes of the food.

Recent years have introduced many novel thermal and non-thermal technologies like ohmic heating, microwave heating, dielectric heating, infrared heating, HPP, Pulse light, pulse electric field, cold plasma etc. for the preservation of food without losing the quality and shelf life of the products. These technologies can overcome the excessive cooking times and have direct implications on both heat and energy efficiency (Pereira and Vicente, 2010).

Thermal Technologies

1. Microwave heating:

Microwaves are electromagnetic waves of frequencies varying from 300 MHz to 300 GHz; smaller frequency waves having high penetration power. The principle is that microwaves produces frictional heat and it is strongly penetrable. So the food inside and outside is heated simultaneously along with a rise in temperature. It is another emerging technique extensively used in the food industry for heating, cooking, pasteurization, sterilization and drying. The major advantage with regard to microwave sterilized foods is that they can be stored at ambient temperatures and re-heated in the common household

microwave prior to consumption. These products do not require refrigeration thereby cutting down the cost for food processors and distributors, as well as saving valuable refrigerator/freezer space for consumers. Since the heat is produced directly in the food, the thermal processing time is sharply reduced. Microwave sterilization technique guarantees better color, texture and other sensory attributes to the foods in comparison to those that are conventionally retorted simultaneously meeting microbial safety requirements.

Principle: Food containing water is a good absorber of microwave energy. Water exist as dipolar contains both positive and negative charges and the microwaves excites and polarized the water molecules in the food. The water molecules get pulled back and forth at a rate of 2.5 billion times/sec by the electric fields. This rapid motion between water molecules creates friction and hence generates heat.

2. Infrared heating:

Infrared energy is a form of electromagnetic energy. It is transmitted as a wave, which penetrates the food, and is then converted to heat. Infrared radiation is classified as the region of wavelength between visible light (0.38 to 0.78μm) and microwaves (1 to 1000 mm). In Far Infra-Red (FIR) heating, heat is supplied to food by electromagnetic radiation from the FIR heaters. The rate of energy transfers between the heater and the food depends on the temperature difference between the heater and the food. The FIR energy emitted from the heater passes through air and is absorbed by the food; the energy is then converted into heat by interaction with molecules in the food. Heat passes throughout the food from the surface layer by conduction. The related process of near-infrared radiation (NIR) heating is based on the same principle, using the appropriate wavelength. On the other hand, in conventional heating, heat is mainly supplied to the surface of the food by convection from circulating hot air and products of combustion. The difference of heating mechanism between IR and conventional heating makes the difference in cost and quality of the products. The features of IR heating for food processing are as follows:

• The efficient heat transfer to the food reduces the processing time and energy costs.

• The air in the equipment is not heated, and consequently the ambient temperature could be kept at normal levels.

• It is possible to design compact and automatic constructions with high controllability and safety.

• Exact heating control is required, because there is danger of overheating owing to the rapid heating rates.

3. Ohmic heating (OH):

Ohmic heating (also called Joule heating, electrical resistance heating, direct electrical resistance heating, electroheating, or electroconductive heating) is considered an advanced technique for continuous processing of particulate food products. Ohmic heating is defined as a process wherein electric current is passed through materials with the primary purpose of heating the object. During ohmic heating, heating occurs in the form of internal energy transformation (from electric to thermal) within the material. Therefore, it can be explained as an internal thermal energy generation technology and it enables the material to heat at extremely rapid rates from a few seconds to a few minutes. Ohmic heating have a large

number of actual and potential future applications, including its use in blanching, evaporation, dehydration, fermentation, extraction, sterilization, pasteurization and heating of foods. The microbial inactivation due to ohmic heating can be explained by the presence of electric field. The additional effect of ohmic treatment may be its low frequency (usually 50 Hz to 60 Hz), which allows cell walls to build up charges and form pores. As a main consequence of this effect, the D value observed for the microbial inactivation under ohmic heating is reduced when compared to traditional heating methods.

The OH system allows for the production of new, high-added-value, shelf stable products with a quality previously unattainable with alternative sterilization techniques, especially for particulate foods. Its major advantages are:

- Continuous production without heat transfer surfaces
- Rapid and uniform treatment of liquid and solid phases with minimal heat damages and nutrient losses (e.g., unlike microwave heating, which has a finite penetration depth into solid materials)
- Ideal process for shear-sensitive products because of low flow velocity
- Optimization of capital investment and product safety as a result of high solids loading
- Reduced fouling when compared to conventional heating
- Better and simpler process control with reduced maintenance costs
- Environmentally friendly system

Some of the disadvantages accounting for OH are the higher initial operational costs and the lack of information or validation procedures for this technology.

4. Radio frequency (RF) dielectric heating:

RF dielectric heating is a heating technology that allows for rapid, uniform heating throughout a medium. This technology generates heat energy within the product and throughout its mass simultaneously due to the frictional interactions of polar dielectric molecules rotating in response to an externally applied AC electric field.RF dielectric heating offers several advantages over conventional heating methods in food application, including saving energy by increasing heat efficiency; achieving rapid and even heating; reducing checking, the uneven stresses in the product as a result of evening the product moisture profile; avoiding pollution, as there are no by-products of combustion; increasing production without an increase in overall plant length; saving floor space, as efficient heat transfer results in faster product transfer and reduced oven length; and automatically compensating for variations in product moisture. In addition, this technology can be easily adapted during implementation to be compatible with automated production batch or continuous-flow processing

The novel thermal technologies for the inactivation of microorganism and reduction of enzyme activity, has resulted in making safe product with extended shelf life than its raw counterparts. But despite its substantial benefits, these treatments end with significant changes that can alter its sensorial attributes like flavor, colour, texture and nutrient content (Barbosa-Canovas and Bermudez-Aguirre, 2011). The introduction of non-thermal

technologies in food processing opens a new era of minimally processed food with high nutritive value, retains the fresh attributes of the product without compromising the safety and quality.

Non thermal technologies

Many novel non thermal technologies like high pressure processing, pulsed light, pulsed electric field, ultrasound, irradiation etc. find application in preservation of food and is in the line of commercialization. Among all non-thermal technologies, HPP offers promising possibilities for the processing and preservation especially in meat, poultry and seafood.

1. High pressure Processing (HPP)

Application of very high pressures (100-900 MPa) for the preservation of food substance with or without the addition of heat, to achieve microbial inactivation or to alter the food attributes in order to achieve consumer-desired qualities. This technology is also known as high hydrostatic pressure processing or ultra-high pressure processing. HPP retains food quality, maintains natural freshness, and extends microbiological shelf life of the product. This technology is now recognized by the USFDA for RTE foods. The processing can be conducted at ambient or refrigerated temperature eliminating thermal effects and cooked off flavors and thus highly beneficial for heat sensitive products.

The first line of HPP was demonstrated in 1899 by Bert H Hite, as a possible food preservation process at West Virginia Agricultural Experimental Station (Hoover et al., 1989; Knorr, 1999). In 1992, commercialized high pressure processed products (high acid products including apple, strawberry, and pineapple jams) were marketed in Japan and since after 1992 High pressure processed foods are available in the markets of Japan (Suzuki, 2002) and in Europe and in the United States since 1996 (Knorr, 1999). Other, commercially available high pressure processed products in Australia, Europe and the U.S. include juices, tomato salsa, smoothies, fruit & vegetable purees, and ready to eat meals.

Later there was a growing interest in the area of seafood safety that led seafood processors to explore high pressure technology in product development and extension of shelf life. This technology was utilized in the area of extending shelf life of product mainly be destroying the spoilage and pathogenic microorganisms (Toepfl et. al., 2006) and also used as an alternative thermal treatment to packaged food materials. This non thermal preservation technique could also showed many benefits like complete separation of meat from shells of clams, crabs, lobsters, and oysters providing high yield of product without any mechanical damage. HPP could open up the new eras of product development and product improvements in all segments of meat and fish industry. Another advent is pressure assisted freezing and thawing, which finds its unique application in food industry especially in product development and product quality improvement (Urrutia et.al. 2007). Since HPP has minimal detrimental impact on thermally labile bioactive compounds the technology is becoming a topic of major interest for cosmetic, nutraceutical and pharmaceutical industry.

During the time HPP has turned to be an explored technologies and today it is a commercial reality. HPP products find its place in the world food market with high quality and high value addition. Today the use of high pressure (300-700 MPa) for commercial application comes in vessels ranging 35-420L capacity which had given an annual production of >150,000 tons (Wan et. al., 2009). Regulatory agencies like FDA has approved HPP as substitute to pasteurization but in February, 2009, a combination of pressure with heat called

as PATS (Pressure assisted thermal sterilization) found to be effective instead of conventional sterilization (NCFST, 2009).

The basic principles that govern the high pressure effect on the behaviour of foods are (i) Pascal's Isostatic principle and (ii) Le Chatelier's principle.

According to Pascal's isostatic principle high pressure acts uniformly and instantly throughout the sample, independently of the size and shape of the food product (Smelt,1998). A uniform pressure will be applied to the product from all direction, thereby the product will not get damage and return to its original shape on the release of pressure. The fundamental principle of physico-chemical changes occurring during HPP follow the Le Chatelier's principle, which states that 'when a system at equilibrium is disturbed, the system then respond in a way that tends to minimizes the disturbance'. So at high pressure any reactions like change in conformation, or transition of phase that is accompanied by a volume decrease will be favored, while inhibit those reactions involving an increase in volume (Lopez-Malo et. al., 2000).

Mechanism of Pressure Treatment

Each processing cycle in HPP consists of an initial pressurization period where the pressure builds up and the processing operation can be done either with or without the application of heat. The packaged product should be in flexible or semi flexible pouch, that can sustain very high pressures. The product is then submerged into a pressure transmitting fluid, where water is commonly used. Other liquids like ethanol or glycol, castor oil, silicone oil etc. can also use in various combinations with water or use separately. This fluid is able to protect the inner vessel from being corroded and fluid is selected based on the manufacture's specification. During the pressure processing adiabatic heating occurs and the product gets heated up. The temperature increase due to adiabatic heating depends on the type of fluid, pressurization rate, temperature and pressure.

Once the process starts, the hydraulic fluid is pressurized with a pump and the generated pressure is transmitted into the packaged food uniformly from all sides. Since this processing is independent of size and geometry of foods, also acts instantaneously there by the total processing time can be reduced. The process is suitably applied for liquid foods and to liquid foods, having a certain amount of moisture content. The transmitted pressure is uniform and simultaneously applied from all directions so that food retained its structure even at high pressures. Once the pressure is build up to the desired level the product is held at this pressure for a few minutes and then decompression or pressure release takes place. Once there is a fall in pressure the product temperature falls below that of the initial product temperature.

Major Advantages of the Technology

1. HPP does not involve in breaking covalent bonds which prevents the development of unpleasant flavours to the product and maintains the natural freshness and quality.
2. High pressure is able to modify the palatability and functional properties by inducing denaturation and muscle protein gelation.
3. Process can be carried out at ambient temperatures, that helps in reducing the thermal energy used during conventional processing.
4. High pressure processing is isostatic in nature, equally applied to all particles of food, with no particle escapes.

5. Since high pressure is not time-mass dependent, pressure acts instantaneously thereby reducing the processing time.
6. This non thermal technology is independent of size and geometry of the food.
7. The process is ecofriendly, with no waste and requires only electric energy.

Application in marine Products

- Used to extend shelf life of products
- Develop new gel based products with desired sensory attributes and mouth-feel
- Used in shell fish processing for 100% removal of meat from shells
- Reduces the microbial risks during raw sea food consumption
- Inactivates vegetative micro-organism and reduces the bacterial contamination and the pathogens
- Modify functional properties of the food material
- HPP in combination with salting and smoking helps to extend the shelf life
- Pressure assisted thermal processing used for development of shelf stable ready to eat products
- Pressure assisted freezing and thawing helps in retaining the microstructure and reduces drip loss in fish products

High Pressure Processing Facility at ICAR-CIFT

A Research model of 2 litre capacity High Pressure machine from M/s Stansted Fluid Power Ltd, United Kingdom at Central Institute of Fisheries Technology, Cochin.

Seafood is a highly perishable commodity and technologies like high pressure processing are essential to increase the market value of some high value fishes. High pressure processing has now experiencing a growing demand in the global market. A lot of researches have been carried out on HPP from the past decade. Further studies on the effects of this technology on the textural and functional modification, biochemical characteristics and microbial kinetics of fish and shellfishes are necessary. The effectiveness of high pressure on microbial and enzyme inactivation, while maintaining optimal product quality is a crucial factor for the commercialization of this technology. HP processing offers many advantages over conventional processing methods known to seafood. This is exemplified by the success of HP-processed oysters in USA by Motivatit Seafood, Goose Point Oysters and Joey Oysters. However, as HP processing becomes more widely available, initial capital costs may be reduced, making technology accessible to more producers. In addition, the commercialization of the technology for other foods may provide encouragement for seafood processors, by allaying apprehension regarding the use of this novel technology and demonstrating consumer acceptance of HP-processed products.

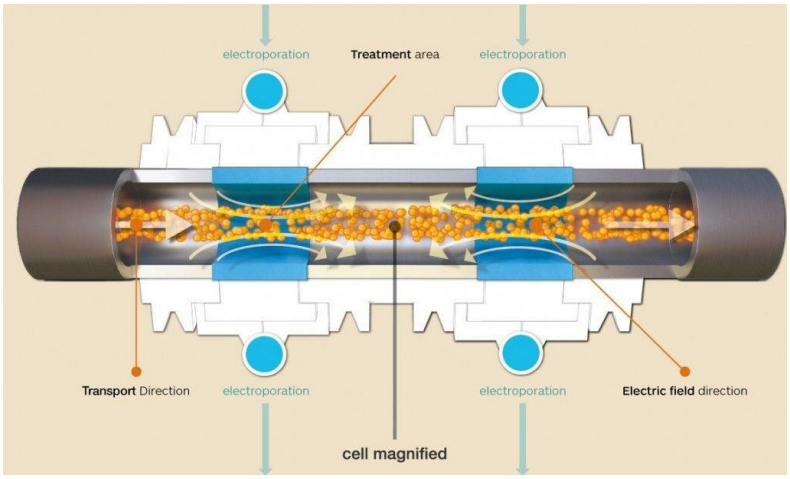
2. Pulse electric field

Pulsed electric field processing is a non-thermal food preservation technique used mainly for inactivation of microbes. PEF technology is the application of short pulses of high electric fields with duration of micro- to milliseconds and intensity in the order of 10-80 kV/cm in order to preserve the food. The processing time is calculated by multiplying the number of pulses times with effective pulse duration. The process is based on pulsed electrical currents delivered to a product placed between a set of electrodes and the distance between electrodes is termed as the treatment gap of the PEF chamber. The applied high voltage results in an electric field that causes microbial inactivation.

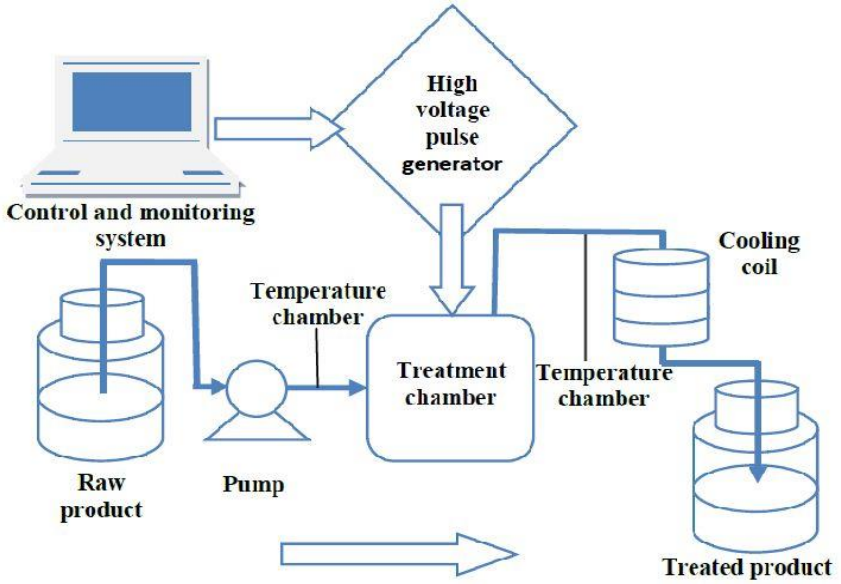
The pulsed electric field induces poration of cell membranes and thereby the cell membranes of microorganisms, plant or animal tissue are permeable. This process of electroporation is suitable for use in a broad range of food processes and bioprocesses using low levels of energy. PEF technology has many advantageous in comparison to heat treatments, because it kills microorganisms and at the same time maintains the original color, flavor, texture, and nutritional value of the unprocessed food. It is suitable for preserving liquid and semi-liquid foods removing micro-organisms and producing functional constituents. Most PEF studies have focused on PEF treatments effects on the microbial inactivation in milk, milk products, egg products, juice and other liquid foods.

Working

PEF technology is based on a pulsing power delivered to the product placed between a set of electrodes confining the treatment gap of the PEF chamber. The equipment consists of a high voltage pulse generator and a treatment chamber with a suitable fluid handling system and necessary monitoring and controlling devices. Food product is placed in the treatment chamber, either in a static or continuous design, where two electrodes are connected together with a nonconductive material to avoid electrical flow from one to the other. Generated high voltage electrical pulses are applied to the electrodes, which then conduct the high intensity electrical pulse to the product placed between the two electrodes. The food product experiences a force per unit charge, the so-called electric field, which is responsible for the irreversible cell membrane breakdown in microorganisms. This leads to dielectric breakdown of the microbial cell membranes and to interaction with the charged molecules of food. Hence, PEF technology has been suggested for the pasteurization of foods such as juices, soups, and other liquid based products.



(Source i[3] foods)



Pulsed Electric Field Preservation

Pulsed electric field can be applied in fishes fresh and frozen fish dried, brined or marinated fish. Mass transport processes, such as moisture transport and removal, are improved by the electroporation of fish tissue, resulting in enhanced drying, brining and marinating of fish. The required field strength for cell disintegration of fish is 1.0 – 3.0 kV/cm and the energy delivery is 3 – 10 kJ/kg. The applied pulsed electric field leads to cell disintegration in tissue, enhancing product quality and production processes. It also helps in inactivation of parasites such as nematodes. PEF processing enhances mass transport, processes during extraction, pressing, drying, brining and marinating processes. PEF technology speeds up drying of food products, minimizing processing times and energy consumption. The process can be applied to fruits, vegetables, potatoes and meat. Enhancement of extraction processes is also an advantage of electroporation. Extraction and pressing yields are increased, for example for fruit juice, vegetable oil and algae oil and protein. PEF technology speeds up freezing of food products, allowing a reduction of processing times and energy consumption. The cell disintegration increases the freezing rates.

Cellular water flows easily out of the cell and ice nucleation outside the cell starts. As smaller ice molecules are formed, product quality of frozen food is improved. (www. pulsemaster).

3. Pulse Light technology

Pulse light technology is one such explored Non thermal technology in the food industry, especially for decontamination of food surfaces and food packages. This technique works by applying high-voltage, high-current short electrical pulse to the inert gas in the lamp, which results in strong collision between electrons and gas molecules cause excitation of the latter, which then emit an intense, very short light pulse to decontaminate and sterilize foods (Palmieri & Cacace, 2005). Usually short pulses of light one to twenty flashes per second is used in food industry. The term light is generally used to mean radiations having wavelength ranging from 180 to 1100 nm, which includes ultraviolet rays (UV 180–400 nm, roughly subdivided into UV-A, 315–400 nm; UV-B, 280–315 nm; UV-C, 180–280 nm); visible light (400–700 nm) and infrared rays (IR 700–1100 nm) (Palmieri and Cacace, 2005). This technology can be used for the rapid inactivation of microorganisms on food surfaces, equipments and food packaging materials (Dunn et al., 1995). The effect on microorganisms is mostly due to the photochemical action of the ultra violet part of the light spectrum that causes thymine dimerization in the DNA chain preventing replication and ultimately leading to cell death (Gomez-Lopez et al., 2007).

The principle involved in generating high intensity light is that a gradual increase of low to moderate power energy can be released in highly concentrated bursts of more powerful energy. The key component of a Pulse Light unit is a flash lamp filled with an inert gas. A high-voltage, high-current electrical pulse is applied to the inert gas in the lamp, and the strong collision between electrons and gas molecules cause excitation of the latter, which then emit an intense, very short light pulse. It is generally accepted that UV plays a critical role in microbial inactivation. So pulsed light is a modified and claimed improved version of delivering UV-C to bodies. The classical UV-C treatment works in a continuous mode, called continuous-wave (CW) UV light. Inactivation of microorganisms with CW-UV systems is achieved by using low-pressure mercury lamps designed to produce energy at 254 nm (monochromatic light), called germicidal light (Bintsis et al., 2000). More recently, medium-pressure UV lamps have been used because of their much higher germicidal UV power per unit length. Medium-pressure UV lamps emit a polychromatic output, including germicidal wavelengths from 200 to 300 nm (Bolton & Linden, 2003). Pulse Light treatment of foods has been approved by the FDA (1996) under the code 21CFR179.41. The treatment is most effective on smooth, nonreflecting surfaces or in liquids that are free of suspended particulates. In surface treatments, rough surfaces hinder inactivation due to cell hiding.

Generation of Pulsed Light

Light can be emitted from different sources by different mechanisms, due to the spontaneous transition of some atoms from an excited state to a condition of lower energy. Light can be delivered either continuously or in the form of pulses. (Palmieri and Cacace, 2005). Pulsed light works with Xenon lamps that can produce several flashes per second. During the pulse treatment the spectrum produced is 20000 times brighter than sunlight at the surface of the earth (Dunn et al., 1995). Electromagnetic energy is accumulated in a capacitor during fractions of a second and then released in the form of light within a short time (nanoseconds to milliseconds), resulting in an amplification of power with a minimum of additional energy consumption. As the current passes through the gas chamber of the lamp unit, a short, intense burst of light is emitted. The light produced by the lamp includes broad-

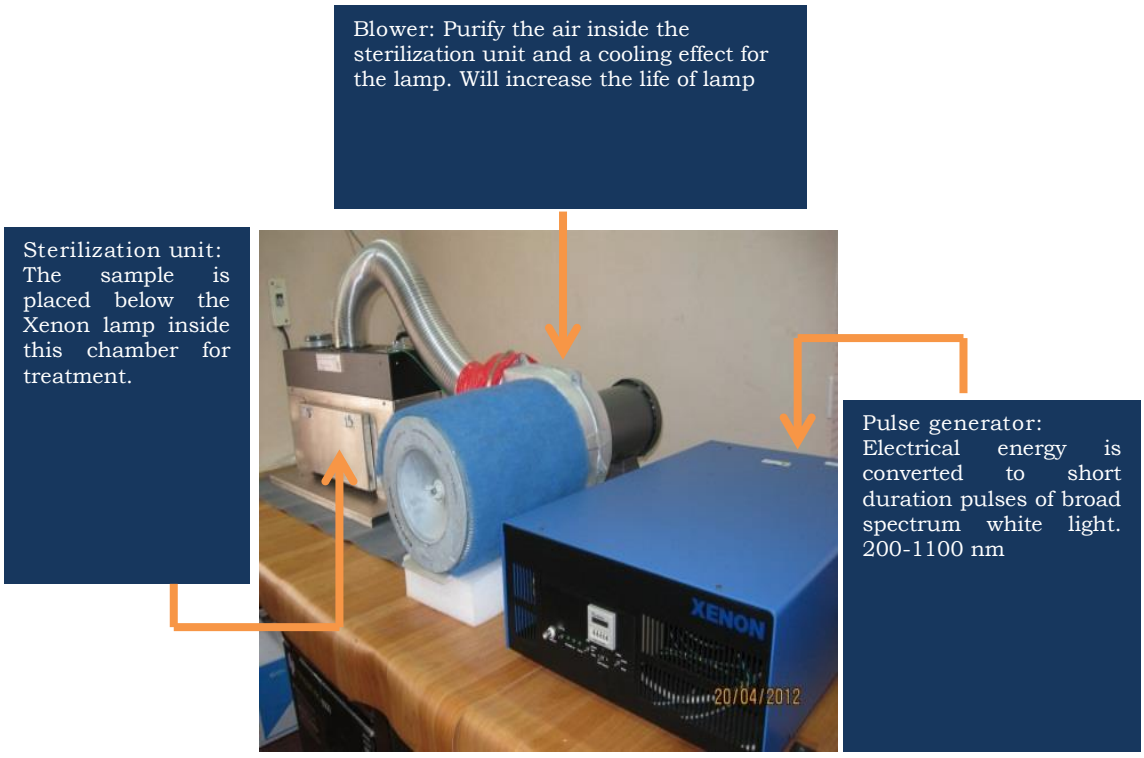
spectrum wavelengths from UV to near infrared. The wavelength distribution ranges from 100 to 1,100 nm.

Merits and Demerits

Merits: The inactivation of microbes by Pulse Light is very fast process and cause rapid disinfection in a very short period. It is a green technology as the consumption of energy is very less during its application. Pulse Light has been proven as a safe technology for living being and their environment without producing harmful residuals, chemicals and toxic by-products in the treated foods. It does not affect the nutritional and sensory quality of the products. The concerns of ionized radicals and radioactive by-products in foods by consumers are removed in Pulse Light due to its nonionizing spectrum (Dunn et al.1995).

Demerits: Pulse Light application in meat industry has some constraints as the low penetration power and chances of lipid oxidation (Fine & Gervais, 2004). To get the desired outcome, the packaging materials showing high penetration of light should be used while treating the packed food by this method. The limited control of food heating still remains the main concern in Pulse Light technology. Sample heating is perhaps the most important limiting factor of this technology for practical applications (Gomez-Lopez et al., 2007).

Pulsed Light Equipment at CIFT



4. Ultrasound processing

The application of ultrasound in food processing has been stared as another area in non-thermal approaches, which exploits the preservative effect of the high intensity sound waves. The preservative effect is by the inactivation of microbes and spoilage enzyme by mechanical actions. Mechanism is that when propagates through biological structures, Ultrasonic

cavitation produces shear forces, which causes mechanical cell breakage and allows material transfer from cell into solvents. Cavitation causes particle size reduction thereby increases the surface area in contact when extracting a compounds.

The technology finds its application in the field of extraction of proteins, lipids and their functional modifications, emulsification, viscosity improvement, homogenization and improvement of dispersion stability in liquid foods (Mohd. Adzahan and Benchamaporn, 2007). So this technology is utilized in the field of processing, preservation and extraction, which makes use of physical and chemical phenomena that are fundamentally different from conventional extraction, processing or preservation techniques.

In food industry, the application of ultrasound can be divided based on range of frequency:

- *Low power ultrasound:* Uses a small power level that the waves cause no physical and chemical alteration in the properties of the material through which it passes. This property is being utilized for non-invasive analysis and monitoring of various food materials during processing and storage, to ensure quality and safety.
- *High power ultrasound*: Uses high energy [high power, high intensity] ultrasound of 20 and 500 kHz. It causes disruptive and enforce effect on the physical, mechanical, or biochemical properties of foods. These effects are promising in food processing, preservation and safety.

5. Irradiation

Irradiation is the process of applying low levels of radiation to any food material to sterilize or extend its shelf life. It is a physical method that involves exposing the prepackaged or bulk foodstuffs to gamma rays, x-rays, or electrons. Foods is generally irradiated with gamma radiation from a radioisotope source, or with electrons or x-rays generated using an electron accelerator (Barbosa-Canovas et al., 1998). These rays have high penetration power and thus can treat foods for the purpose of preservation and quality improvement. During exposure of food the amount of ionizing radiation absorbed is termed 'radiation absorbed dose' (rad) and is measured in units of rads or Grays. A strictly regulated process of dosimetry is used to measure the exact dose of radiation absorbed by the food. One Gray is equal to one joule of energy absorption per kilogram of a material. Irradiation has been approved for the microbial disinfestations of various food products in the US (USFDA, 1998). A number of countries have marketed irradiated products worldwide. Irradiation has the potential to enhance food safety for fresh foods that will be consumed raw and for raw foods that require further processing. Food irradiation mainly is done by the radioactive element cobalt-60 as the source of high energy gamma rays. Gamma rays are electromagnetic waves or photons emitted from the nucleus of an atom. These gamma rays have energy to dislodge electrons from food molecules, and to convert them into ions which are electrically charged. However, the rays do not have enough energy to dislodge the neutrons in the nuclei of these molecules and hence they are not capable of inducing radioactivity in the treated food. The radiation dose varies depending on the thickness moisture, and characteristics of the foods. External factors, such as temperature, the presence or absence of oxygen, and subsequent storage conditions, also influence the effectiveness of radiation (Doyle, 1990).

In general, irradiation of food does not significantly affect the protein, lipid, and carbohydrate quality. Minerals are stable to food irradiation. The overall chemical changes in food due to irradiation are relatively minor and hence there is little change in the nutritional quality.

Irradiation of moist food under frozen condition and in the absence of oxygen significantly decreases the overall chemical yields by about 80%; So the cumulative effects of irradiating to a dose of 50 kGy at −30°C is essentially equivalent to a dose of 10 kGy at room or chilled temperature. A dose of 1-10 kGy can control food-borne parasites responsible for diseases such as trichinosis. A minimum dose of 0.15 kGy can prevent development of insect infestation in dried fish. Irradiation is considered as a phytosanitary measure often obligatory if certain agricultural commodities are to be exported. The unique feature of radiation decontamination is that it can be performed in packaged foods even when the food is in a frozen state.

Table I gives details of irradiation processes for seafood.

Table 1: Radiation processes of seafoods (Source: Venugopal, Protech 2013-Pg28)

Treatment and storage temperature	Radiation process	Benefits
-10° to -20°C Packaged, frozen, ready-to-export fish can be treated before shipment. Frozen storage	Radicidation (Radiation hygienization) Dose required: 4-6 kGy Elimination of non-spore forming pathogens such as *Salmonella, Vibrio, Listeria* etc.	Improvement of hygienic quality of frozen, materials for export such as frozen shrimp, cuttlefish, squid, finfish, fillets, and IQF items.
15° to 30°C Ambient storage	Radiation disinfestation Dose required < 1 kGy Elimination of eggs and larvae of insects.	Dry products free from spoilage due to insects, from dried fishery products including fish meal and feed for aquaculture. Inactivation of *Salmonella* spp. and other pathogens
-1°to +3°C (Post-irradiation storage: under ice).	Radurization (Radiation pasteurization for shelf life extension) Dose: 1-3 kGy Reduction of initial microbial content by 1 to 2 log cycles. Specific reduction of spoilage causing organisms.	Extends chilled shelf life of fresh marine and freshwater fishery products two to three times. Additional benefit includes reduction of non-spore forming pathogens

6.Cold Plasma Technology

Recently, plasma technology has emerged as a potential preservation technique in food industry for exploring its preservation and shelf-life extension potentials. This technology has the feasibility of being energy efficient, short processing duration and operational at reasonable temperatures. The application of plasma technology in seafood sector, include direct application in fresh and dried products as well as indirect application of

plasma activated water and seafood industry wastewater purification. However, this technology is globally less explored in the seafood sector. The atmospheric cold plasma has been demonstrated to be effective in reducing microbial and enzymatic actions in various vegetables, beverages and meat products. But the application for control of pathogenic and spoilage bacteria in fish products has got meager attention, especially the studies reported in value added fishery products are very rare. However, few studies conducted in plasma application in seafoods viz., fresh and dried products widen the application potential of plasma technology in the sector. However, a few disadvantages reported in these investigations viz., effect of plasma in oxidizing the products have to be addressed. Comprehensive investigations are required in this regard for efficient exploration of this technology to deliver safe and stable seafood in the supply chain in a cost-effective way.

References

3. Barbosa-Canovas, G. V and Bermudez-Aguirre, D. (2011). In Zang, H. Q., Barbosa-Canovas, G.V., balasubramaniam, V. M., Dunne, C.P., Farkas, D.F and Yuan, J.T.C (Ed.) Nonthermal Processing Technologies for Food. IFT press, Wiley- Blackwell Publishers

4. Barbosa-Cánovas, G. V., Pothakamury, U. R., Palou, E., Swanson, B. G., eds. 1998. Food irradiation. Non thermal preservation of foods, pp.161-213. New York: Marcel Dekker.

5. Bintsis, T., Litopoulou-Tzanetaki, E. and Robinson, R. K. (2000). Existing and potential application of ultraviolet light in the food industry-a critical review. J. Sci. Food Agr. 90: 637-645

6. Bolton, J. R. and Linden, K. G. (2003). Standardization of methods for fluence (UV dose) determination in bench-scale UV experiments. J. Environ. Eng. 129: 209-215

7. Dunn, J., Ott, T. and Clark, W. (1995). Pulsed light treatment of food and packaging. Food Technologist. 49(9): 95–98

8. Fine, F. and Gervais, P. (2004). Efficiency of pulsed UV light for microbial decontamination of food powders. J. Food Protect. 67: 787–792

9. Gomez-Lopez, V.M., Ragaerta, P., Debeverea, J. and Devlieghere, F. (2007). Pulsed light for food decontamination: A review. Trends Food Sci. Technol. 18: 464-473

10. Hoover, D.G., Metrick, C., Papineau, A.M., Farkas, D.F., Knorr, D., (1989). Biological effects of high hydrostatic pressure on food microorganisms. Food Technology 43(3), 99-107.

11. https://www.pulsemaster.us/pef-pulsemaster/product-process-improvement

12. Knorr, D., (1999). Novel approaches in food-processing technology: new technologies for preserving foods and modifying function. Current Opinion in Biotechnology 10(5), 485-491.

13. Lopez-Malo, A.; Palou, E.; Barbosa- Canovas, G. V Swanson, B. G.; Welti-Chanes, J.,(2000). Minimally processed foods and high hydrostatic pressure. In Advances in food Engineering; Lozano, J, Anon, M. C., Parada-Arias, E., Barbosa-Canovas, G. V., Eds.; Technomic Publishing Co.; Lancaster, P A. 267-286

14. Mohd. Adzahan, N. and Benchamaporn, P. (2007). Potential of Non-Thermal Processing for Food Preservation in southeast Asian countries. ASEAN Food Journal 14(3):141-152

15. National Center for Food Safety and Technology (2009). NFSCT receives regulatory acceptance of novel food sterilization process. Press release, February 27, 2009. Summit-Argo, IL

16. Palmieri L and Cacace, D (2005). High Intensity pulsed light technology. In: Emerging Technologies for food processing (Da-Wen Sun., Ed), pp 279-306, Elsevier Academic Press, UK

17. Smelt, J.P.P.M. (1998). Recent advances in the microbiology of high pressure processing. Trends in Food Science & Technology, 9, 152-158
18. Suzuki, A., (2002). High pressure-processed foods in Japan and the world, in: Rikimaru, H. (Ed.), Progress in Biotechnology. Elsevier, pp. 365-374.
19. Toepfl S, Mathys A, Heinz V, Knorr D. Review: potential of high hydrostatic pressure and pulsed electric fields for energy efficient and environmentally friendly food processing. Food Rev Int. 2006;22: 405–423. doi: 10.1080/87559120600865164
20. U.S.FDA, (2011) Fish and Fishery Products Hazards and Controls Guidance (contains 21 chapters) Fourth Edition, Food and Drug Administration.
21. Urrutia, G.; Arabas, J.; Autio, K.; Brul, S.; Hendrickx, M.; Ka˛kolewski, A.; Knorr, D.; Le Bail, A.; Lille, M.; Molina-Garcı´a, A. D.; Ousegui, A.; Sanz, P. D.; Shen, T. & Van Buggenhout, S. (2007). SAFE ICE: Low-temperature pressure processing of foods: Safety and quality aspects, process parameters and consumer acceptance. Journal of Food Engineering, 83, 293–315
22. Venugopal, V., Doke, S.N. and Thomas, P., (1999) Radiation processing to improve the quality of fishery products, Critical Reviews in Food Science and Nutrition, 39, 391-440,
23. Wan J., Coventry, J., Swiergon, P., Sanguansri, P., and Versteeg, C. 2009. Advances in innovative processing technologies for microbial inactivation and enhancement of food safety – pulsed electric field and low-temperature plasma. Trends in Food Science and Technology. doi:10.1016/j.tifs.2009.01.050

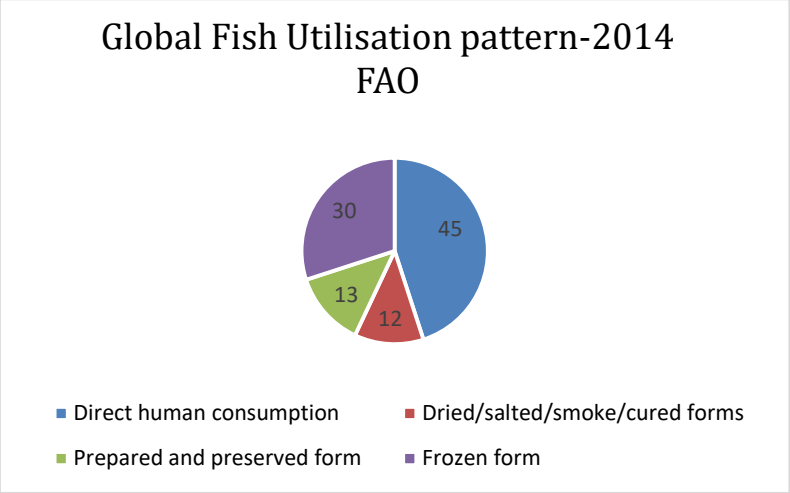
Chapter 13

Fishery waste utilization

Dr. Binsi P.K.
Senior Scientist, Fish Processing Division
ICAR-Central Institute of Fisheries Technology, Cochin
Email: binsipk@gmail.com

Introduction

Global fish production has witnessed a remarkable growth in recent past (excluding aquatic plants) reaching 167.2 million tonnes in 2014, with 93.4 million tonnes from capture and 73.8 million tonnes from aquaculture. A parallel development was observed in the share of world fish production utilised for direct human consumption from 67% in the 1960s to 87%, or more than 146 million tonnes, in 2014. Historically, fish has been considered as an important food source and even today it is one of the most traded commodities in international markets. Interestingly, about 15% of the world requirement for animal proteins is being met from fish alone which accounts to 4–5% of the calculated minimum requirements for protein (Guerardet al., 2005). The estimate in 2013, indicated a slightly higher value of 17% which account to 6.7% of all protein consumed (Seafish, 2014). However, there are growing concerns about the sustainability and management of seafood industry, in parallel with the increasing global demand for seafood. Recent reports project a figure of US$ 50 billion as the loss from seafood sector every year, due to poor management of available resources. Wastes are generated at different points in the value chain, viz. by-catch, onboard handling, landing centres, transportation, storage, retailers, and consumers. The waste generation begins with the practice of ‘discard at sea’ of unintentional catches. Subsequently, during processing operations, only the muscle parts are consumed and the rest is discarded. Global fish waste generation is estimated to be in excess of 100 mMT, and in the Indian scenario it is >4 mMT. It is estimated that fish processing waste after filleting accounts for approximately 75% of the total fish weight. This figure is too high before the challenging task of feeding the 9 billions of world population by the middle of this century.



Waste and By-products: Global Terminologies

In literature, quite often by-products, waste, discards etc are cited as alternate terms. However, a clear distinction between by-products that can be used for human consumption and waste ⁄ discards ⁄ viscera is made in regulatory papers (Rustad, 2003). The term 'waste' includes the remnants that cannot be recycled or converted to another high value products, and have to be composted, burned or destroyed (Bekkevold&Olafsen, 2007). On the other hand, the term 'by-products' refers to the left outs that are not generally regarded as conventional marketable products, but can be converted to industrial or edible products. Whereas, the EC regulation on animal by-products (ECNr 1774 ⁄ 2002, 2002), adopted on 3 October 2002, defines animal by-products as whole carcasses or parts of animals or products not intended for human consumption; by-products intended for human consumption is not included in this definition. There are several other terms in usage to alternatively represent the by-products, such as waste via co-products or co-streams etc. Lately, as more and more research evidences were mounted on the potential biomolecules derived from marine sources, especially from fish other than meat part, there is a raising tendency to treat these as raw material rather than 'discards/waste'. Consequently, the term 'rest raw material' and 'secondary raw material' is the newly evolved expression today to highlight the importance of treating these materials as equivalent to 'targeted product'. For instance, fish skin is a rest raw material, whereas collagen is a by-product.

Global waste generation Profile

In seafood industry, the general understanding is that the edible meat part constitute forms the 'main product' and the remaining parts including head, trimmings, skin, viscera, scale, bone etc. are considered as 'left over', now as 'rest raw material/secondary raw material'. In a different angle, this perception is a bit ironical. This becomes more apparent, when a global estimate of waste generation profile is taken in to account. The amount of waste generated from seafood sector begins at the site of harvest itself. For the last few decades, the FAO estimate on postharvest losses in seafood sector remains to be 20-35% of the catch, at various stages of value chain. Approximately, 17.9 to 39.5 million tonnes of whole fish is discarded each year by commercial fishing operations. Apart from the quality losses in the supply chain, worldwide, around 130 million tonnes of fish waste is produced each year, which is approximated to more than 75% of total fish production. Normally in capture fisheries, a considerable portion of marine catch is dumped back to the sea, either as untargeted catch or as 'discards' in the case where on-board processing activities are carried out. Generally, bulk of demersal catch is processed on board. As the waste material is rarely landed onshore, a considerable proportion (11%) of the total capture biomass is disposed of at sea, mainly in the form of viscera and heads. This figure may be a bit less in the case of culture fisheries.

Table 1: Waste generation during industrial processing of fish in India

Products	Waste Generated (%; w/w)
Shrimp products	50
Fish fillets	65
Fish steaks	30
Whole and gutted fish	10
Surimi	70
Cuttle fish rings	50
Cuttle fish whole	30
Cuttle fish fillets	50
Squids whole cleaned	20
Squid tubes	50
Squid rings	55

Nature and composition of secondary raw materials from seafood industry

The nature and quantum of secondary raw materials generated in seafood industry depends on several factors, which may be broadly categorised into resource related factors and process related factors. The former category includes species, size, age, biological nature (including presence of toxins and allergens) and morphological features. Generally, 40-70% of original raw material is discarded in commercial processing operations depending on intended product, style of dressing, type of handling (manual/ mechanical), skill of handling person, intended use and to a greater extent on the quality of raw material. Largely, seafood processing operations generate both liquid and solid wastes; solid waste being the bulk ranging from 30% to 65% of the weight of the landed fish. Head, viscera, skin, fin, swim bladder, bone, frame meat, dark meat, scale, gills, shells (crustacean, mollusca), cephalopod pen, ink sac etc. are the major components of solid waste. The liquid effluents mainly consist of blood, slime, mucus, wash off and other solubles. In surimi processing, soluble proteins are washed off to a greater extent during repeated water washing steps

Table 2: Typical composition of secondary raw materials from fish processing operations

Waste Component	% of whole fish	Active component
Head	15 - 25	Protein, PUFA, Minerals, Plasmalogens, GAG
Frame Meat	~10% of frame	Protein
Skin	3 - 5	Protein
Scale	6 - 7	Protein, Minerals
Bone	8-10	Protein, Minerals, Chondroitin
Viscera	5 - 12	Protein, Enzyme, fat
Gill	4-5	Protein, Fe

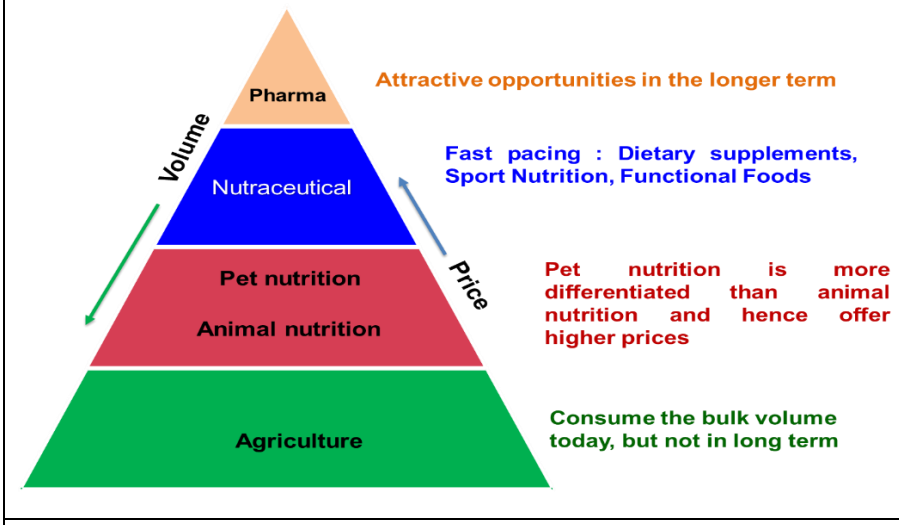
Global utilisation pattern of secondary raw materials

Presently, a major portion of the discards and low value catch, mainly pelagic varieties, are going for the production of fish meal and oil, which accounts to as much 30% of the world's total catch. A significant, but declining, proportion of world fisheries production is processed into fishmeal and fish oil thereby contributing indirectly to human consumption when they are used as feed in aquaculture and livestock raising. As per FAO projection, by 2025, fish meal produced from fish waste will represent 38% of world fish meal production, compared with 29% for the 2013 to 2015 average level. Apart from fishmeal, a reasonable portion is going for fermented products such as fish sauce and silage. Norway is the main producer of fish silage that is being used almost entirely for feed. A meagre portion is used for human consumption, to the tune of maximum 10%.

Value addition options and opportunities

Generally, two different methods, mass transformation and sorting, have been developed to improve the economic value of fish wastes. Mass transformation involves the conversion of fish waste into a single product. Sorting enables the production of specialised products such as liver oil, gelatin, omega-3, protein containing sports food and drinks, calcium, cosmetics, and pharmaceuticals. Wider acceptance and adoption of both methods

could lead to significant reductions in wastes going to landfill and reduce the damaging impact of fish wastes on the environment.



Pyramidal representation of opportunities in the utilisation of secondary raw materials

Legislatory framework and Regulatory norms

As secondary raw materials are heterogeneous mixtures of a number of biomolecules, there are several EU and national regulations and recommendations internationally concerning the norms for pathogens, toxins, allergens and biogenic amines in products, particularly for those intended for man and animal nutrition. The major ones are listed below.

- EC **Disposal, Processing and Placing on the Market of Animal By-products Regulations** (SI 257, 1994) that regulates the use, sale and disposal of high and low risk animal by-products which provides limited options for their use.
- EC Regulation No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down **health rules concerning animal by-products not intended for human consumption** (amended by Commission Regulation (EC) No 808/2003 of 12 May 2003). Provides a mechanism for the reclassification of all animal by-products not intended for human consumption based on their potential risk - this will drive fish waste utilisation and disposal options in future years.
- Commission Regulation (EC) No. 811/2003 on the intra-species recycling ban for fish, the burial and burning of by-products and certain transitional measures provides additional clarification of Regulation (EC) No. 1774/2002 as follows:
  - ✓ Derogation to permit the feeding of fish with processed animal protein derived from bodies/parts of bodies of the same species. However this is academic, as a) it does not apply to feeding farmed fish with processed animal protein from farmed fish of the same species and b) doing this is already voluntarily banned by the feed industry.
  - ✓ Wild fish and by products from wild fish may be used for the production of fish feeds or directly as a feed.
  - ✓ Fish and animal by-products intended for feed for fish must:
    - Be handled and processed separately from other material

- Originate from wild fish or non-mammal sea animals caught for the purpose of fish meal production or from fresh by-products from wild fish processed for human consumption
- Be packaged after treatment and clearly identified appropriate for feeding of fish.

- A draft Commission Regulation SANCO/2153/2003 implementing EC Regulation No 1774/2002, approves six additional means of disposal or uses of animal by-products, including (i) alkaline hydrolysis, biodiesel production and combustion of animal fat in a thermal boiler for the treatment and disposal of Category 1 material, as well as (ii) the processes of alkaline hydrolysis, high pressure high temperature hydrolysis, high pressure hydrolysis biogas, biodiesel production, Brookes gasification, and combustion of animal fat in a thermal boiler for the treatment and use or disposal of Categories 2 or 3 material.Fish by-products do not arise in Category 1.

Table 3: Categorisation of Animal By-Product Materials

(Source: https://www2.gov.scot/Publications/2005/03/20717/52862)

Category	Raw material	Storage and disposal requirements
1	• All body parts affected by TSE, pet/zoo/circus animals, experimental animals. • Wild animals suspected of being infected with disease communicable to humans or animals, • Animals containing residues of environmental contaminants; • Animal material collected when treating waste water from Category 1 processing plants • Mixtures of Category 1 material with either Categories 2 or 3 materials or both.	• Incineration • Processing in an approved Category 1 processing plants • For certain marked non-TSE material, may be buried in approved landfill sites
2	• Fish farming mortalities • Animal by-products containing digestive tract or manure components • Animal material collected from treating waste water from slaughter houses or Category 2 processing plants • Products containing residues of veterinary drugs and contaminants listed in Group B(1) and (2) of Annex I to Directive 96/23/EC • Non-Category 1 by-products from non-member States.	• Incineration • Processing in an approved Category 2 processing plants • Certain marked material may be (i) used as an organic fertiliser, (ii) transformed in a biogas plant or (iii) buried in approved landfill sites • For material of fish origin, may be ensiled or composted (subject to approval). • Where authorised, used as a feed for zoo, circus, fur animal, hounds, maggot / worm (as bait)

	• Animals or parts of animals that have been slaughtered for human consumption, inc those killed to eradicate an epizootic disease • Mixtures of Category 2 material with Category 3 material	
3	• Parts of slaughtered animals for human consumption • Fish or other sea animals (exc. sea mammals) caught in the open sea for the purpose of reduction to fish meal • Fresh fish by-products from plants manufacturing fish products for human consumption.	• Incineration • Processing in an approved Category 3 processing plants • Used as a raw material in pet foods • Transformed in a biogas or composting plant • For material of fish origin, may be ensiled or composted • Where authorised, used as a feed for zoo, circus, fur animal, hounds, maggot / worm (as bait)

Table 4: Categorisation of Aquaculture By-products

Source: SEERAD, pers. comm., 2004

Source of Waste	**Waste Category**		
	1	**2**	**3**
On-farm mortalities			
- where no disease has been confirmed		✓	
- where controls have been applied because of the presence or suspected presence of notifiable disease		✓	
- as a result of jellyfish attack		✓	
- as a result of algal bloom		✓	
- as a result of adverse weather conditions		✓	
- due to a compulsory slaughter notice		✓	
Mortalities at the processor			
- where the fish are dead on arrival		✓	
- show clinical signs of disease and are not processed		✓	
Processing waste			
- where source is subject to disease controls (but fish show no clinical signs of disease)			✓
- where source is not subject to controls			✓

- The Animal By-Products Regulations, 2003 provides a recent (October 2003) enactment of Regulation (EC) 1774/2002 (and the subsequent Regulation (EC) 811/2003 mentioned above). This Regulation recognises the ability to utilise fish by-products (primarily Category 2) for zoo, circus, fur, certain dogs (e.g. hounds) and maggot farming under approved circumstances. In addition, the burning or burial of animal by-products is permitted in certain remote areas, so long these sites are monitored at regular intervals.
- EC 1999/31/EC Landfill Directive: requires Member States to reduce the quantities of biodegradable wastes to 35% of 1995 levels by 2020. This will inevitably encourage alternative disposal techniques, such as composting and incineration.
- UK Animal Protein Regulations (2001): prohibits the use of mammalian protein (with certain specified exceptions) to ruminants and the feeding for mammalian meat and bone meal to all farmed livestock.
- UK Environmental Protection Act 1990: prohibits the keeping, treatment or disposal of waste on land unless a waste management licence has been granted for that purpose.
- UK Food and Environment Protection Act (1985): controls the disposal at sea through strict licensing. This order allows the unlicensed disposal of fish wastes at sea, even after landing its catch. However the disposal at sea from processing onshore is not permitted without a licence.
- UK Food Hygiene (Fishery Products and Live Shellfish (Hygiene) Regulations 1998. Sets out the conditions under which fish and shellfish products must be produced in order to be placed on the market. Includes provision that:
  - ✓ Offal and viscera must be kept separate from products intended for human consumption
  - ✓ Onshore processing facilities must regularly remove waste from the processing area
  - ✓ Containers holding waste material must be water tight, corrosion-resistant and be designed to facilitate cleaning and disinfection
  - ✓ Waste material held overnight must be housed in a designated area
- The Fur Farming (Prohibition) Act 2002 prohibits the farming of animals solely or primarily for their fur
- UK Integrated Pollution Prevention and Control Regulations (2000): lay down measures to reduce the emissions to air, water and land from a range of activities including food processing. Affected business need to prove that the best available techniques have been introduced to reduce the environmental impact of its operation.
- UK Landfill Tax Regulations (1996): levy charges on waste disposed of in landfill sites and thus encourages waste minimisation and maximisation of recycling opportunities. Waste is either classified as inactive/inert and other - the latter attracts a higher tax rate per tonne.
- UK Waste Management Licensing Regulations (1994): permits a number of unlicensed exemptions for waste disposal, including the spreading of shell on agricultural land and the use of shell for land reclamation or improvement. Such unlicensed disposal must be registered.

Fishery by-products and high value products from fish waste

Fish meal

Fish meal is highly concentrated nutritious feed supplement consisting of high quality protein, minerals, vitamins of B group and other vitamins and other unknown growth factors. Fishmeal is rich in essential amino acids. It is produced by cooking, pressing, drying and grinding the fish, by-catch fish, miscellaneous fish, filleting waste, waste from canneries and other processing operations. The composition of fishmeal differs considerably due to the variations in the raw material used and the processing methods and conditions employed.

Traditional fishmeal production in India was from the sun dried fish collected from various drying centers and the products were mainly used as manure. Better quality fish meal has been a prominent item of export from the very beginning of this industry. BIS has brought out the specification for fish meal as live stock feed for facilitating proper quality control.
The proximate composition of fish meal in general is given below:

Protein	-	50-57%
Fat	-	5-10%
Ash	-	12-33%
Moisture	-	6-10%

Manufacturing process

Fish can be reduced by two general processes (1) Dry rendering (2) Wet rendering process.

Dry Rendering Process

Dry rendering or dry reduction process is suitable for only lean or non-oil fish such as silver bellies, jew fish, sciaenids, ribbon fish, sole, anchoviella, carcasses of shark, fish offal and filleting waste. In this process, the material is dried to moisture content of 10% and pulverized. If the quantity to be handled is sufficiently large a steam jacketed cooker dryer equipped with power devises for stirring is used. Sometimes, if the size of the fish is comparatively large a coarse grinding is also done before being fed into the cooker drier. The cooker dryer may be operated at atmospheric pressure or under partial vacuum. Being a batch operation the process will have only limited capacity and labour cost is very high. Merit of this process is that the water-soluble materials are retained in the meal.

Wet rendering process

Wet rendering or wet reduction process is normally applied to fatty fish or offal where simultaneous production of fish meal and fish body oil is envisaged. The process consists of grinding, cooking to soften the flesh and bones and to release the oil, pressing to expel the liquor and oil, fluffing the press cake drying, grinding and packing the meal. Further, the press liquor is centrifuged to remove the suspended particles and to separate oil. The stick water is concentrated. The process requires elaborate equipment and is normally a continuous one and therefore adaptable to the reduction of large quantities of fish.

In a continuous wet reduction process the coarsely ground fish or fresh raw fish or offal is passed through a stationary horizontal cylindrical cooker by means of a screw conveyor at a predetermined rate. Steam is admitted through a series of jets. The cooked mass is passed through a continuous screw press. The press cake is fluffed and dried to a

moisture level of 8%. The suspended fish meal present in the press liquor is separated by centrifugal sedimentation and the oil by centrifugation or other conventional methods.

Fish body oil

The main source of fish body oil in India is oil sardine. A survey of the oil industry reveals that the extraction is done on a cottage scale in isolated places near the leading centers and is not well organized. The method of extraction followed is cooking the fish in iron vessels and pressing and separating the oil. Apart from sardine oil, fish body oil is also obtained from the fish meal plants operating in the country. In India oil sardine is a fishery which exhibited wide fluctuations from as low as 1% to as high as 32% of the total landings. The seasonal variation in oil content is predominant in Kerala and Karnataka coast. During the peak season fish has oil content of 17%. By the wet rendering process the fish will yield, on average 12% oil having analytical characteristics similar to other fish oils. Fatty acid composition of oil revealed that they contain high amounts of polyunsaturated fatty acids (PUFA). At present the medicinal values of fish oils are well known.

Fish liver oil

The therapeutic value of fish liver oil was discovered in 18th century and fish liver oil becomes a common medicinal product especially for Vitamin A and D. Cod, shark and haddock livers are the important sources of Vitamin A and D. The weight of liver, fat content and presence of vitamins are dependent on a number of factors like species, age, sex, nutritional status, stages of spawning, and area from where it is caught.

In cod (*Gadus collarius*), coal fish (*Pollahius vireus*) and haddock (*Melanggrammus aenglefinus*), the weight of liver normally amount to 4-9% of whole fish and livers contain about 45% to 67% oil. The species of shark such as dog fish (*Squalus acanthias*), Greenland shark (*Somniosus microcephalus*) and barking shark (*Certrohinus maximus*) have large fatty livers weighing up to 10-25% of the whole fish containing 60-75% oil. But halibut, tuna, and whale have 1% liver having 4 to 25% oil with high vitamin A & D content. Depending on the oil content and vitamin A potency fish livers are generally classified in to three groups.

Low oil content - high vitamin A potency

High oil content - low vitamin A potency

High oil content - medium vitamin A potency

Processing

The processing procedures of fish liver without affecting the quality of the oil extracted can be summarized as (1) steaming (2) solvent extraction and (3) alkali/enzyme/acid digestion. The process selected should depend on the vitamin and oil content of the livers.

Certain species of shark contain high oil content with high hydrocarbon content, viz. squalene. Squalene a highly unsaturated aliphatic hydrocarbon is present in shark liver oils, mainly of the family squalidae, cod and some vegetable oils like olive oil, wheat gum oil, and rice bran oil. Chemically it is known as 2,6,10,15,19,23 hexamethyl, 2,6,10,14,18,22 tetracosahexane having a molecular weight of 410.70, it is an isoprenoid compound containing six isoprene units.

Presentation and storage

Vitamin oils are stored in rust free, well washed and dried air tight drums. The head space should be kept minimum to avoid oxidation. It is advisable to fill head space with inert gas such as nitrogen. If properly processed and stored the oil will remain in satisfactory condition without the use of preservative. Small amounts of antioxidants like BHA, αtocopherol, BHT, NDGA can be used to preserve the oil for longer periods.

Fish hydrolysates

This is also liquefied fish product but it differs from silage. They are produced by a process employing commercially available proteolytic enzymes for isolation of protein from fish waste. By selection of suitable enzymes and controlling the conditions the properties of the end product can be selected. Hydrolysates find application as milk replacer and food flavouring agents. Enzymes like papain, nisin, trypsin, bromelein, pancreatin are used for hydrolysis of fish protein. The process consists of chopping, mincing, cooking, cooling to the desired temperature, hydrolysis, sieving, pasteurizing the liquid, concentrating and vacuum drying or spray drying of the product. This is deliquescent, so care should be taken to keep it in fine airtight bottles. It can be incorporated in to beverages as a high energy drink for children and convalescent persons.

Fish maws and isinglass

The world isinglass is derived from the Dutch and German words, which have the meaning sturgeon's air bladder or swimming bladders. Not all air bladders are used for this preparation. The air bladder of deepwater hake is most suitable for production of isinglass. In India air bladders of eel and catfishes are used for the production of isinglass.

The air bladders are separated from fish and temporarily preserved in salt during transport. On reaching the shore they are split open, washed thoroughly, outer membrane is removed by scraping and then air dried. Cleaned, desalted, air dried and hardened swimming bladders (fish maws) are softened by immersing in chilled water for several hours. They are mechanically cut into small pieces and rolled or compressed between hollow iron rollers that are cooled by water and provided with scraper for the removal of any adhering dried material. The rolling process converts the isinglass into thin strips or sheets of 1/8 to ¼" thickness. There are processes for the production of isinglass in powder form also.

Isinglass dissolves readily in most dilute acids or alkalis, but is insoluble in alcohol. In hot water isinglass swells uniformly producing opalescent jelly with fibrous structure in contrast to gelatin. It is used as a clarifying agent for beverages like wine, beer, vinegar etc. by enmeshing the suspended impurities in the fibrous structure of the swollen isinglass.

India exports dried fish maws, which form the raw material for the production of isinglass and other such products. Process has been developed to produce the finished products from fish maws.

Fish Gelatin

Skin of fish constitute nearly 3% of the total weight and is suitable for the extraction of gelatin. Bones and scales can also be processed into gelatin. The process involves alternate washing of skin with alkali and acid and extracting gelatin with hot water. Gelatin finds applications in pharmaceutical products as encapsulation and in food industry as gelling agent. Fish gelatin has better release of a product's aroma and flavor with less inherent off-flavor and off-odor than a commercial pork gelatin.

Fish calcium

The recommended daily intake of calcium is 1000 mg for the adults, and 1300 mg for elderly women. Fish bones and scales are excellent source of calcium. Whole small fish or fish bone/scale can be used for calcium separation. The filleting frames of carps and other fishes can be used for extraction of calcium. The frames are washed and boiled to separate the adhering meat portions. It is washed again and treated with enzymes to remove the adhering connective tissue, washed, dried and powdered. Fish calcium is essentially dicalcium phosphate which has better nutritional qualities.

Hydroxyapatite

The hydroxyapatite extracted from the scale are having uses as bioceramic coatings and bone fillers. The coatings of hydroxyapatite are often applied to metallic implants to alter the surface properties so as to avoid rejection by the body. Similarly, hydroxyapatite can be employed in forms such as powders, porous blocks or beads to fill bone defects or voids. For permanent filling of teeth hydroxyapatite is found to be a better option for import substitution.

Utilization of prawn shell waste

Head and shell of prawn and other crustaceans form the major fishery waste. The waste contains a good percentage of protein and chitin other than minerals. The protein can be extracted along with the flavour bearing compounds and converted into shrimp extract having potential use as a natural flavoring material. Chitosan, deacetylated chitin, is one of such products, which has application in many fields. It is a modified natural carbohydrate polymer. It is a cationic polyelectrolyte, insoluble in water, organic solvents and alkaline solutions and is soluble in most organic acids, and dilute mineral acids except sulphuric acid. It can form ionic bonds and films. Chitosan finds applications in many industries.

Chitin

The residual shell waste obtained after extraction of protein with hot 0.5% caustic soda may contain small amounts of protein. This is then removed by boiling with 3% caustic soda for few minutes and filtering off the liquor. It should be washed free of alkali before demineralisation. The demineralization is done by treatment with dilute hydrochloric acid at room temperature. Demineralization reduces the volume of the shell considerably and therefore deproteiniser can hold more material if the demineralization is done initially.

Glucosamine hydrochloride

Chitin can be hydrolysed to glucosamine hydrochloride by adding concentrated hydrochloric acid and warming until the solution no longer gives opalescence and diluting with water. The excess acid can be distilled off under vacuum. The crude glucosamine hydrochloride is diluted with water and clarified with activated charcoal. The solution is filtered and evaporated under vacuum. The crude glucosamine hydrochloride can be separated by adding alcohol.

Chitosan

Chitin is dried or centrifuged or pressed to remove water. The deacetylation is done by heating at 90-95°C with 40% (w/w) caustic soda for 90-120 min. The water present in the chitin cake should also be taken in to account while preparing caustic soda solution. To achieve this 50% caustic soda is prepared and calculated quantity of it is added to the chitin cake. The reaction is followed by testing the solubility of the residue in 1% acetic acid. As soon as the dissolution is completed caustic soda is removed from the reaction mixture. The

drained caustic soda can be reused for the next batch of deacetylation by fortification if necessary. The residue is washed with water free of alkali. It is then centrifuged and dried in the sun or an artificial drier at a temperature not exceeding 80°C and pulverized to coarse particles.

Chitosan is almost colourless, light in weight and soluble in dilute organic acids but soluble in water, alkali and organic solvents. It gives viscous solution when dissolved in dilute organic acids such as formic acid, acetic acid etc. Chitosan finds extensive applications in following areas viz; food industries, pharmaceutical applications, chemical industries, dental and surgical uses as a haemostatic agent, wound healing, biodegradable films as a substitute for artificial skins for removing toxic heavy metals, wine clarification, Industrial effluent treatment, agriculture, photography, cosmetic applications and textiles, and in nano applications.

Future market trends

The market for high-end by products from marine sources is fairly high, especially for nutraceutical and medical field. The market demand for high quality oil for functional foods alone is projected to be doubled in next five years (Skjævestad& Vogt, 2009).As of today, the actual market potential of marine biomolecules has not been fully realised. Even though the marine proteins are known to have superior nutritional quality index in terms of amino acid composition and bioavailability, meagre effort is put towards protein isolate or hydrolysate production, except for a few stakeholders in Western and European markets. There is huge demand from health and sports nutrition industry for high quality proteins and peptides, where marine proteins could be ideally place in. The market for sports nutrition products is growing with 5–7% per year. Apart from marine oil and protein, several bioactive ingredients from process discards have entered beverage market as functional and medicinal supplements. These are primarily, chitins, pigments, taurine, squalene, proteoglycans, polyphenols, probiotics, polysaccharides, enzymes, vitamins and minerals. These bioactive molecules offer innumerable health benefits, including anti-oxidant, anti-arthritic, anti-hypertensive, anti-bacterial, anti-carcinogenic, anti-obese, and anti-inflammatory activities.

Challenges and way backwards

The key to successful seafood waste utilisation and management is to develop appropriate eco-friendly reprocessing technologies that can convert all the valuable components present in the waste into valuable products and reduce the amount of waste going to disposal route. However, there are many challenges that must be overcome to achieve this goal.

1. Consumer awareness and education is a major challenge. Without consumer acceptance of food waste reduction approaches, no sustainable eco-friendly food waste utilisation and management strategy can succeed. This demands proper extension efforts from the research and extension organizations.
2. Seafood sector is a poorly organised sector. Highly scattered nature of seafood processing operations (across domestic market and processing facilities) poses problems in collection and processing.
3. Seafoods are highly perishable in nature owing to its unique richness in terms of protein, peptides, enzymes and microbial flora. This quite often leads to the mass resistance from public in starting up a business venture in the vicinity.

4. Stringent legal and environmental restrictions from the regulatory bodies as seafood waste is not categorised as “inactive/inert” waste is a major discouraging for the entrepreneurs to invest upon this resource
5. Inappropriate cold chain management from the source of generation to the point of conversion as the processors are least interested to invest further on discards
6. There is no baseline data on the availability and economics of production collected over the past years, which poses uncertainty about economics and market demand of secondary products
7. Lack of clear legal classification of secondary products in the international market is yet another major challenge to the investors
8. Lack of unified protocols for quality assurance (such as HACCP) for secondary products leads to frequent rejections from the buyers

Strategies for future development

- Strengthening the baseline data (waste generation, local facilities, current disposal plan, major stakeholders etc)
- SWOT analysis accommodating regional disparities for the development of an economically and ecologically sustainable waste management plan
- Improve public awareness on fishery waste value addition options through effective extension efforts
- Establish locality-specific value chain routes covering waste generators (Market, peeling sheds etc), regional producers (SMEs, SHGs etc), and user groups (farmers, dealers etc.)
- Networking & establishing inter-industrial linkages between potential stakeholders (Timely follow-up and review of the efforts undertaken is a must)
- Develop mobile pilot technological platforms for testing and demonstrating different technologies
- Public-Private-organisational partnership (incubation centres for pilot production)
- Public policies and legislations against waste dumping
- Framing policies for better use of fishery wastes(such as coupling of licensing of markets and processing facilities with waste conversion measures taken at the source of generation)
- There are bigger challenges with regard to clinical testing, documentation, standardisation andquality, which need to be addressed in a greater way

Suggested Readings

- Rustad, Turid, IvarStorrø, and Rasa Slizyte. "Possibilities for the utilisation of marine by-products." *International Journal of Food Science & Technology* 46, no. 10 (2011): 2001-2014.
- Skjævestad, B. & Vogt, G. (2009). Omega-3 oljerfrafersktmarintra˚stoff. En muligkonkurransestrategi for den norske omega-3 industrien. Trondheim: Rubin.
- Venugopal, V. (1995). Methods for processing and utilization of low cost fishes: a critical appraisal. Journal of Food Science and Technology, 32, 1–12.

- Shahidi, F. (1994a). Proteins from seafood processing discards. In: Seafood Proteins (edited by Z.E. Sikorski, B. Sun Pan & F. Shahidi). Pp. 171–193. New York: Chapman and Hall.
- Shahidi, F. (1994b). Seafood processing by-products. In: Seafoods: Chemistry, Processing Technology and Quality (edited by F. Shahidi& J.R. Botta). Pp. 320–330. London: Blackie Academic & Professional.
- Kim, S.-K. &Mendis, E. (2006). Bioactive compounds from marine processing byproducts – a review. Food Research International, 39, 383–393.

Chapter 14

Regulations for exporting marine products

Shri. G. Jayapalan
Deputy Director, Export Inspection Agency, Kochi
Email; eia-kochilab@eicindia.gov.in

Introduction

As early as 1980, there was an international drive towards reforming fish inspection systems to move away from end-product sampling and inspection into preventative Hazard Analysis Critical Control Point (HACCP)-based safety and quality systems (FAO). There is a growing and strong evidence that the implementation of HACCP-based systems have contributed to improve fish safety and quality in India, there has been an increasing awareness of the importance of an integrated, multidisciplinary approach to food safety and quality throughout the entire food chain.

In India the food chain approach is based on the supply of safe, health and nutritious food involved from production, processing, trade and consumption (farm to fork approach). The implementation of such an approach requires policies and regulatory environment at national levels with clear rules and standards and establishment of an appropriate food control system. In fisheries there are five broadly defined needs a) Fish safety and quality b) Traceability c) Harmonized standards d) Equivalence in food safety system e) Prevention at source.

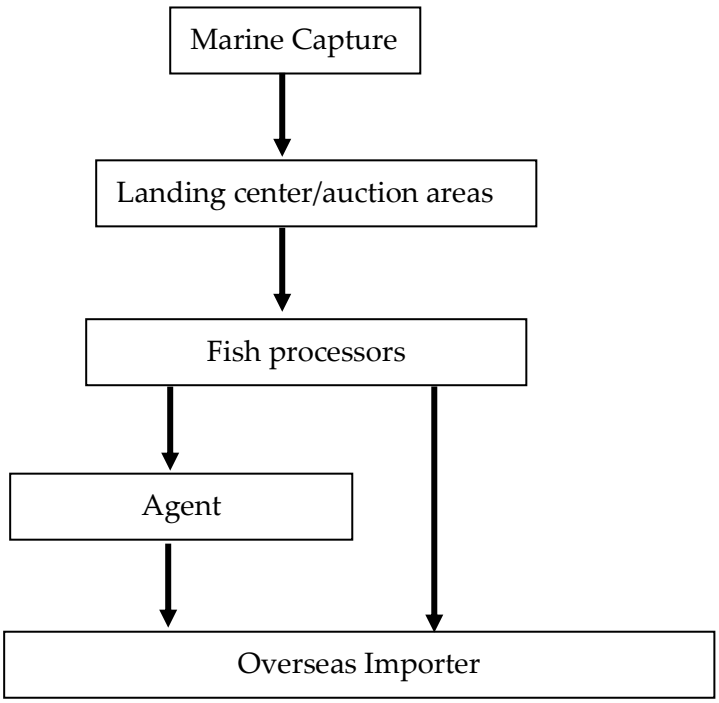
India do have an overarching food control system where Export Inspection Council (EIC), a statutory body under Ministry of Commerce and Industry, Govt. of India formed under the act of parliament, Export (Quality Control & Inspection) Act, 1963 is entrusted to ensure sound development of India's export trade through quality control and inspection for notified commodities which includes fish and fishery products. It does its activities of quality control and inspection through its field offices i.e the Export Inspection Agencies (EIA) located at Kochi, Mumbai, Kolkata, Chennai and Delhi.

Overarching standards

The principles of achieving harmonization of standards and equivalency in food control systems and the use of scientifically-based standards are embodied in two binding agreements of WTO - the SPS and TBT Agreements. The SPS agreement confirms the right of WTO member countries to apply measures necessary to protect human, animal and plant life and health. The objective of the TBT Agreement is to prevent the use of national or regional technical requirements, or standards in general, as unjustified technical barriers to trade.

When it comes to Indian fishery sector the marine production consists of capture fisheries based along India's 8,129 km coastline, which encompasses an Exclusive Economic Zone (EEZ) of 2.02 million km^2. As a relatively "high-risk" food, fish and fishery products are subject to a range of food safety requirements related to general hygiene and specific microbiological and chemical residues and contaminants. These requirements can be subject to change over time in response to emerging problems, advances in scientific knowledge, consumer concerns, dynamicity of standards/regulations and political pressures. Figure 1 details the supply chain in India for fish and fishery products, including fin fish, crustaceans (for example, shrimp), and cephalopods (for example, squid, cuttlefish, and octopus)

Figure 1. Marine export supply chain for fish and fishery products in India



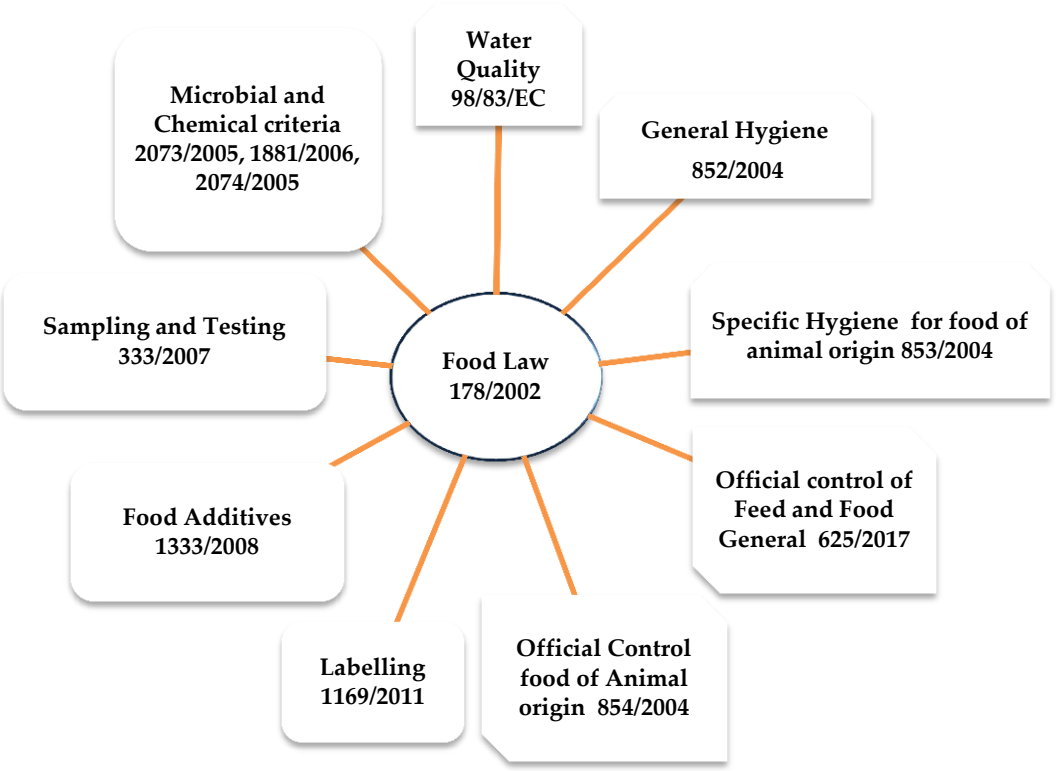
One of the major challenges facing exporters of fish and fishery products in developing countries is progressively stricter food safety requirements in major industrialized countries. Importing countries specify the requirements based on the countries food safety requirements. Primary requirement are mainly for EU, USA, Japan, Russia, China, South Africa, Korea, Australia, Saudi Arabia. The following sections examine how this international framework for fish and seafood safety and quality is applied in international fish trade by the major importing countries/regions, with a particular focus on border controls.

The European Union

The goal of European Union (EU) is that food shall not be placed on the market if it is unsafe. The EU requires that fish processing facilities undertake "own checks." Key elements of these requirements include (1) identification of critical points in the processing establishment on the basis of the manufacturing process used; (2) establishment and implementation of methods for monitoring and checking such critical points; (3) taking samples for analysis in an approved laboratory for the purposes of checking, cleaning, and

disinfection methods and checking compliance with the standards established by EU (regulation, directive, decision); and (4) keeping a written record of these controls for at least two years. More specifically, "own checks" refers to all actions aimed at ensuring and demonstrating compliance with standards laid down by EU legislation in accordance with the general principles of Hazard Analysis and Critical Control Point (HACCP). Processing plants are inspected and approved on an individual basis by a specified "Competent Authority" in the country of origin, whether an EU Member State or a Third Country, to ensure that they comply with these requirements. The European Commission (EC) undertakes checks to ensure that the Competent Authority undertakes this task in a satisfactory manner and to ensure provisions of the Regulations/Directive/Decision are complied with. These legislation pertaining to fish and fishery products for implementation of Quality and safety is represented in Figure 2.

Figure 2. EU legislation regarding quality and safety of fishery products



United States

The majority of United States Federal regulatory authority and activity for seafood regulation is vested with the Food and Drug Administration (FDA) within the Department of Health and Human Service. The FDA's mission is to enforce laws enacted by the United States of America Congress and regulations promulgated by the Agency to protect the consumer's health, safety, and pocketbook. Among the main laws associated with seafood safety there is the Federal Food, Drug and Cosmetic Act (the Act) of 1938, as amended time to time. The guidelines for chemical contaminants and microbiological requirements as per FDA is given in Table 1 and 2. There has been dynamicity in the limits laid down for animal drug residues with recent amendment (Table 3)

Table: 1 FDA guidelines for certain chemical contaminants in fishery products

Substances	**Levels**	**Fishery products**	**Reference**
Aldrin/ Dieldrin	0.3ppm	All fishes	Compliance Policy Guide (575.100)
Chlordane	0.3ppm	All fishes	-do-
Chlordecone	0.3ppm	All fishes	-do-
DDT, TDE, DDE 5.0 ppm All fishes -do-	5.0 ppm	All fishes	-do-
Cadmium	3ppm	Crustaceans	FDA Guidance Documents
Lead	1.5 ppm	Crustaceans	FDA Guidance Documents
Methyl Mercury	1 ppm	All fishes	Compliance Policy Guide (540.600)
Heptachlor	0.3 ppm	All fishes	Compliance Policy Guide (575.100)
Polychlorinated Biphenyls	2.0 ppm	All fishes	21 CFR 109.30

Table: 2 FDA guidelines for certain microbiological contaminants in fishery products

Parameters	Levels	Fishery products	Reference
Salmonella	Absence /25 g	All fishes	Compliance Policy Guide 555.300
Staphylococcus aureus	10^4 / 1g (MPN)	All fishes	Compliance Policy Guide 7303.842
Clostridium botulinum	Absence of viable spore & toxin	All fishes	Compliance Policy Guide 7303.842
Listeria moncytogenes	Absent	Ready to eat product	Compliance Policy Guide 7303.842
Vibrio cholerae	Absent	Ready to eat product	Compliance Policy Guide 7303.842

Table: 3 FDA guidelines for certain Animal drug residues in fishery products

PROGRAM 7304.018

C. Target Testing Level (TTL)/ Regulatory Action Level (RAL)

The following values are the current Target Testing Levels (TTL) or tolerance level (TL) for each chemotherapeutic agent. These levels are also considered as Regulatory Action Levels (RAL). However, TTL is not and should not be interpreted as a safe concentration or a tolerance level and it does not imply that an approval exists for that drug [21CFR530.3(g)].

Animal Drug Residue	Target Testing Level or Tolerance Level (ppb)
Chloramphenicol[1]	0.15
Nitrofurans[1] AOZ metabolite of Furazolidone AMOZ metabolite of Furaltadone SC metabolite of Nitrofurazone AHD metabolite of Nitrofurantoin	 0.5 0.5 0.5 0.5

China:

GAIN Report (Food and Agricultural Import Regulations and Standards) Number CH18025 (2018) lays out requirements of various tolerance limits.

For exports the Food Business Operators needs to comply the following:

- Enlisting of the establishment through EIC in the Chinese site
- Requirements to be met as per GAIN report 2018

Russia:

For exports the Food Business Operators needs to comply the following:

- Separate approval and enlistment of the establishment in CU (Russia) site
- Physical Facility requirements as per Sanitary rules and Norms SanPiN No. 6 dated 11-03-1996
- Common Veterinary and sanitary requirements as per Decision by CU No. 317 dated 18-06-2010
- Technical regulation requirements as per Decision No. 880 Dated 09-12-2011

Japan:

For exports the Food Business Operators needs to comply to the following:

- Should meet the requirements laid down in Japan Food Sanitation Law (JETRO).
- Consignment of aquaculture shrimps meant for export to Japan shall be sampled and tested by EIA for banned antibiotics including nitrofuran metabolites, Pendimethalin and Ethoxyquin.

Vietnam

For exports the Food Business Operators needs to rregister their establishments through EIC with the National Agro-Forestry -Fisheries Quality Assurance Department (NAFFQAD), Vietnam

Saudi Arabia

- All the consignments meant for export to Saudi Arabia shall be tested for Vibrio cholera by the EIA concerned at EIA lab.
- In case of fresh chilled fishery products, five composite sample from each consignment shall be submitted by the establishment at EIA for testing V.cholerae on post facto basis
- Aquaculture shrimps should be tested for viruses namely, YHV & WSSV

Australia

For exports the Food Business Operators needs to comply the following:

- All consignment originating from India shall be exported to Australia with Health certificate mentioning that that *"the fish were inspected under the supervision of the Competent Authority"* as per requirement of Department of Agriculture, Fisheries and Forestry, Australia
- All the consignments shall be inspected by Competent Authority.
- Aquaculture raw shrimps shall be tested for virus namely, YHV & WSSV tested and the sampling must be as per guideline stipulated (13 samples per lot and each sample must be of 5 pcs and all the 13 samples must pass) by Australia.

Korea

For exports the Food Business Operators needs to comply the following requirement as per KFDA:

- Mandatory health certificate for export of chilled, frozen and live fish
- Aquaculture shrimps shall be sampled and tested by EIA for Nitrofuran metabolites and viruses namely, WSSV, YHV

Brazil

For exports the Food Business Operators needs to comply the following

- The establishments intending to export of Fishery products to Brazil shall provide registration form specified by Brazilian authorities for the registration of labels of the products to be exported in Portuguese or Spanish language.

New Zealand

For exports the Food Business Operators needs to comply the following

- Sampling and testing should be in accordance with NZFSA's
- Samples should be taken for each product type, eg, cooked or raw, pieces, packaging, size etc., 5 samples per lot for microbiological analysis and each lot sample must weigh at least 100g.

Canada

For exports the Food Business Operators needs to comply the following:

- Health Certificate is mandatory as per the CFIA requirements
- Declaration from the exporter stating that the product does not come in contact with the ink used for printing the labels

South Africa

For exports the Food Business Operators needs to comply the following:

- Code wise sampling and testing by EIA for Vibrio spp. (four species)

References/websites to visit:

- Scheme for approval and monitoring of establishments/factory vessels/ freezer vessels processing/storing fish & fishery products for export.
- http://115.112.238.112/eic/inspection/marine.pdf
- https://www.eicindia.gov.in/
- https://www.fda.gov/food/seafood-guidance-documents-regulatory-information/fish-and-fishery-products-hazards-and-controls

Chapter 15

Packaging of fishery products

Dr. J. Bindu
Principal Scientist, Fish Processing Division, ICAR-CIFT

Introduction

Packaging is crucial to our modern food distribution and marketing systems. Without protective packaging, food spoilage and wastage would increase tremendously. The advent of modern packaging technologies and new methods of packaging materials made possible the era of convenience products. In the past packaging emphasized the expectations of the producers and distributors but now it has shifted towards the consumer since they are becoming more demanding and aware of different choices to choose from. A food package usually provides a number of functions in addition to protection. Fish is one of the most perishable of all foods. The best package material cannot improve the quality of the contents and so the fish must be of high quality prior to processing and packaging. Different products have different packaging requirements and it is important to choose suitable packaging material accordingly. The intended storage conditions of the product, i.e., temperature, relative humidity and expected shelf life have to be known. Multilayered plastics are very popular since properties of different films can be effectively used to pack different products. The basic function of food packaging is to protect the product from physical damage and contaminants, to delay microbial spoilage, to allow greater handling and to improve presentation.

Types of Packaging Material

Glass

Glass containers have been used for many centuries and still one of the important food packaging material. Glass has its unique place in food packaging since it is strong, rigid and chemically inert. It does not appreciably deteriorate with age and offers excellent barrier to solids, liquids and gases. It also gives excellent protection against odour and flavor and product visibility. Glass can also be moulded to variety of shapes and sizes. But it has disadvantages like fragility, photo oxidation and heavier in weight.

Cans

Most frequently used container for packing food for canning is tin plate can. Tin plate containers made their appearance in 1810. The tin can be made of about 98% steel and 2% tin coating on either side. The base steel used for making cans is referred as CMQ or can making quality steel. Corrosion behavior, strength and durability of the tin plate depend upon the chemical composition of the steel base. The active elements are principally copper and phosphorous. The more of these elements present the greater the corrosiveness of steel. Cans are traditionally used for heat sterilized products and different types are standard tin plates, tin free steel and vacuum deposited aluminium on steel and aluminium cans. For food

products packing they are coated inside to get desirable properties like acid resistance and sulphur resistance. But care has to be taken to avoid tainting of the lacquer.

Polymer coated two-piece cans of 6 oz capacity (307 x 109) with a universal polymer coating can be widely used for a variety of products. The can is made of Electrochemically chromium coated steel (ECCS) plate with clear polyethylene terephtahalate (PET) coating on either side The finished plate has a thickness of 0.19mm (0.15 mm of base steel + 20 µ PET coating on either side). The cans are made out of the steel plate by draw and redraw (DRD) process. The chromium coating along with the PET coating provides the can with a smooth, greyish, glistening appearance in addition to act as a barrier between the product and the base steel. The bottom of the can is designed for better stackability so that it can be stacked vertically without risk of toppling on the shelf. This also helps to reduce the storage space requirement for the cans. These cans are found to be suitable for thermal processing of fish and fish products. These cans are having easy open ends. Metal cans are advantageous as packages because of superior strength, high speed manufacturing and easy filling and dosing. Disadvantages of metal cans are weight, difficulty in reclosing and disposal.

Paper

A very considerable portion of packaged foods is stored and distributed in packages made out of paper or paper based materials. Because of its low cost, easy availability and versatility, paper is likely to retain its predominant position in packaging industries. Paper is highly permeable to gases, vapour and moisture and loses its strength when wet. Ordinary paper is not grease and oil resistant, but can be made resistant by mechanical processes during manufacturing.

Paper board

Thicker paper is called as paper board. There is not a clear cut dividing line between the heaviest grade of paper and the lightest board. The lightest standard board is 0.19 mm thick and heavy papers are of 0.125 mm in thickness. Paper boards are used for making corrugated fibre board cartons.

Polymer Packaging

Plastics offer several advantages over other packaging materials since they are light in weight, flexible and offers resistant to cracking. Plastics have the advantage that most of them possess excellent physical properties such as strength and toughness. The requirements with a particular food may not be met with in a single packaging material, as it may not possess all the desired properties. In such cases copolymers or laminates consisting of two or more layers of different polymers having different properties can also be used.

Low Density Polyethylene (LDPE)

Most commonly used as it possesses qualities such as transparency, water vapour impermeability, heat sealability, chemical inertness and low cost of production. Organic vapours, oxygen and carbon dioxide permeabilities are high and has poor grease barrier property. Resists temperature between – 40°C to 85°C. Polyethylene (polythene, PE) is the material consumed in the largest quantity by the packaging industry.

High Density Polyethylene (HDPE)

HDPE resins are produced by low-pressure process. HDPE posses a much more linear structure than LDPE and has up to 90% crystallinity, compared with LDPE which

exhibits crystallinities as low as 50%. It is stronger, thicker, less flexible and more brittle than LDPE and has lower permeability to gases and moisture. It has a higher softening temperature (121°C) and can therefore be heat sterilized. High molecular weight high density polythene (HM-HDPE) has very good mechanical strength, less creep and better environmental stress crack resistance property.

Linear Low Density Polythene (LLDPE)

Linear low density polythene is low density polythene produced by a low pressure process. Normal low density polythene has many $-C_5H_{11}$ side chains. These are absent in LLDPE, allowing the molecules to pack closer together to give a very tough resin. It is virtually free of long chain branches but does contain numerous short side chains. Generally, the advantages of LLDPE over LDPE are improved chemical resistance, improved performance at both low and high temperatures, higher surface gloss, higher strength at a given density and a greater resistance to environmental stress cracking. LLDPE shows improved puncture resistance and tear strength. The superior properties of LLDPE have led to its use in new applications for polyethylene as well as the replacement of LDPE and HDPE in some areas.

Polypropylene (PP)

Polypropylene is produced by the polymerisation of propylene. All PP films have permeability about ¼ to ½ that of polyethylene. It is stronger, rigid and lighter than polyethylene.

Cast polypropylene (CPP)

It is an extruded, non oriented film and is characterized by good stiffness, grease and heat resistance and also has good moisture barrier. However, it is not a good gas barrier.

Oriented, Heat set Polypropylene (OPP):

Orientation can be in one direction (unbalanced) or in two directions equally (balanced). The resulting film is characterized by good low temperature durability, high stiffness and excellent moisture vapour transmission rate. One drawback of OPP is its low tensile strength.

Polystyrene

The material is manufactured from ethylene and benzene, which are cheap. The polymer is normally a tactic and it is thus completely amorphous because of the bulky nature of the benzene rings prevents a close approach of the chains. The material offers reasonably good barrier to gases but is a poor barrier to water vapour. New applications of polystyrene involve coextrusion with barrier resins such as EVOH and poly vinylidene chloride copolymer to produce thermoformed, wide mouthed containers for shelf stable food products and multi layer blow moulded bottles. To overcome the brittleness of polystyrene, synthetic rubbers can be incorporated at levels generally not exceeding 14% w/w. High impact polystyrene is an excellent material for thermoforming. Co-polymerisation with other polymers like acrylonitrile butadene improves the flexibility. Since it is crystal clear and sparkling, it is used in blister packs and as a breathing film for packaging fresh produce. These materials have low heat sealability and often tend to stick to the jaws of heat sealer.

Polyester

Polyester can be produced by reacting ethylene glycol with terephthalic acid. Polyester film's outstanding properties as a food packaging material are its great tensile

strength, low gas permeability, excellent chemical resistance, lightweight, elasticity and stability over a wide range of temperature (-60° to 220°C). The later property has led to the use of PET for boil in the bag products which are frozen before use and as over bags where they are able to withstand cooking temperatures without decomposing.

Although many films can be metallized, polyester is the most commonly used one. Metallization results in considerable improvement in barrier properties. A fast growing application for polyester is ovenable trays for frozen food and prepared meals. They are preferable to foil trays because of their ability to be micro wave processed without the necessity for an outer board carton.

Polyamides (Nylon)

Polyamides are condensation products of diacids and diamine. The first polyamide produced was Nylon-6,6 made from adipic acid and hexamethylene diamine. Various grades of nylons are available. Nylon-6 is easy to handle and is abrasion-resistant. Nylon-11 and nylon-12 have superior barrier properties against oxygen and water and have lower heat seal temperatures. However, nylon-6,6 has a high melting point and hence, it is difficult to heat seal. Nylons are strong, tough, highly crystalline materials with high melting and softening points. High abrasion resistance and low gas permeability are other characteristic properties.

Polyvinyl Chloride (PVC)

The monomer is made by the addition of reaction between acetylene and hydrochloric acid. It must be plasticised to obtain the required flexibility and durability. Films with excellent gloss and transparency can be obtained provided that the correct stabilizer and plasticizer are used. Thin plasticized PVC film is widely used in supermarkets for the stretch wrapping of trays containing fresh red meat and produce. The relatively high water vapour transmission rate of PVC prevents condensation on the inside of the film. Oriented films are used for shrink-wrapping of produce and fresh meat. Unplasticized PVC as a rigid sheet material is thermoformed to produce a wide range of inserts from chocolate boxes to biscuit trays. Unplasticized PVC bottles have better clarity, oil resistance and barrier properties than those made from polyethylene. They have made extensive penetration into the market for a wide range of foods including fruit juices and edible oils.

Copolymers

When polythene resins are being manufactured it is possible to mix other monomers with ethylene so that these are incorporated in the polymer molecules. These inclusions alter the characteristics of the polythene. Vinyl acetate is commonly used and the resulting ethylene vinyl acetate (EVA) copolymers display better sealing than modified polythene. Butyl acetate is incorporated with similar effects.

Aluminium foil

Aluminium foil is defined as a solid sheet section rolled to a thickness less than 0.006 inches. Aluminium has excellent properties like thermal conductivity, light weight, corrosion resistance, grease and oil resistance, tastelessness , odourlessness, heat and flame resistance, opacity and non-toxicity. Aluminium foil free from defects is a perfect moisture and oxygen barrier. In all flexible packaging applications using aluminium foil where good moisture and oxygen barrier properties are important, the foil is almost always combined with heat sealing media such as polythene or polypropylene. It is the cheapest material to use for the properties obtained. Foils of thickness 8 to 40 microns are generally used in food packaging.

Foil as such is soft and susceptible for creasing. Hence, foil is generally used as an inner layer.

Packaging of fresh fish

A suitable package for fresh fish should keep the fish moist, prevent dehydration, retard chemical and bacterial spoilage, provide a barrier against moisture and oxygen to reduce fat oxidation and prevent permeation of external odors. Generally baskets made of split bamboo, palmyrah leaf and similar plant materials were traditionally used for packing fresh iced fish. However, they do not possess adequate mechanical strength and get deformed under stacking. The porous surface of these containers tends to absorb water and accumulate slime, creating an ideal breeding ground for spoilage bacteria, which can contaminate the fish. Even though washing cleans the contaminated surfaces of the container it has been shown to be ineffective in reducing the bacterial load significantly. Sharp edges of bamboo also cause bruises on the skin of fish. Used tea chests provided with 2.5 cm thick foamed polystyrene slabs inside have been found extremely beneficial for transport of fish over long distances up to 60 hours duration.

Modern insulated containers are made of HDPE or polypropylene with polyurethane insulation sandwiched between the inner and outer walls of the double walled containers. They are durable and in normal use have a life span of over 5 years. Materials such as aluminium, steel and fibre glass are also used in the construction of insulated containers. Insulation properties of these containers depend on the integrity of the layer of insulation. Contamination of insulation layer with water drastically reduces insulation properties of the medium. An insulated corrugated polypropylene container which is the lightest of all packages is used for iced fish transport. It lasts for 5 trips and being of collapsible design and lightweight, return of empty container is very easy. The use of fibre board containers for the transportation of iced fish and frozen fish showed that fish could be transported in good with effective insulation.

Packaging of frozen fish

World trade in frozen fishery products has been increasing every year. Fish being highly perishable transportation and storage of frozen fishery products requires a cold chain and these fishery products are to be stored at temperatures below –18° C. Fishery products are frozen at – 40° C. However cold storage temperature where they are subsequently stored varies from -30 to –18° C. The enzymatic activities bring about deteriorative changes like rancidity in frozen fish products. Exposure to low temperatures for a long time may result in freezer burns. Hence for extending shelf life and further storage, packaging is of absolute importance. To get a quality frozen product in perfect condition the package must provide protection against dehydration, oxidation, flavour and odour loss and physical changes. Evaporation of moisture from the surface of the fish may occur resulting in freezer burns. In order to overcome these problems suitable packaging is absolutely necessary. The advantages of packaging frozen fish are, prevention of dehydration, prevention of rancidity in fatty fishes, protection against contamination and physical damages, convenience of handling the product and using a portion of the product, retention of flavour and colour attractive appearance of the product and to allow pack for thawing without leaching.

Primary wrap for block frozen products

The material used as a primary wrap for contact with the food is mainly Low-density polythene (LDPE). This can be in the shape of a bag or a film. Usually 2 kg or 5 lbs fish is packed along with 10-20 % glaze. Glazing should be optimum at the recommended level, since this will add to cost and weight during packaging and transportation. Alternately, films

of high molecular weight high-density polyethylene (HM-HDPE), which is not as transparent as LDPE film are also used being more cost effective. 100 gauge LDPE is used for wrap while 200 gauge is used for bag. The corresponding values for HDPE are 60 and 120 gauge. Polythene films should be of food grade conforming to IS: 9845 specifications.

Duplex carton/ Inner carton

There are four types of cartons used for packaging of seafood products, which are top opening, end opening, end loading and tray type. In top opening carton system filling is done from the top. This is mainly for filling larger pieces of fish and cephalopods. End opening type cartons are used when the product is smaller and free flowing, like packaging of fish curry or soup. Here the carton is coated with polyethylene on both the inside and outside. The end loading system feeds the product from one end into a horizontal glued carton. End flaps are heat sealed or closed by tucks in flap. End loading is suitable for products packed in aluminium /carton trays. Tray type cartons consist of cartons systems/ polypropylene trays, which are sealed with a lid and used for production of frozen precooked food that will be heated and thawed in the package itself. To withstand heating, the board is coated with polypropylene.

The frozen blocks are wrapped in film and then packed in duplex cartons. A number of such blocks are packed in a master poly bag and then packed into master cartons. The carton should have details like net weight, type and size, name and address of the producer and the country of origin.

Master carton

In the case of frozen shrimps about 6 units of 2 kg each or 10 units of 2 kg each are packed into master cartons. Corrugated fiberboards are used for the packaging of frozen fish. They may be of virgin material and having three or five ply with liners. The cartons may be wax coated or supported with liner paper with higher wet strength to make it moisture resistant. The specifications for master carton vary depending upon the country or the type of pack.

Strapping and tying

Boxes are now mainly closed at the top and bottom by using cellophane tapes. They are also stapled or strapped by using polypropylene / high density/ rayon extruded straps. The straps are clipped or heat-sealed. The tensile strength must be great enough to withstand the load. In the case of polypropylene the fluctuations in the tensile strength and elongation at break (%) at –20°C are comparatively less. Hence this material is most suitable when compared to HDPE where the tensile strength and elongation at break vary.

Packaging of Individually Quick Frozen (IQF) Products

Packaging requirements of IQF shrimps vary from those of block frozen. IQF shrimps are mainly packed for retail marketing in consumer packs ranging from 100g to 5 kg. An IQF pack has a single glaze on its surface and because of the larger surface area, they are vulnerable to several risk. Essential characteristics required for packaging materials of IQF shrimps are

- Low water vapour transmission rate to reduce the risk of dehydration
- Low gas/oxygen permeability, thereby reducing the risk of oxidation and changes in colour, flavour and odour
- Flexibility to fix the contours of the food
- Resistance to puncture, brittleness and deterioration at low temperatures.
- Ease of filling

IQF shrimps are filled in primary containers along with code slip and weighed. Bar coding is nowadays adopted which will depict various product and inventory details through a series of bars. Bar coding is compulsory for products imported to the EEC and US markets. The product is filled into primary pack which heat sealed and further it is packed in master cartons for storage and transportation. The primary pack may be plastic film pouches (monofilm co-extruded film or laminated pouches). The unit pouches may be provided with unit/intermediate cartons or directly packed into master cartons. The unit/intermediate cartons are made of duplex or three ply corrugated fibre board laminated with plastic film on the inside and outside to improve the functional properties as well as aesthetic value of the pack. The most functional cost effective film has been identified as 10 μ biaxially oriented polypropylene (BOPP). Some duplex cartons are also wax-coated. One major requirement of the master carton is high compression strength to bear weight without damage to the product. Compression strength of 500 kg is the minimum recommended specification, which might give reasonable safety to the product. The cartons are made of 5 or 7 ply corrugated fibre board.

Battered and Breaded fish products

This forms an important class of value added products in convenience form. The battering and breading process increase the bulk of the product thus reducing the cost element. A number of value added marine products both for export and internal markets can be prepared from shrimp, squids, cuttle fish, certain species of fish and minced meat from low priced fishes. The changes taking place during frozen storage of the value added products are desiccation, discoloration, development of rancidity etc. Application of proper packaging prevents/retards these changes and enhances shelf life. Conventional packaging materials like flexible plastic films alone are not suitable for these products as they provide little mechanical protection to the products and as a result the products get damaged or broken during handling and transportation. Hence, thermoformed containers are commonly used for this purpose. The thermoformed trays produced from food grade materials are suitable for the packaging of value added fishery products both for internal and export markets. Trays made of materials like PVC, HIP and HDPE are unaffected by low temperature of frozen storage and provide protection to the contents against desiccation, oxidation etc. during prolonged storage.

Dry fish

Traditionally, coconut leaf baskets, palmyrah leaf baskets, jute sacks and news paper baskets have been used for packing and transportation of dried fish. These containers only help in transportation of the fish. They do not protect or preserve the fish. The dry fish packed in such containers have a very short shelf life and is usually not of good quality. These fishes are often found to be rancid or have mould growth. Since the packaging is permeable, the product absorbs moisture and gets soggy. Hence these packaging materials afford least protection to the product. Plywood boxes and waxed corrugated cartons are also used for packing large quantities. High density polythene woven gusseted bags laminated with 100 gauge low density polythene are suitable for packaging dried fish. HDPE is impervious to microbial and insect attack. HDPE is a material which will not spoil even if it gets wet. It is hard and translucent and has high tensile strength.

In the consumer market the dried fish is packed in low-density polyethylene or polypropylene. Due to the high moisture content of about 35 % in certain salted fishes they are often attacked by microbes. Hence fish should be dried to a moisture level of 25 % or below. Packets of different sizes and weights ranging from 50g up to 2 kg and bulk packs are

available. Nowadays monolayer and multilayer films, combination and co extruded films are used for bulk packing and consumer packaging of dry fish. Polyester polythene laminates and thermoform containers are used to pack dried prawns and value added dried products. In consumer packaging 100 to 700 gauge LDPE and PP were found suitable for storing dry fish. It also showed that dry fish when packed in films of higher gauge remained in good condition for a longer period. This is mainly due to the low water vapour transmission rate and oxygen transmission rate, which decrease with increase in thickness. In the case of overall quality 200, 300 and 400 gauge LDPE films also showed promising results. The advantages of low density polythene are clarity, low water vapour transmission rate, good bursting and tearing strength and heat sealing capacity. The main disadvantage is the high gas transmission rate which is undesirable in dried fish packaging because the smell dissipates to the surrounding atmosphere.

Dry shell on prawns are packed mostly in duplex cartons or polystyrene trays and then covered with a laminate film. This is mainly due to the fact the spines will puncture the packaging material. Polypropylene pouches of 300 gauge are recommended for salted fishery products with moisture content of 35% and above for obtaining a shelf life of 6 months. The advantages being good clarity, Low WVTR, good bursting strength and tearing strength. Currently laminate films of Polyester/polythene are mostly used for packaging of dried fish. Polyester films are capable of giving good mechanical strength and reverse colour printing can also be done. Polythene is heat sealable and has good food contact application. The keeping quality of dry fish can be enhanced in an air-conditioned room where the temperature and humidity is low.

Dry fish is irregular in shape and size leading to difficulty in packing. . They also have spines and projections which may puncture the packaging materials. In the case of jute bags because of its permeable nature salted fish may absorb moisture depending on the relative humidity of the environment. In the coastal place where RH is always above 80 % this invariably takes place making the fish wet. Thus a suitable packaging material will ensure protection against migration of moisture and oxygen, and odour and insect attacks.

Accelerated freeze dried (AFD)

AFD products demand a very high price in the export trade. The final moisture content of AFD products generally is about 2 %. Low moisture content and large surface area make these foods extremely hygroscopic. Most dried products deteriorate when exposed to oxygen. Changes in colour may also take place as a result of bleaching. Light accelerates oxidative reactions and hence contact with light should be prevented. If proper packaging materials are not used there is every chance that the materials may undergo flavour changes due to the oxidation of the product and also migration of flavour from the packaging material. Since, fish contains fat there may be also a chance of it taking up the taints from the packaging material. The particular structural properties of freeze-dried products lead to damage by mechanical means. The light porous nature causes them to be very fragile and easily prone to breakage during handling and transportation. Freeze dried products are also liable to damage caused by free movement within the package. Measures must be taken to fit the product compactly in the container, while leaving the minimum headspace for filling inert gas.

Rigid containers both glass and cans were used earlier for packaging of freeze dried products. However, now metallised polyester laminated with polythene or aluminum foil /paper/polythenes are used since they have low oxygen transmission rate and water vapour transmission rate. Most of the packages are filled with an inert gas. The product can also be packed under vacuum to give better protection against damage.

Packaging of thermal process fish products

Retort pouches consist of three or four layers consisting of an outer polyester layer, a middle aluminum layer and an inner cast polypropylene layer. Aluminium foil is the barrier layer which gives the product a longer shelf life. Polypropylene has a high melting point of about 138°C and is used as the inner layer to provide critical seal integrity, flexibility, strength, taste and odour compatibility with a wide range of products. The different layers are held together with adhesives which are usually modified polyolefins such as ethylene vinyl acetate (EVA). Some pouches contain polyvinylidiene chloride, ethylene vinyl alcohol or nylon instead of the aluminium layer to permit viewing of the product. These are foil free laminated materials. These plastics are good barriers to oxygen molecules but are not complete barriers and therefore the shelf life is reduced. There are mainly two types of retort pouches viz, preformed and pouches which are made from laminates on the process line. Preformed retort pouches are more commonly used and they are filled manually or by using automatic filling machines. Sauces and curry products are packed instantaneously in pouches that are produced from laminated rolls which are simultaneously formed, filled and sealed. In case of products with solid contents, either pouch are filled with solids together with some liquid and sealed using a vacuum sealing machine. Once the product is filled and sealed it is then subjected to temperatures of 121.1°C with counter pressure so that the cold point or slowest heating point within the food reaches the predetermined time temperature integral.

Fish pickles

Fish pickle is a value added item whose bulk is contributed by low value items like ginger, chilly, acetic acid etc. Generally low cost fish, clam meat is used in fish pickles. Conventionally glass bottles are used as containers, which offer properties like inertness, non-toxicity, durability, non-permeability to gases, moisture etc. But they are heavy, prone to break, voluminous and expensive. New flexible packaging materials developed for fish pickle is based on plain polyester laminated with LDPE-HDPE Co-extruded film or Nylon/Surlyn or LD/BA/Nylon/BA/Primacore. These are inert to the product, can be attractively fabricated as stand up packs and can be printed on the reverse side of the polyester film.

Fish soup powder

Fish soup powder is a speciality product containing partially hydrolysed fish, protein, carbohydrates, fat and several other seasonings including salt. The product is hygroscopic and hence the selection of the package assumes great significance. Appropriate package developed for such products are 12 micron plain polyester laminated with LDPE-HDPE co-extruded film or 90-100 micron LD/BA/Nylon/BA/Primacore multilayer films which ensure a safe storage of the product up to six months.

Extruded products

Ready to eat breakfast cereals, pasta, ready-to-eat, snacks, pet foods, and textured vegetable protein (TVP) are prepared by the extrusion process. An extruder consists of one or two screws rotating a stationary barrel and the mixed raw material is fed from one end and comes out through a die at the other end where it gets puffed up due to the release of steam. It is either in the ready to eat form and hence have to be hygienically packed for consumption. The extruded products are highly hygroscopic in nature and hence they should not come into contact with moisture. Since the extruded product contains fat, the product should not be

exposed to air. It is also highly brittle and may powder when crushed. Hence packaging films of high barrier strength and low permeability to oxygen and water vapour are required. Generally extruded products are packed in LDPE/ metallised polyster laminated pouches flushed with Nitrogen.

Surimi and surimi based products

Surimi is an intermediate product / raw material for processing several value added products like fabricated foods, shrimp and crab analogues and a variety of other products. Surimi requires to be preserved frozen until used for processing different products. For this purpose surimi is generally frozen as rectangular blocks. In order to prevent oxidative rancidity and desiccation care has to be taken to ensure that the frozen block does not contain any voids and that the packaging materials used have low water vapour permeability and low permeability to gases and odours. The packaging materials employed should be sufficiently strong and durable to withstand stress during handling, storage and distribution. LDPE and HDPE packaging films employed for block frozen shrimp are considered safe for surimi.

Fish Sausage

Fish sausage is a minced based product. Surimi is the base material, which is homogenised after mixing with several other ingredients. The homogenised mass is stuffed in synthetic casings like Ryphan (Rubber hydrochloride) or Kurehalon (Vinylidene chloride). The casing is closed using metal rings after which it is heated in water at 85-90°C and then slowly cooled. After drying the surface the sausage is wrapped in cellophane laminated with polythene. Fish sausage is kept at refrigerator temperatures for retail; however when prolonged storage is needed it is better kept frozen. Fish sausage is also processed in polyamide and cellulose and fibrous casing. For thermal processing polypropylene casings are used so as to withstand high temperatures.

Glucosamine hydrochloride

D-Glucosamine hydrochloride is used to cure rheumatic arthritis, and is also used as an additive in the food & cosmetic industry. D-Glucosamine hydrochloride Powder is stored in a cool and dry well-closed container, the temperature should be lower than 25°C, and the relative humidity should not exceed 50%. Glucosamine is packed in polybottle, namely PP or HDPE of 1kg, 500g and 20 g, 1kg metallised bag, 25kg in drums for commercial use and smaller quantities are packed in auto sample vials.

Chitin and Chitosan

Chitin and chitosan are derived from prawn shell waste and is exported in large quantities. The product should be protected against moisture gain as well as microbial and insect attacks. Bulk packaging of chitosan is done in HDPE woven gusseted bag laminated with 100 gauge LDPE liner. Chitosan is also marketed in capsule forms for consumption. Capsules made of gelatin are used for filling chitosan. Since chitosan is in the powdered form or flakes they are filled into the capsules. A particular numbers of capsules are then placed in HDPE containers.

Fish Hydrolysate

Fish Hydrolysate is prepared from fish mince which has contain oil and is undiluted, and so is a richer food source for beneficial microbes and especially beneficial fungi in the soil. It is generally cold-processed and hence retains the amino acids and protein chains as such. Fish hydrolysate is concentrated, and when diluted can be used ideally as soil fertliser,

and is suitable for all soils, crops, ornamentals, trees and vegetables It contains a wide spectrum of major nutrients and trace elements in organic, plant available form. It can be used as a foliar spray, but since the oil is present it may show patches on the leaves. The liquid is generally packed in jars or cans which are made of polypropylene or HDPE.

Fish Meal

Fish meal is a source of high quality protein (60%) and is also a rich in omega-3 essential fatty acids EPA and DHA due to the high fat content. Incorporation of DHA and EPA in fish meal will in turn ensure its concentration in the diets of fish and poultry, ultimately reaching the human diet. Hence the packaging should be impermeable to moisture, oxygen and other insets and pests. Fish meal is generally packed in HDPE sacks for bulk transportation. The fishmeal whether in ground or pelletised form should contain moisture 6-12 %. The fat content should not exceed 18% and the final meal should contain at least 100 ppm antioxidant (ethoxyquin). If the temperature exceeds°130 F or 55° C then the ventilation should be provided. The fish meal is generally packed in jute bags, multiwall paper bag which are lined with polythene and in HDPE woven bags with liner.

Fish oils

Fish oils are highly unsaturated and easily susceptible to oxidation when exposed to air. Hence they have to be packed in containers which have high barrier properties which are moisture proof, oil resistant and impermeable to oxygen. Larger quantities of fish oil are mainly packed in LLDE/Nylon films or in glass bottles. Bulk transportation food grade flexi tanks made of 4 layered polyethylene and tubular PP. Advantages of using flexi tanks are that they can carry 50% more than bottles and therefore will save on storage space, packaging and transportation cost.

Fish oil is also marketed for regular oral dosage in the form soft gel capsules. The shell is made of gelatin, water, glycerol or sorbitol. The process of encapsulation is by using the rotary die encapsulation process. The encapsulation process is a FFS operation. Two flat gelatin ribbons manufactured on the machine are brought together on a twin set of rotating dies that contain recesses in the desired size and shape, these cuts out the ribbon into a two-dimensional shape, and form a seal around the outside. At the same time a pump delivers a precise dose of oil through a nozzle incorporated into a filling wedge whose tip sits between the two ribbons in between two die pockets at the point of cut out. The wedge is heated to facilitate the sealing process. The wedge injection causes the two flat ribbons to expand into the die pockets, giving rise to the three-dimensional finished product. After encapsulation, the soft gels are further dried depending on the product. They are then further packed in glass or plastic bottles. The soft gels are also packed as blister packs.

Fish silage

Fish silage is a product made from whole fish or parts of the fish which are mainly processing discards and to which an acid is added. The liquefaction of the fish is brought about by enzymes inherent in the fish. The product is a stable liquid and contains all the water present in the original material. Hence it is in the liquid form. Fish silage is generally stored in huge drums or polycontainers so that they can be transported.

Suggested Reading

1. Gordon L. Robertson (2006). Food Packaging -Principles and Practice, CRC Press, Taylor and Francis, Boca Raton, FL.
2. Kerry. P.J (2013). Advances in meat, poultry and seafood packaging. Woodhead Publishing Ltd. UK.

Chapter 16

Recent advances in packaging of fishery products

Dr. C.O. Mohan
Senior Scientist, Fish Processing Division
ICAR-Central Institute of Fisheries Technology, Cochin
Email: comohan@gmail.com

There is ever increase in the demand for good quality food product with improved quality and shelf life. Over the years, packaging have brought out a revolution in the marketing and distribution of food products including fish. Among the food categories, seafood ranks 3rd with respect to consumption which explains the importance of fish. Fish is a vital source of food for people. It is the most important single source of high-quality protein, providing approximately 16% of the animal protein consumed by the world's population (Food and Agriculture Organisation (FAO), United Nations, 1997). By any measure, fishes are among the world's most important natural resources. Fisheries production was 171 mmt in 2016 of which capture and culture fisheries accounted to 90.9 and 80 mmt, respectively (FAO, 2018). The total first sale value of fisheries was USD 362 billion. Additionally, with over 25000 known species, the biodiversity and ecological roles of fish are being increasingly recognized in aquatic conservation, ecosystem management, restoration and aquatic environmental regulation.

Like any other food commodities, fish is one of the highly perishable items which undergoes spoilage if sufficient care is not taken. Various preservation methods have been in place to overcome the spoilage of fish. Chilling and refrigeration is the most preferred preservation method as it helps in preserving fresh like quality. Chilling or icing is reducing the temperature of fish so as to prolong the lag phase of bacteria and helps in reducing the spoilage rate. Fish being one of the most perishable foods, its freshness is rapidly lost even when stored under chilled conditions. Further, consumers demands to have fish in as fresh a state as possible so that the characteristics flavours are retained. Bulk transportation of fresh fish in ice has several limitations like limited extension of shelf life, unnecessary expenditure on freight due to ice, difficulty in handling and maintaining hygienic conditions due to leaching of ice melt water with leaching losses of soluble nutrients and flavouring compounds. Proper packaging will help in improving the keeping quality of fish. Packaging is an important aspect for improving the shelf life and marketability. Packaging enhances the consumer acceptability and hence saleability of the product. Traditionally, food packaging is meant for protection, communication, convenience and containment. The package is used to protect the product from the deteriorative effects of the external environmental conditionals like heat, light, presence or absence of moisture, pressure, microorganisms, and gaseous emissions and so on. Packaging is an integral part of the food processing and plays an important role in preventing or reducing the generation of waste in the supply of food. Packaging assists the preservation of the world's resources through the prevention of product

spoilage and wastage, and by protecting products until they have performed their function. Basic requirements of a package are good marketing properties, reasonable price, and technical feasibility, utility for food contact, low environmental stress, and suitability for recycling. Simply packing fish is suitable packaging material will enhance the shelf life of chilled and refrigerated fish to 7 to 15 days depending on fish species (Stammen et al. 1990; Mohan et al. 2008, 2009a,b, 2010, 2012, 2017, 2018; Ozogul et al. 2006a; Pons-Sanchez-Cascado et al. 2006; Ruiz-Capillas and Moral, 2005; Ozogul et al. 2006b; Ozugul et al. 2007; Losada et al. 2005; Campos et al. 2006; Remya et al., 2016, 2017).. However, in the normal packaging the spoilage process will be accelerated due to presence of O_2 in the normal air packing. Alteration in the package atmosphere will help in overcoming the problem of shelf life, which can be achieved by vacuum packaging or modified atmosphere packaging.

Vacuum packaging

Important properties by which consumers judge fish and shell fish products are appearance, texture and flavour. Appearance, specifically colour, is an important quality attribute influencing the consumer's decision to purchase. In fresh red meat fishes, myoglobin can exist in one of three chemical forms. Deoxymyoglobin, which is purple, is rapidly oxygenated to cherry red oxymyoglobin on exposure to air. Over time, oxymyoglobin is oxidised to metmyoglobin which results in a brown discoloration associated with a lack of freshness. Low oxygen concentrations favour oxidation of oxymyoglobin to metmyoglobin. Therefore, in order to minimize metmyoglobin formation in fresh red meats, oxygen must be excluded from the packaging environment to below 0.05% or present at saturating levels. Lipid oxidation is another major quality deteriorative process in muscle foods resulting in a variety of breakdown products which produce undesirable off-odours and flavours. Hence O_2 may cause off-flavours (e.g. rancidity as a result of lipid oxidation), colour changes (e.g. discolouration of pigments such as carotenoids, oxidation), nutrient losses (e.g. oxidation of vitamin E, β-carotene, ascorbic acid) and accelerates microbial spoilage thereby causing significant reduction in the shelf life of foods. Therefore, control of oxygen levels in food package is important to limit the rate of such deteriorative and spoilage reactions in foods. Oxygen level in the package can be controlled by using the vacuum packaging technique in which, the air present in the pack is completely evacuated by applying vacuum and then package is sealed. Vacuum packaging, which is also referred as skin packaging involves removal of air inside the pack completely and maintaining food material under vacuum conditions, so that oxygen available for the growth of microbes and oxidation will be limited. This will help in doubling the shelf life of fish under chilled conditions. This technique is particularly useful in fatty fishes, where the development of undesirable odour due to the oxidation of fat is the major problem. Vacuum packaging for chilled and refrigerated fishes doubles the shelf life compared to normal air packaging (Mohan et al., 2008). Application of this to frozen fishes is also commonly followed as it helps in reducing problem of freezer burn. This technique can be applied to fresh meat and fishes, processed meat and fishes, cheese, coffee, cut vegetables etc. One of the important aspect in the vacuum packaging is the use of packaging material with good barrier properties. Normally polyester-polyethylene or nylon-polyethylene laminates are used. Polyester and nylon provides good strength and acts as good barrier to oxygen. Polyethylene proves good heat sealing property and is resistant to water transmission. The advantages of vacuum packaging include reduction in fat oxidation, growth of aerobic microorganisms, reduction in evaporation thereby dryness and freezer burn in frozen products, extends shelf life and reduces volume for bulk packs containing lighter materials. Disadvantages include difficulty in use for sensitive crispy products and products with sharp edges, requires high barrier packaging material to maintain vacuum, creates anaerobic condition, which may trigger the growth and toxin production of *Clostridium*

botulinum and the growth of *Listeria monocytogenes*. Additional barriers / hurdles are needed to control these microorganisms and also it is capital intensive. Alternative to vacuum packaging, reduced oxygen level in the package can be achieved by using active packaging system like oxygen scavenger. Use of oxygen scavenger is very effective in reducing the oxygen level to <0.01% within 24 h, which helps in preserving the quality of food (Mohan, 2008). This is not capital intensive and can be applied to any products including crispy and products with sharp edges.

Modified atmosphere packaging (map)

Marketing of modified atmosphere packaged (MAP) foods have increased, as food manufacturers have attempted to meet consumer demands for fresh, refrigerated foods with extended shelf-life. It is also used widely, as a supplement to ice or refrigeration to delay spoilage and extend the shelf life of fresh fishery products while maintaining a high-quality end product. A modified atmosphere can be defined as one that is created by altering the normal composition of air (78% nitrogen, 21% oxygen, 0.03% carbon dioxide and traces of noble gases) to provide an optimum atmosphere for increasing the storage length and quality of food/produce (Moleyar and Narasimham 1994; Phillips, 1996). Oxygen, CO2, and N2, are most often used in MAP (Parry 1993; Phillips 1996). Other gases such as, nitrous and nitric oxides, sulphur dioxide, ethylene, chlorine (Phillips 1996), as well as ozone and propylene oxide (Parry 1993) have been suggested for a variety of products and investigated experimentally. However, due to safety, regulatory and cost considerations, they have not been applied commercially. These gases are combined in three ways for use in modified atmospheres: inert blanketing using N_2, semi-reactive blanketing using $CO_2 : N_2$ or $O_2 : CO_2 : N_2$ or fully reactive blanketing using CO_2 or $CO_2 : O_2$.

Development of modified atmosphere packaging

Kolbe was the first to investigate and discover the preservative effect of carbon dioxide on meat in 18th century and Coyne was the first to apply modified atmospheres to fishery products as early as 1930's. Modified atmosphere packaging (MAP) is the removal and/or replacement of the atmosphere surrounding the product before sealing in vapor-barrier materials. While technically different many forms of map are also case ready packaging, where meat is cut and packaged at a centralized location for transport to and display at a retail store. Most of the shelf life properties of meat are extended by use of map, but anoxic forms of MAP without carbon monoxide do not provide bloomed red meat color and MAP without oxygen may promote oxidation of lipids and pigments. Advances in plastic materials and equipment have propelled advances in MAP, but other technological and logistical considerations are needed for successful MAP systems for raw chilled fresh meat. The growth inhibition of microorganisms in MA is determined by the concentration of dissolved CO_2 in the product. The preservation effect of MAP is due to the drop in surface pH in MA products because of the acidic effect of dissolved CO_2, but this could not entirely explain all of CO_2's bacteriostatic effect. The possibility of intracellular accumulation of CO_2 would upset the normal physiological equilibrium by slowing down enzymatic processes. Thus, the effect of CO_2 on bacterial growth is complex and four mechanisms of CO_2 on micro-organisms has been identified (Parkin and Brown, 1982; Daniels et al. 1985; Dixon and Kell, 1989; Farber, 1991):

1. Alteration of cell membrane functions including effects on nutrient uptake and absorption
2. Direct inhibition of enzymes or decrease in the rate of enzyme reactions
3. Penetration of bacterial membranes, leading to intracellular pH changes

4. Direct changes in the physico-chemical properties of proteins.

Probably a combination of all these activities account for the bacteriostatic effect. A certain amount (depending on the foodstuff) of CO_2 has to dissolve into the product to inhibit bacterial growth. The ratio between the volume of gas and volume of food product (G/P ratio) should be usually 2 : 1 or 3 : 1 (gas : food product). This high G/P ratio is also necessary to prevent package collapse because of the CO_2 solubility in wet foods. The CO_2 solubility could also alter the food-water holding capacity and thus increase drip.

The major function of carbon dioxide in MAP is to inhibit growth of spoilage microbes. Carbon dioxide (CO_2) is soluble in both water and lipid it has a bacteriostatic and fungistatic properties. Carbon dioxide lowers the intra and extra cellular pH of tissue including that of microorganisms. It affects the membrane potential and influence the equilibrium of decarboxylating enzymes of microorganisms. CO_2 increases the lag phase and a slower rate of growth of microbes during logarithmic phase. This bacteriostatic effect is influenced by the concentration of CO_2, the partial pressure of CO_2, volume of headspace gas, the type of micro organism, the age and load of the initial bacterial population, the microbial growth phase, the growth medium used, the storage temperature, acidity, water activity, and the type of the product being packaged. Pathogens like *Clostridium perfringens* and *Clostridium botulinum* are not affected by the presence of carbon dioxide and their growth is encouraged by anaerobic conditions. In general, carbon dioxide is most effective in foods where the normal spoilage organisms consist of aerobic, Gram negative psychrotropicbacteria. The CO_2 is flushed into the modified atmosphere package by evacuating the air and flushing the appropriate gas mixture into the package prior to sealing. Another method to create a modified atmosphere for a product is either to generate the CO_2 and/or remove O_2 inside the package after packaging or to dissolve the CO_2 into the product prior to packaging. Both methods can give appropriate packages with smaller gas/product ratio to the package. The solubility of CO_2 decreases with increasing temperature, hence MAP products should be stored at lower temperatures to get the maximum antimicrobial effect. Also the temperature fluctuations will usually eliminate the beneficial effects of CO_2. The rate of absorption of CO_2 depends on the moisture and fat content of the product. If product absorbs excess CO_2, the total volume inside the package will be reduced, giving a vacuum package look known as “pack collapse”. Excess CO_2 absorption along with “pack collapse” results in the reduction of water holding capacity and further drip loss to the products.

The major function of oxygen is to avoid anaerobic condition which favours the growth and toxin production of *C botulinum* and growth of *L monocytogenes*. Oxygen in the MAP is also useful to maintain the muscle pigment myoglobin in its oxygenated form, oxymyoglobin. In fresh red meats, myoglobin can exist in one of three chemical forms. Deoxymyoglobin, which is purple, is rapidly oxygenated to cherry red oxymyoglobin on exposure to air. Over time, oxymyoglobin is oxidised to metmyoglobin which results in a brown discoloration associated with a lack of freshness. Low oxygen concentrations favour oxidation of oxymyoglobin to metmyoglobin. Therefore, in order to minimize metmyoglobin formation in fresh red meats, oxygen must be excluded from the packaging environment to below 0.05% or present at saturating levels. High oxygen levels within MAP also promote oxidation of muscle lipids over time with deleterious effect on fresh meat colour. O_2 in MA-packages of fresh fish will also inhibit reduction of TMAO to TMA. Nitrogen (N_2) is an inert and tasteless gas, and is mostly used as a filler gas in MAP, either to reduce the proportions of the other gases or to maintain pack shape by preventing packaging collapse due to dissolution of CO_2 into the product. Nitrogen is used to prevent package collapse because of its low solubility in water and fat. Nitrogen is used to replace O_2 in packages to delay

oxidative rancidity and to inhibit the growth of aerobic microorganisms. The exact combination to be sued depends on many factors such as the type of the product, packaging materials and storage temperature. The gas ratio normally used are 60% CO_2 and 40% N_2, for fatty fishes and 40% CO_2, 30% O_2 and 30% N_2 for lean variety fishes. Shelf life of different fishes packed under vacuum and MAP at different storage conditions are given in Table 1.

Advantages of MAP

- The natural colour of the product is preserved
- The product retains its form and texture
- Reduces the growth of microogranisms
- Product retains its vitamins, taste and reduces fat oxidation
- The need to use preserving agents is reduced
- Helps in marketing products to distant locations
- Improved presentation –clear view of product
- Hygienic stackable pack, sealed and free from product drip
- Longer durability of perishable food / decrease of spoilage
- Extends the shelf life of fish in chilled / refrigerated storage by 2 – 3 times
- Helps in reducing post-harvest loss

Disadvantages of MAP

- Capital intensive due to high cost of machinery
- Cost of gases and packaging materials
- Additional cost of gas analyser to ensure adequate gas composition
- No control over the gas composition after packing
- Increase of pack volume which will adversely affect transportation cost and retail display space
- Benefits of MAP are lost once the pack is opened or leaks
- High concentration of CO_2 may favour anaerobiosis
- Strict maintenance of temperature has to be ensured to avoid the risks of *C botulinum* and *L monocytogenes.*

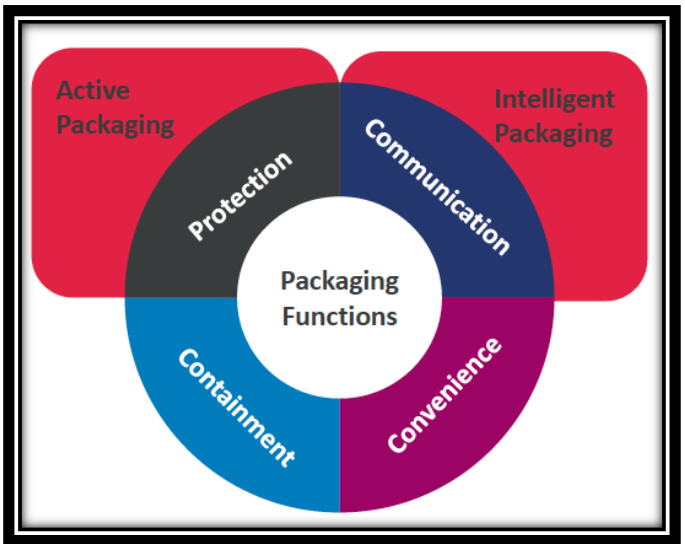
Smart Packaging Technologies

Traditional packaging concepts are limited in their ability to prolong the shelf-life of fish products. This can be overcome by adopting vacuum and modified atmosphere packaging technologies. However, these require capital investment apart from requirement of fresh food grade gas in case of MAP. This promoted the researchers to develop new and improved methods for maintaining food quality and for extending shelf life. Active and intelligent packaging, which are regarded as smart packaging technologies, is one such advanced packaging technique which is finding its way in the preservation of various food systems including fish and shellfish. The market for active and intelligent packaging systems are fast growing and their demand is projected to reach $10.5 billion by 2021, fuelled by the development of new generations of products and more cost competitive prices, which will spur greater market acceptance for many product types.

Basis of Smart Packaging

Packaging has four basic functions, viz., Containment, convenience, protection and communication. Conventional packaging systems offer limited protection and communicates only through the labelling. It will not provide any information about the quality and safety of the product. Active and intelligent packaging enhances the protection and communication

functions, respectively. The following graphics explains how this enhanced functionality works.



Source: AWA Alexander Watson Associates

Active Packaging

Active packaging is an innovative concept that can be defined as '*a type of packaging that changes the condition of the packaging and maintains these conditions throughout the storage period to extend shelf-life or to improve safety or sensory properties while maintaining the quality of packaged food*' (Vermeiren et al. 1999; Rooney, 1992; Ahvenainen, 2003). Active packaging (AP) performs some desired role other than providing an inert barrier between the product and external conditions and combines advances in food technology, bio-technology, packaging and material science, in an effort to comply with consumer demands for 'fresh like' products. This involves incorporation of certain additives into the packaging film or within packaging containers with the aim of maintaining and extending product shelf life. Active packaging technique is either scavenging or emitting systems added to emit (e.g., N_2, CO_2, ethanol, antimicrobials, antioxidants) and/or to remove (e.g., O_2, CO_2, odour, ethylene) gases during packaging, storage and distribution. In case of a gas-scavenging or emitting system, reactive compounds are either contained in individual sachets or stickers associated to the packaging material or, more recently, directly incorporated into the packaging material. Major active packaging techniques are concerned with substances that absorb oxygen, ethylene, moisture, carbon dioxide, flavours/odours and those which release carbon dioxide, antimicrobial agents, antioxidants and flavours. The most important active packaging concepts for fishery products include O_2 scavenging, CO_2 emitters, moisture regulators, antimicrobial packaging concepts, antioxidant release are discussed here.

O_2- scavenger

Fish products are highly susceptible to oxygen as it leads to the growth of aerobic microorganisms and oxidation which causes undesirable colour changes (e.g. discolouration of pigments such as myoglobin, carotenoids), off-odours and flavours (e.g. rancidity as a result of lipid oxidation) and leads to loss of nutrients (e.g. oxidation of vitamin E, β-carotene, ascorbic acid) which adversely affects the quality. Therefore, control of oxygen levels in food package is important to limit the rate of such deteriorative and spoilage reactions in foods. Although O_2-sensitive foods can be packed appropriately using modified atmosphere packaging (MAP) or vacuum packaging, these technologies do not always

remove O_2 completely. Moreover, the O_2 that permeates through the packaging film cannot be removed by these techniques. By use of an O_2-scavenger, which absorbs the residual O_2 after packaging, quality changes of O_2-sensitive foods associated with low residual oxygen levels can be minimized. O_2 scavengers were first commercialized in the late 1970s by Japan's Mitsubishi Gas Chemical Company (Ageless®). O_2 scavengers are able to eliminate oxygen contained in the packaging headspace and in the product or permeating through the packaging material during storage. O_2 scavengers are efficient in preventing discolouration of fresh and cured fish, rancidity problems, mould spoilage of intermediate and high moisture products or oxidative flavour changes. O_2 scavenging concepts are mainly based on iron powder oxidation, ascorbic acid oxidation, photosensitive dye oxidation, enzymatic oxidation (e.g. glucose oxidase and alcohol oxidase), unsaturated fatty acids (e.g. oleic or linolenic acid), rice extract or immobilized yeast on a solid substrate. Structurally, the oxygen scavenging component of a package can take the form of a sachet, label or film (incorporation of scavenging agent into the packaging film, which avoids the accidental consumption of sachet), card, closure liner or concentrate.

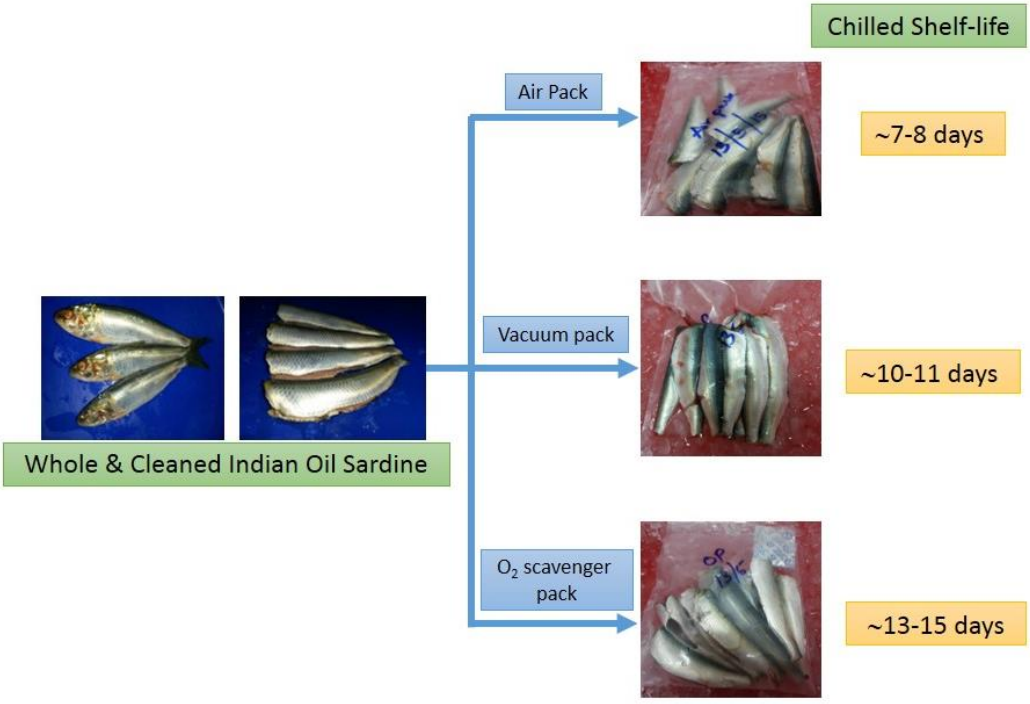


Figure 1. Schematic representation of Influence of active packaging on the shelf life of Indian Oil sardine

CO_2- emitter

The method of preserving food products using CO_2 is not new. Modified atmosphere packaging which mainly employs the gases like CO_2, N_2 and O_2 has been in use for extending the freshness of fish products since many decades. The high CO_2-levels (10-80%) are desirable for moist food products like fish, shellfish and meat products which inhibit surface microbial growth and thereby extend shelf-life. The overall effect of CO_2 is to increase both the lag phase and the generation time of spoilage microorganisms. Over the years this has been achieved by modified atmosphere packaging, in which a package is flushed with a mixture of gases including carbon dioxide at sufficient levels. However the concentration of CO_2 within the package will change due to the partial dissolution of CO_2 in to the product and permeability through the packaging film. Normally, the permeability of carbon dioxide is

3–5 times higher than that of oxygen in most plastic films, so it must be continuously produced to maintain the desired concentration within the package. A carbon dioxide generating system can be viewed as a technique complimentary to MAP to overcome the drawbacks. The potential of CO_2 in MAP and more recently generation of CO_2 inside the packaging system have been explored in relation to a number of commodities for their successful preservation. Such systems are based on sodium bicarbonate, ferrous carbonate, ascorbate, citric acid etc. Sodium bicarbonate, when used together with ascorbic acid or citric acid in the presence of sufficient moisture generates CO_2. This technique is very simple and economical as it does not require any costly equipment and pure gases.

Moisture regulator

Wet food has a high vapour pressure, and hence the humidity in the food package increases. Apart from this a certain amount of moisture will be trapped in the packaging due to temperature fluctuations in high equilibrium relative humidity food packages or the drip of tissue fluid from cut fish and fish products. If it is not removed, this moisture will be absorbed by the product or condense on the surface, which cause microbial spoilage and/or low consumer appeal. An excessive level of water causes softening of dry crispy products. On the other hand, excessive water evaporation through the packaging material might result in desiccation of the packed foodstuffs. It may also favour rancidity of lipids. The controlling of this excess moisture in food package is important to lower the water activity of the product, thereby suppressing microbial growth and preventing foggy film formation. Apart from this, removal of drip from chilled fish and melting water from frozen fish and shellfish makes the package more attractive to the consumer. An effective way of controlling excess water accumulation in a food package is the use of high barrier film material with the appropriate water vapour permeability and use of moisture scavenger, such as silica gel, molecular sieves, natural clays, calcium oxide, calcium chloride and modified starch etc. Among these, silica gel is the most widely used desiccant because it is not toxic and non-corrosive. Drip-absorbent sheets for liquid water control in high a_w foods such as fresh fish and shellfish basically consist of a super absorbent polymer in between two layers. Large sheets are also used for absorption of melted ice in packages of seafood during air transportation. The preferred polymers for absorbing water are polyacrylate salts and graft copolymers of starch. For dried fish applications, desiccants such as silica gel, molecular sieves, CaO and natural clays (e.g. montmorillonite) packed in sachets can be used.

Antimicrobial packaging

Major part of the fish spoilage is attributed to the microbial contamination and subsequent growth which reduces the shelf life of foods and increases the risk of food borne illness. Traditional methods of preserving fish from the effect of microbial growth include thermal processing, drying, freezing, refrigeration, irradiation, MAP and addition of antimicrobial agents or salts. However, some of these techniques cannot be applied to fresh fish products as they alter its fresh nature. Antimicrobial packaging is a fast developing active packaging especially for fish and meat products. Since microbial contamination of these products occurs primarily at the surface, due to post-processing handling the use of antimicrobials either by spray or dip treatment and more recently using antimicrobial packaging can be advantageous to improve safety and to delay spoilage. The principle action of antimicrobial films is based on the release of antimicrobial entities into the food which extends the lag phase and reduce the growth phase of microorganisms in order to prolong shelf life and to maintain product quality and safety. To confer antimicrobial activity, antimicrobial agents may be coated, incorporated, immobilised or surface modified onto package materials. Promising active packaging systems are based on the incorporation of

antimicrobial substances in food packaging materials in order to control undesirable growth of microorganisms on the surface of food. The antimicrobial compound embedded into the polymer acts by two different kinds of mechanisms. In the first method, the preservative is covalently immobilized into the polymer matrix and acts directly from the film when the food is brought in contact with the active material. Regarding the latter, the preservative is embedded into the matrix in the dry state. When the active material is brought in contact with a moist food or a liquid-like food, the preservative is released from the material and acts directly. In both cases the aim of the system is to extend the shelf life of the packaged foodstuff, inhibiting the microbial growth and preserving its properties. The classes of antimicrobials range from acid anhydride, alcohol, bacteriocins, chelators, enzymes, organic acids and polysaccharides. Apart from these, various plant derivatives and derivatives from fishery waste like chitosan can be incorporated into the packaging system as antimicrobials.

Antioxidant release

Antioxidants are widely used as food additives to improve oxidation stability of lipids and to prolong shelf-life, mainly for dried products and O_2-sensitive foods such as fishes as they contain highly unsaturated fatty acids. Antioxidants can also be incorporated into plastic films for polymer stabilization in order to protect the films from degradation. Incorporation of butylated hydroxytoluene (BHT) into the packaging film as an antioxidant is widely practiced. However, there has been some concern regarding the physiological effects of consuming BHT due to its tendency to accumulate in human adipose tissue. Hence, the use of synthetic antioxidants in contact with foods is decreasing. It is therefore desirable to use natural and harmless antioxidants. Vitamins E and C are the common natural antioxidants, and their incorporation in polymer films to exert antioxidative effects is still at the experimental stage. Vitamin E is stable under processing conditions and has an excellent solubility in polyolefins. Apart from these, natural antioxidants extracted from plant and animal substances and their use as antioxidant packaging is under experimental stages.

Active packaging systems with dual functionality

A more sophisticated way of extending the shelf life of packaged foods with active packaging systems is to use multiple function active systems. For example, the combination of oxygen scavengers with carbon dioxide and/or antimicrobial / antioxidant releasing systems significantly improves the storage stability of packaged foods. In the packages with O_2 scavenger alone, the removal of oxygen from the package creates a partial vacuum, which may result in the collapse of flexible packaging. Also, when a package is flushed with a mixture of gases including carbon dioxide, the carbon dioxide dissolves in the product creating a partial vacuum and certain amount of CO_2 permeates through the packaging film. But relatively high CO_2 levels are necessary in order to inhibit surface microbial growth and to extend the shelf life. In such cases, the self-working systems, which absorb O_2 and generate sufficient volume of CO_2 will be promising in extending the shelf life of foods particularly fishery products. ICAR-CIFT has developed the technologies for these active packaging systems to be adopted in different food systems to enhance the shelf-life.

Intelligent Packaging

Intelligent packaging senses some properties of the food it encloses or the environment in which it is kept and inform the manufacturer, retailer and consumer of the state of these properties. Although it is distinctly different from the active packaging concept, features of intelligent packaging can be used to check the effectiveness and integrity of active packaging systems. Intelligent packaging has been defined as '*packaging systems which monitor the condition of packaged foods to provide information about the quality of the packaged food*

during transport and storage'. Smart packaging devices, which may be an integral component or inherent property of a foodstuff's packaging, can be used to monitor a plethora of food pack attributes. A variety of indicators such as temperature, time-temperature, pack integrity, microbial growth, product authenticity and freshness are of interest to the fish packaging industry.

Time-temperature indicators

The basic idea behind this indicator is that the quality of food deteriorates more rapidly at higher temperature due to biochemical and microbial reactions. Operation of TTIs is based on mechanical, chemical, electrochemical, enzymatic or microbiological change usually expressed as a visible response in the form of a mechanical deformation, colour development or colour movement. The visible response thus gives a cumulative indication of the storage temperature to which the TTI has been exposed. Essentially TTIs are small tags or labels that keep track of time-temperature histories to which a perishable product like fish is exposed from the point of production / manufacture to the retail outlet or end-consumer. Their use in fish and shellfish products offers enormous potential where monitoring of the cold distribution chain, microbial safety and quality are of paramount importance. Hence, a time-temperature indicator or integrator (TTI) may be defined as a small measuring device that shows a time and temperature dependent, easily, accurately and precisely measurable irreversible change that reflects the full or partial temperature history of a food product to which it is attached.

Leakage indicator

The development of improved methods to determine food quality such as freshness, microbial spoilage, oxidative rancidity or oxygen and/or heat induced deterioration is extremely important to food manufacturers. In order to maximise the quality and safety of foodstuffs, prediction of shelf-life, based on standard quality control procedures is normally undertaken. Replacement of such time-consuming and expensive quality measurements with rapid, reliable and inexpensive alternatives has lead to greater efforts being made to identify and measure chemical or physical indicators of food quality. Determination of indicator headspace gases provides a means by which the quality of a fish and meat product and the integrity of the packaging in which it is held can be established rapidly and inexpensively. One means of doing so is through the intelligent packaging incorporating gas sensor technology for sensing the oxygen and CO_2, as these two are the most commonly used gases. The monitoring of these gases in the package helps in establishing the food quality. The profiles of oxygen and carbon dioxide can change over time and are influenced by product type, respiration, packaging material, pack size, volume ratios, storage conditions, package integrity etc. A number of analytical techniques are available to monitor gas phases in MAP products. Instrumental techniques such as GC and GC/MS require breakage of package integrity and are time-consuming and expensive. Portable headspace oxygen and/or carbon dioxide gas analysers use 'minimally destructive' techniques (packages can be re-sealed) but tend not to be applicable to real-time, on-line control of packaging processes or large scale usage. An optical sensor approach offers a realistic alternative to such conventional methods. They can be used as a leak indicator or to verify the efficiency of O_2- scavenger, CO_2 emitter or MAP systems. Most of these indicators assume a colour change as a result of a chemical or enzymatic reaction. The most common redox dye used for leak indicators is methylene blue.

Freshness indicators

An ideal indicator for the quality control of packaged food products should indicate the spoilage or lack of freshness of the product, in addition to temperature abuse or package leak.

The information provided by intelligent packaging systems on the quality of food products may be either indirect (e.g deviation from storage temperature and changes in packaging O_2/CO_2 concentration may imply quality deterioration through established correlation) or direct. These freshness indicators are based on the detection of volatile metabolites produced during ageing of foods, such as CO_2, diacetyl, amines, ammonia and hydrogen sulphide. Freshness indicators provide direct product quality information resulting from microbial growth or chemical changes within a food product. Microbiological quality may be determined through reactions between indicators included within the package and microbial growth metabolites. The chemical detection of spoilage of fish and the chemical changes in fish during storage provide the basis for which freshness indicators may be developed based on target metabolites. Total volatile nitrogenous compounds and biogenic amines such as histamine, putrescine, tyramine and cadaverine have been implicated as indicators of fish product decomposition. As the biogenic amines are toxic compounds and they cannot be detected sensorily, the development of effective amine indicators would be beneficial. Hydrogen sulphide, a breakdown product of cysteine, with intense off-flavours and low threshold levels is produced during the spoilage of fish and shellfish by a number of bacterial species. It forms a green pigment, sulphmyocin, when bound to myoglobin and this pigment can be used as a basis for the development of a freshness indicator in red meat fishes. Normally, the freshness indicators are incorporated into the packaging film, which reacts with volatile amines and other indicating agents produced during the storage of fish and other seafoods, and the freshness is indicated by a colour change.

Future prospects

Smart packaging systems contribute to the improvement of food safety and extend the shelf-life of the packaged foods. However these are evolving technologies in the seafood area and many of these systems are in the developmental stage. Continued innovations in active and intelligent packaging are expected to lead to further improvements in food quality, safety and stability.

References:

1. Ahvenainen, R., 2003. Active and intelligent packaging: An introduction. *In:* Novel food packaging techniques (ed. Ahvenainen, R.). Cambridge, UK: Woodhead Publishing Ltd., pp. 5–21.
2. Brody, A. L., 1989. Modified atmosphere packaging of seafoods. *In*: Controlled / Modified Atmosphere / Vacuum Packaging of Foods (ed. Brody, A. L.). Food & Nutrition Press, Trumbull, CT, pp. 59-65.
3. Brody, A. L., Strupinsky, E. R. and Kline, L. R., 2001. Active Packaging for Food Applications. Technomic Publishing Company, Pennsylvania.
4. Vermeiren, L., Devlieghere, F., Van Beest, M., De Kruijf, N. and Debevere, J., 1999. Developments in the active packaging of foods. *Trends Food Sci. Technol.*, 10(3): 77-86.

Chapter 17

Entrepreneurship opportunities in fishery products

Dr. George Ninan
Principal Scientist, Fish Processing Division, ICAR-CIFT
George.Ninan@icar.gov.in

Introduction

Fish is a source of valuable animal protein and is now considered a health food. This has resulted in increased consumer demand. Fish is now more expensive than meat and other animal foods. Being a highly perishable commodity, fish require immediate processing and various options are available for the value addition of fish. Fish processing, particularly seafood processing and marketing have become highly complex and competitive and exporters are trying to process more value added products to increase their profitability. Value can be added to fish and fishery products according to the requirements of different markets. These products range from live fish and shellfish to ready to serve convenience products. In general value-added food products are raw or pre-processed commodities whose value has been increased through the addition of ingredients or processes that make them more attractive to the buyer and/or more readily usable by the consumer. It is a production/marketing strategy driven by customer needs and perceptions.

Freezing represents the main method of processing fish for human consumption; it accounted for 56 % of total processed fish for human consumption and 27 % of total fish production in 2016 (FAO, 2018). Post-harvest losses of fish account for about 35% of the total global fish production (Gustavsson et al., 2011). According to the recent statistics, the annual capture and culture-based fish production in India is around 90, 00000 MT. Seafood export sector is one of major foreign exchange earner in India. In 2019-20, India has exported 1,28,9651 MT of Seafood worth Rs.46,663 crores. USA and South East Asia are continued to be the major importers of Indian seafood. Frozen Shrimp continued to be the major export item followed by frozen fish . Marketing of value-added products is completely different from the traditional seafood trade. It is dynamic, sensitive, complex and very expensive. Market surveys, packaging and advertising are a few of the very important areas, which ultimately determine the successful marketing of a new product. Most of the market channels currently used is not suitable to trade value added products. A new appropriate channel would be the super market chains which procure directly from the source of supply of the products and control most of the components of production and supply chain like packaging, advertising and retail marketing. Appearance, packaging and display are all important factors leading to successful marketing of any new value added product. The retail pack must be clean, crisp and clear and make the contents appear attractive to the consumer. The consumer must be given confidence to experiment with a new product launched in the market. Packaging requirements change with product form, target group, market area, species used

and so on. The packaging technology needs to be evolved which should be attractive, convenient and adding to the shelf life of the processed products.

Technology developments in fish processing sector offer scope for innovation, increase in productivity, increase in shelf life, improve food safety and reduce waste during processing operations. A large number of value added and diversified products both for export and internal market based on fish, shrimp, lobster, squid, cuttlefish, bivalves etc. have been identified (Ninan & Ravishankar,2018). However, the commercialisation of fish products still pose lot of challenges to the entrepreneur and researcher in terms of optimization of technologies and ultimately developing the technologies into a commercially viable business plan.

The Indian Council of Agricultural Research (ICAR) is the apex public research organization which has been playing a key role in the innovation processes concerning agriculture in the NARES system. ICAR harnesses and synergizes the innovative research mechanism and business support ecosystem by utilizing the efficient scientific manpower and vast resources. This ensures the efficient utilization of innovative technologies, processes and products, thus leading to significant enhancement of the Agri-economic system as a whole. As part of this drive and to ensure dissemination/commercialization of its research outcomes and knowledge base, ICAR created an institutional mechanism connecting its 101 Research & Development (R&D) institutes, serving diversified fields like fisheries, horticulture, crop science, animal science and natural resource management. This chain of Agri Business Incubation (ABI) centres across India, became one of the successful initiatives of ICAR, where scientific knowledge is translated into innovation led commercial ventures developing market-driven products (ICAR, 2006).

Constitution of Intellectual Property and Technology Management (IPTM) Division at Headquarters, and integration of aspects of intellectual property rights (IPR) in the technology management of R&D institutions was the initial step taken by ICAR (ICAR, 2014). The IPTM division formulated the guidelines for Intellectual Property Management and Technology, and created a decentralized 3-tier IPR and technology management mechanism. The implementation of these guidelines helped in the systematic organization of IPR filings and commercialization intellectual assets developed by its research institutes catering to diverse and specialized fields of agriculture (ICAR, 2018).

Taking into consideration the vast potential of the fisheries sector and the needs to promote techno-entrepreneurship among fishermen community, ICAR started India’s first fisheries Business Incubation Centre at ICAR-Central Institute of Fisheries Technology, Kochi, Kerala, for establishing sustainable businesses in fisheries and allied agricultural fields. The role of the Agri-Business Incubation Centre (ABI) is to facilitate the innovator and the researcher to turn their ideas into commercial ventures with focus on incubation and business development programme, including entrepreneurship, skill development and Grassroot innovators activities. Numerous technologies have been transferred by the Institute through this incubation mechanism and one of them is the technology for Hybrid Solar Dryers. The technology achieved so much popularity due to its economic feasibility and easy adoption by fishers, micro, small and medium scale entrepreneurs and women Self Help Groups (SHG). This technology goes in tandem with the flagship programmes of the Government of India such as Atma Nirbhar Bharat, Swatch Bharath and National Mission for Green India. It effectively contributes to the country’s commitment in reducing carbon emission, and aids in improving the livelihood of fishermen community by assuring returns even during off-season period.

Health benefits of fish

As a rich source of nutrients, fish provide a good balance of protein, vitamins and minerals, and a relatively low caloric content. In addition fish are excellent sources of Omega-3 polyunsaturated fatty acids which appear to have beneficial effects in reducing the risk of cardio- vascular diseases and are linked with positive benefits in many other pathological conditions particularly, certain types of cancer and arthritis.

Fish represents an excellent option as a major source of nutrients. On a unit caloric basis fish can provide a broad range of nutrients. A high intake of fish is compatible with a reduction of both calorie and saturated fatty acid intakes. Coronary heart disease, hypertension, cancer, obesity, iron deficiency, protein deficiency, osteoporosis and arthritis are contemporary health problems for which fish provide a number of nutritional advantages and some therapeutic benefits. Nutritional factors of importance are calories, proteins, lipids, cholesterol, minerals and vitamins.

Conventional finfish and fishes potentially provide from 100 to 200 kcal/100g, which is mainly attributed to the protein and fat contents of fish. The amount of carbohydrates in fish is very small. Finfish usually contains less than 1% carbohydrate whereas shellfish have very low fat content. Compared to other muscle food, they contribute very low fat calories to the average diet. For example, each gram of fish muscle provides only 0.05 – 0.2g of fat compared to 0.25 – 0.5 fat per gram of red meat. The most important constituent of fish muscle is protein. The protein content in fish varies from 17 to 25%, though values as low as 9% are sometimes encountered as in the case of Bombay Duck. Fish protein is highly digestible because of very low stroma protein and has an excellent spectrum of essential amino acids. Like milk, egg and mammalian meat proteins, fish protein has a high biological value. Cereal grains are usually low in lysine and/ or the sulfur containing amino acids, whereas fish protein is an excellent source of these amino acids. In diets based mainly on cereals, fish as a supplement can, therefore, raise the biological value significantly.

Fish oil contains primarily the Omega -3 series of fatty acids. The polyunsaturated components of fish lipids can be effective in reducing plasma lipids. Epidemiological data from Japan and the Netherlands indicate that frequent consumption of fish even in quantities as low as 30g/ day may have beneficial effects in reducing heart disease. Consumption of medium (100g) to large amounts especially triglycerides, prevent thrombosis and ameliorate ischemic heart disease. These effects are mediated by the Omega -3 PUFA of fish lipids which alter the production of certain biologically important components called eicosanoid. The efficiency of the Omega -3 PUFA components is influenced by the amount ingested and the concentration of other unsaturated fatty acids in the diet, especially Omega -6 PUFA. Squalene, an isoprenoid molecule present in shark liver oil in higher quantities, has been reported to possess antilipidemic, antioxidant and membrane stabilizing properties. Fish and shellfish, particularly anchovies, clams, oysters and sardines are rich sources of vitamin B 12.

Fish consumption is compatible with optimum dietary practices / recommendations and that substitution of fish for other foods can help to maintain a balanced nutrient intake compatible with a low-fat consumption. In addition, the consumption of fish- or more precisely, fish lipids – may provide significant health benefits.

Entrepreneurship Initiatives in Fisheries Sector

Fisheries sector with its important role played in the socio-economic development of the country has become a powerful income and employment generator, and stimulates the

growth of a number of subsidiary small, medium and large-scale industries. In order to translate the research results arising from the field of fisheries and other agricultural sectors, ICAR have set up an innovation-based Agri Business Incubation Centre (ABI) at the ICAR-Central Institute of Fisheries Technology (CIFT), Cochin. ABI aims at establishment of food business enterprises through IPR enabled ICAR technologies.

ABI supports operations on business projects as a measure of enhancing the foundation for new technology based industries and establishing a knowledge-based economy. It focuses on finding new ways of doing business in fisheries and allied agricultural fields by finding doors to unexplored markets. The Centre helps prospective entrepreneurs, by providing pro-active and value-added business support in terms of technical consultancy, infrastructure facility, experts' guidance and training to develop technology based business ideas and establish sustainable enterprises. It acts as a platform for the speedy commercialization of the ICAR technologies, through an interfacing and networking mechanism between research institutions, industries and financial institutions. The Incubator at ICAR-CIFT differs from traditional Business Incubators as it is tailored specifically for technology based industries and is operational at an area with a high concentration of fish production. This industry-specific incubator also allows new firms to tap into local knowledge and business networks that are already in place. BIC offers their services to industries not only in Cochin, but also all over India through virtual incubation. Beyond promoting business growth, the Centre is also trying to bring its benefits to all the fisheries communities in India.

This unique Business Incubator is now known as a "One Stop Shop", where entrepreneurs can receive pro-active, value-added support in terms of technical consultancy, and access to critical tools such as entrepreneur ready technologies, vast infrastructure and other resources that may otherwise be unaffordable, inaccessible or unknown. With the aim of transforming the incubator into a symbol of entrepreneurship and innovation, the ABI Unit has created an environment for accessing timely scientific and technical assistance and support required for establishment of technology based business ventures. The activities of the ABI Unit focuses on finding creative and innovative ways for linking public sector resources and private sector initiatives within and across regional and national boundaries for promoting economic growth. The Centre uses the right expertise in relevant fields to identify and analyze the constraints and barriers hindering the growth of a business, and devise appropriate strategies. It explores the various structures and strategies to help small enterprises to grow and ensure a promising future in the global market. It fosters corporate and community collaborative efforts, while nurturing positive government-research-business relationships.

Process of Incubation

The Business Incubation Centre targets entrepreneurs, from fledgling start-ups in need of basic small scale processing capacity to sophisticated businesses in need of R&D back up, office infrastructure and pilot / test market processing facility for the development of new products. It possesses good infrastructure facilities suitable for providing direct incubation of nine entrepreneurs in a corporate environment within the premises of ICAR-CIFT, at a time. The purpose of direct incubation is to support emerging companies through their infancy. ABI apart from being a multi-tenant facility with on-site management that delivers an array of entrepreneurial services to clients operating with the facility, it also serves clients that are not located in the facility through virtual incubation or incubation without walls.

The Centre regularly conducts industry interface and technology promotional programmes for sensitization of entrepreneurs and to identify interested potential candidates for physical and virtual incubation. The Clients at ABI gets the privilege of meeting Scientists, Business Manager and Business Associates directly, to discuss and finalise the strategies to be adopted to take the business forward. It is also the peer-to-peer relationships that develop within the incubator, that ensures the delivery of basic services such as how to actually incorporate a business; what are the legal issues; how to take intellectual property protection; how to do basic accounting and cash flow; how to do business presentations etc. Those kinds of skills are what are transmitted as part of the incubation process.

The residency period for direct incubatees is normally for two years, extendable by another year in special cases, depending on the progress of incubation. As the business venture becomes mature enough, the concessions and the facilities provided to the incubatee companies will be gradually withdrawn. Each incubatee of the Unit will have to pay to the Institute a charge for utilization of space, at a rate concessional to the benchmark rate which is the prevailing market rent realizable. Incubatee mentoring will continue in virtual mode after graduation, on need basis.

Services and facilities offered by ICAR-CIFT Business Incubator

The Centre through its business support services provides links to supporting industries; upgrade technical / managerial skills; provide scientific / technical know-how; assist in market analysis, brand creation and initial test marketing; protect IP assets; and find potential investors and strategic partners.

Fig. Techno-entrepreneurial support system of ABI (Arakkal et al,2020)

Incubation facilities under one roof are:

- Furnished office suites within the premises of ICAR-CIFT, with shared facilities like secretarial assistance, computing, copying, conferencing, video conferencing, broad band internet and communication services.
- Pilot level production lines
- Culinary facility
- Access to modern laboratory facilities for product testing and quality control
- Access to well-equipped physical and digital libraries

Pilot Level Production Lines

A state-of-the-art generic semi-commercial production facility is made available to incubating entrepreneurs for developing value added products from fish. BIC provides access to these facilities along with support of manpower, and assists the entrepreneurs in production and testing of new product formulations. For the tenants, the pilot plant is an ideal testing arena to determine the commercial viability of new products. The plant also serves as a process lab, a place to see how processing equipment impacts food products under varying conditions. There are production lines for pre-processing, cooking, retort pouch processing, canning, sausage production, extruded products, chitin & chitosan, smoking, curing & drying, breading & battering and product packaging. By providing access to these resources, the Centre greatly reduces one of the major barriers to the commercialization of institute technologies by smaller firms - the high capital cost of intermediate or large scale process equipment.

Business Services

The business oriented services offered by BIC include assistance in complying with business regulations and licensing procedures, financing, information services, marketing, and tailor-made services designed for the various tenant enterprises. Incubator clients can also gain special advantage in terms of tax savings through special regulations for Business Incubators. BIC also offers a wide variety of services, with the help of strong associations throughout the Business Incubation Network

Conclusion

Fish processing and value addition has evolved over the years as the sunrise sector in Agriculture domain. Globally many new species are being introduced in the Aquaculture sector. A comprehensive study on the suitability of these species for value addition has to be carried out to propose optimized utilization protocols. Functional fish products will be in much demand in future; the challenge will be to retain the functional benefits of fish & shellfish meat by way of adopting product specific processing protocols or alternate delivery systems for sensitive components. These issues offer ample scope for Innovation coupled with entrepreneurial skills for the creation of wealth and employment in fisheries sector.

References

1. Arakkal, R.M., Samuel, M.P., Ninan, G. & Nagarajarao, R.C. (2020). Institutional Innovations for Management and Commercialisation of Fishery Technologies in India - A

Case Study. Journal of Research Management & Governance, 3(1), 18-35. Retrieved from https://ejournal.um.edu.my/index.php/JRMG/article/view/21789

2. FAO (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

3. George Ninan & Ravishankar C.N (2018) Entrepreneurship Ventures in Fish Processing. In: Entrepreneurship Development in Food Processing (Sudheer K.P & Indira V Eds.), New India Publishing Agency, New Delhi, pp 269-290.

4. Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. (2011). Global food losses and food waste – extent, causes and prevention. Study conducted for the International Congress Save Food! Düsseldorf, Germany, 16–17 May 2011. Rome, FAO

5. Indian Council of Agricultural Research (ICAR). (2006). ICAR Guidelines for Intellectual Property Management, Technology Transfer and Commercialization. Indian Council of Agricultural Research, New Delhi, India.

6. Indian Council of Agricultural Research (ICAR). (2014). ICAR Rules and Guidelines for Professional Service Functions. Indian Council of Agricultural Research, New Delhi

7. Indian Council of Agricultural Research (ICAR). (2018). ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization. Indian Council of Agricultural Research, New Delhi.

Chapter 18

Quality assessment of fishery products: Notified NABL labs, Referral Labs and Reference Labs in India for fishery products

Dr. A.A. Zynudheen and Dr. S. Remya
Quality Assurance & Management Division, ICAR-CIFT
Email: zynu@rediffmail.com

Demand for seafood has consistently increased during recent years with fish protein being the major animal protein consumed in many parts of the world. According to the Food and Agriculture Organization, fresh seafood represents 40.5 % of the world's seafood production, while processed products (frozen, cured, canned, etc.) represent 45.9 %. To assure the quality of raw material used for processing, fish has to be treated carefully before and after harvest. The quality assessment of fish and other seafood is hampered by the immense variation between species and by the considerable variability between specimens of each species. The challenge, when assessing aquatic animals is that immediately after capture or harvest an alteration in intrinsic properties is initiated firstly by metabolic (autolytic) and secondly by microbiological processes, which last until the final state of spoilage is reached. Several analytical methods (chemical, physical, microbiological and sensory) can be used to determine spoilage depending on its state.

Freshness and quality of seafood

Freshness is the major attribute on quality of fish and of fishery products. For all kinds of products, freshness of the raw material used for processing is essential for the overall quality of the final product. It is impossible to process a high-quality product from raw material with poor freshness characteristics. Besides freshness, many other parameters also contribute to the complex quality of a seafood-based product such as the sensory properties (taste, odour, texture, appearance); the availability/disposability over a long time period; the safety; desired convenience characteristics; appealing packaging, colours and pictures; an attractive price; consistency, uniformity and conformity with standards and legislation; nutritional properties; ethical (stunning and slaughter); and ethnic (halal, kosher) constraints.

Indicators for freshness determination of fish

The properties, which wet fish in ice (fresh, unprocessed, not frozen) should have, when regarded as perfect fresh, can be considered as freshness indicators.

Rigor mortis: Fish regarded as fresh should be pre-rigor, in rigor or should just have passed rigor; it must be 'new', meaning that the time passed between harvesting or catch and marketing (auction) and consumption or processing into final products (including freezing) should be as short as possible.

Sensory quality: The sensory assessment of a cooked sample of the edible part should give high scores for all attributes – appearance, flavour, odour, taste, colour and texture.

Volatiles: The concentrations of basic volatiles like trimethylamine (TMA), dimethylamine (DMA) or total volatile basic nitrogen (TVB-N) are low, and that of trimethylamine oxide (TMAO) is high. Fresh odours (of plants, cucumber and mushroom character) are high in concentration whereas spoilage odours (amines) are insignificant; typical fishy odour is lacking.

Physical methods: The pH is clearly below 7.0 and the impedance measured is high. The microstructure is intact. Mechanical properties of fresh fish are commonly measured post rigor. Elasticity decreases and flesh is softening.

Microorganisms: Only a few microorganisms are present on skin and gills, the muscle is sterile; the proportion and activity of specific spoilage bacteria in microbiological flora determines remaining shelf life (freshness).

ATP and ATP breakdown products: k-value should be low. k-value increases with time.

Proteins: Low proteolysis rate in proteins.

Lipids: The muscle is in a status, where lipid oxidation is inhibited.

Fish spoilage

Seafood deteriorates very quickly due to various spoilage mechanisms. Spoilage can be caused by the metabolic activity of microorganisms, endogenous enzymatic activity (such as autolysis and the enzymatic browning of crustaceans' shells) and by the chemical oxidation of lipids.

- Self-digestion by enzymes (Autolytic changes)
- Bacteria (Microbial changes)
- Oxidation & hydrolysis (Chemical changes)

Seafood flesh has a high amount of non-protein nitrogenous (NPN) compounds and a low acidity (pH > 6), which support the fast growth of microorganisms that are the main cause of spoilage. The growth and metabolic activity of the spoilage microorganisms, especially specific spoilage organisms (SSOs), result in the production of metabolites that affect the organoleptic properties of the product. Immediately following death, autolysis resulting from the action of endogenous enzymes, initially causes loss of the characteristic fresh odour and

taste of fish and then softens the flesh. The main changes that take place are initially the enzymatic degradation of adenosine triphosphate (ATP) and related products and subsequently the action of proteolytic enzymes. Enzymes are also responsible for colour changes. Chemical oxidation of lipids (oxidative rancidity) is one of the most important spoilage mechanisms, especially in fatty fish.

Quality assessment of seafood by chemical methods

The traditional methods, which have been using for evaluating the quality of seafood are as follows.

1. **TMA & TVB-N**: Formation of amines increases when spoilage microorganisms have entered the muscle tissue and microbial degradation of low-molecular substances and proteins starts. Depending on the fish species and on the storage temperature, it takes about 10 days before microbial action on muscle tissue leads to an increase of amines. From this point on, amine formation follows an exponential function and can be used as a measure for spoilage. TVB-N is still the most frequently used method for quality assessment of fish. Conway's microdiffusion method is the routine method used for checking the TMA and TVB-N limit.
2. **Biogenic amines/Histamine**: Histamine, putrescine, cadaverine, tyramine, tryptamine, β-phenylethylamine, spermine and spermidine are the most relevant biogenic amines in seafood. Quality assessment using biogenic amines content such as histamine, cadaverine, putrescine and agmatine was reported by many researchers. Histamine is determined by HPLC method/Spectroflurometric method.
3. **Indole**: Spectroflurometric/ Spectrophotometric method
4. **Hypoxanthine**: HPLC method/Enzyme immobilization technique
5. **K-value**: The extent of breakdown of ATP (adenosintriphosphate) and related products was expressed as K-value, defined as a percentage of the amount of inosin and hypoxanthin to the total amount of ATP-related compounds. HPLC method is used for K-value determination.
6. **Peroxide value**: Iodimetric titration
7. **TBA value**: Steam distillation/Spectrophotometric method

Physical and Instrumental methods for assessing seafood quality

1. Freshness meter: E.g., Torry meter, Intelectron fish tester. As Fish tester and Torry meter measurements are based on the existence of intact cell membranes, they fail when the cells are disrupted or broken (damage, bruising, frozen/thawed fish).
2. Texture measurement: Texturometers/ Universal testing machines
3. Colour determination: Colourimeter
4. pH: Measuring pH in an aqueous muscle homogenate or using an injection electrode directly in the muscle tissue is the simplest method for quality assessment of seafood. A general rule is that when a pH of 7.0 in fish muscle is reached or exceeded, the borderline of edibility is reached though it is considered by many as not a good indicator of freshness and/or spoilage.

Microbial methods for assessing seafood quality

- Determination of total bacterial count
- Determination of specific spoilage bacteria
- Determination of pathogenic bacteria

Sensory quality assessment

At present, the commonly used methods of sensory evaluation include Quality Index Method (QIM), Tasmanian Food Research Unit schemes, and the Torry schemes. Among them, QIM is the most commonly used, which is based on objective assessment of some attributes of raw fish.

Novel Methods for fish quality assessment

1. **Biosensors**
    - Amine gas sensor: Detect the volatile amine gas (ammonia, TMA and DMA) in a short time (60 s) from raw fish flesh
    - Electronic nose: Most widely used technique are based on metal oxide gas sensor
2. **Spectroscopic techniques**
    - Visible/near-infrared (Vis/NIR) spectroscopy: Analyse food quality due to the interaction between food components and electromagnetic radiation emitted from lights

Quality control programmes

The traditional quality control program was based on establishing effective hygiene control. Confirmation of safety and identification of potential problems was obtained by end-product testing. Control of hygiene was ensured by inspection of facilities to ensure adherence to established and generally accepted Codes of Good Hygiene Practices (GHP) and of Good Manufacturing Practices (GMP). Below are listed the most well-known methods to manage quality and/or safety.

- Good Hygienic Practices (GHP) / Good Manufacturing Practice (GMP) or Sanitation Standard Operating Procedures (SSOP) or prerequisite programmes
- Hazard Analysis Critical Control Point (HACCP)
- Quality Assurance (QA) / Quality Management (QM) - ISO standards
- Total Quality Management (TQM)

Food Safety and Standards Authority of India (FSSAI): Ensuring food quality

The Food Safety and Standards Authority of India (FSSAI) was established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science-based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption. Various central acts including the erstwhile Prevention of Food Adulteration Act (1954) were merged under this act. Ministry of Health & Family Welfare, Government of India is the governing Ministry of FSSAI. It has the main Headquarters in Delhi.

The FSSAI is responsible for maintaining the food quality & security in India. FSSAI role in food quality is crucial for food security. The FSSAI's role in food quality is to ensure safety and providing satisfaction to every customer. Food Testing and analysis is an essential part of the food safety ecosystem to assure that the food is safe to consume. For the same, FSSAI recognizes and notifies NABL accredited food laboratories under Section 43 of FSS Act, 2006. FSSAI approved notified laboratories as National Reference Laboratories (NRLs) and as ancillary facility of NRLs (ANRLs) for specific purpose.

1. **Primary food laboratories**: The Food Authority notifies food laboratories and research institutions accredited by National Accreditation Board for Testing and Calibration Laboratories or any other accreditation agency for the purposes of carrying out analysis of samples by the Food Analysts. Presently there are 187 notified food testing laboratories.
2. **Referral food laboratories**: The Food Authority recognizes referral food laboratories for the purposes of carrying out analysis of appeal samples. Presently there are 18 referral food laboratories.
3. **National Reference Laboratories**: FSSAI has recognised National Reference laboratory (NRL) to set up a country wide standard for routine procedures, validation of such standard procedure / testing methods, development of new methods and ensuring proficiency in testing across the food laboratories with special reference to the risks or food categories. Either a primary food laboratory or a referral food laboratory can be considered for declaration as NRL. Presently there are 12 NRLs and 2 ANRLs.

FSSAI Notified Referral Laboratories under section 43 (2) of FSS Act, 2006

1. Central Food Laboratory, 3 Kyd Street, Kolkata- 700016
2. Food Safety & Analytical Quality Control Laboratory, C/o Central Food Technological Research Institute, Mysore-570013
3. State Public Health Laboratory, Stav ely Road, Cantonment Water Works Compound, Pune-411001
4. National Food Laboratory, Ahinsa Khand-II, Indirapuram Ghaziabad-201014
5. Indian Institute of Horticultural Research, Hessaraghatta lake post, Bangalore-560089
6. Quality Evaluation Laboratory, Spices Board, Palarivattom P.O. Kochi-682025
7. Quality Evaluation Laboratory, Spices Board, Chuttugunta Center, GT Road, Guntur-522004
8. Quality Evaluation Laboratory, Spices Board, Plot No. R-11, Sipcot Industrial Complex, Gummidipoondi, Thiruvallur Dt., Chennai-601201
9. Quality Evaluation Laboratory, Spices Board, First Floor, Banking complex II, Sector 19A, Vashi, Navi Mumbai-400703

10. Centre for Analysis and Learning in Livestock in Food (CALF), National Dairy Development Board (NDDB), Anand-388001, Gujarat
11. CSIR-Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad - 500007
12. National Research Centre on Meat, Chengicherla, Buduppal, Hyderabad – 500092
13. Indian Institute of Food Processing Technology, Food Safety and Quality Testing Laboratory, Pudukkottai Road, Thanjavur – 613005, Tamil Nadu
14. ICAR- Central Institute of Fisheries Technology, Indian Council of Agricul tural Research, Willingdon Island, CIFT Junction, Matsyapuri P.O., Cochin – 682029, Kerala
15. ICAR-National Research Centre for Grapes, P.O. Manjiri Farm, Solapur Road, Pune - 412307
16. Pesticide Formulation and Residue Analytical Centre, National Institute of Plant Health Management, Rajendranagar, Hyderabad - 500030
17. Punjab Biotechnology Incubator, Mohali SCO7 & 8, Phase-5, SAS Nagar, Mohali 160059, Punjab
18. CSIR-Indian Institute of Toxicology Research, Vishvigyan Bhawan, 31, Mahatma Gandhi Marg, Lucknow - 226 001, Uttar Pradesh, India

Referral Food Laboratory

The Laboratory having competence to carry out the analysis as per "The Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011" and "Food Safety and Standards (Contaminants, Toxins and Residues) Regulations, 2011". In addition, the Referral laboratory must have the competence to meet the following requirements:

- **R & D Capabilities**: Laboratories having documentary evidence for carrying out R&D in food sector
- **Training Facilities**: The laboratory should have training centre for capacity building by way of organizing professional training, workshops and seminars.
- **Other Facilities**

1. Analysis of samples of food sent by any officer or authority authorized by the Food Authority for the purpose and submission of the certificate of analysis to the authorities concerned;
2. Investigation for the purpose of fixation of standard of any article of food;
3. Investigation in collaboration with the laboratories of Food analysts in the various States and such other laboratories and institutions which the Food Authority may approve on its behalf, for the purpose of standardizing methods of analysis.

4. Ensuring that the laboratory follows the scientific protocols laid down for handling/testing the articles of food.
5. Maintaining high standards of accuracy, reliability and credibility in the operation of the laboratory and achieving and maintaining the required levels of accreditation and reliability.
6. Laying down mechanism for ensuring that personnel of the laboratory adhere to high professional standards and discipline.
7. Such other conditions, as the Authority may lay down for Referral Laboratories such as coordinating proficiency testing programmes in the country etc.

Reference Laboratory

The Food Authority may recognise any notified food laboratory or referral food laboratory as a reference laboratory for the purpose of developing methods of testing, validation, proficiency testing, and training.

The reference laboratory shall carry out the following functions, namely

i. be a resource centre for provision of information for certified reference materials and reference materials
ii. develop standards for routine testing procedures and reliable testing methods
iii. provide technical support in the area of competence
iv. evaluate the performance of other notified laboratories
v. coordinate exchange of information amongst notified food laboratories
vi. collaborate for data generation among the network of notified food laboratories and referral food laboratories and collate the data related to their specific domain
vii. such other functions as may be specified by the Food Authority

Criteria for notifying and recognising food laboratories

For being recognised and notified, every food laboratory shall have-

- Accreditation against ISO/IEC 17025 by the National Accreditation Board for Testing and calibration laboratories or such other equivalent accreditation agency as may be approved by the Food Authority.
- Adequate capability and competence for testing of food safety and quality parameters as per the requirements of the Act.
- Person possessing qualification and experience required for being appointed as Food Analyst under rule 2.1.4of the Food Safety and Standards Rule, 2011: Provided that a food laboratory accredited by an accreditation body having authorised signatory designated by such accreditation body, shall also be considered for being notified subject to the condition that such authorised signatory shall, within one year from the date of such notification, acquire the qualification and experience required for being appointed as Food Analyst under the said rule.

- The infrastructure and facilities including equipment required for carrying out the analysis as per the scope applied for.

ICAR-CIFT: National Reference Laboratory for Fish and Fish Products

ICAR-Central Institute of Fisheries Technology, Cochin has been conferred with a status of "National Reference Laboratory (NRL) for Fish and Fish Products" by Food Safety and Standards Authority of India (FSSAI), Ministry of Health and Family Welfare, Govt. of India under Regulation 3 of Food Safety and Standards (Recognition and Notification of Laboratories) Regulation, 2018 on 19th March, 2019 vide Order No. 12013/02/2017-QA. ICAR-CIFT is the only research Institute under SMD (Fishery), ICAR to be adorned with such a high-profile recognition. The Institute had already been notified as National Referral Laboratory vide Government of India Gazette Notification S.O. 97(E) of Ministry of Health and Family Welfare (Food Safety and Standards Authority of India) dated 10th January, 2017.

Under the NRL notification, ICAR-CIFT has earmarked with the following research activities on emerging issues pertaining to:

- Risk assessment of dietary exposure of persistent organic pollutants and emerging contaminants such as brominated flame retardants and pharmacologically active substances to Indian population from fish and fisheries products.
- Research on ingression of specific migration of chemicals from plastic packaging materials to fishery products
- Research on incidence of biotoxins in finfish/shellfis

Presently there are 12 NRLs. Including ICAR-CIFT, seven laboratories in Government sector and five laboratories in private sector have been given the status of National Reference Laboratory in specific areas.

List of national reference laboratories (NRLs) approved by FSSAI

Sl. No.	Name of the laboratory/ institution/organisation	Specific area for which declared as NRL
Government laboratories		
1.	Central Food Technological Research Institute, Mysore	Nutritional information and labelling
2.	Export Inspection Agency, Kochi	GMO (genetically-modified organism) testing (subject to implementation of GMO regulations)
3.	Punjab Biotechnology Incubator, Mohali	Sweets and confectionery, including honey
4.	ICAR-National Research Centre For Grapes, Pune	Pesticide residues and mycotoxins
5.	Central Institute of Fisheries Technology, Kochi	Fish and fish products
6.	Centre for Analysis and Learning in	Dairy and dairy products

	Livestock and Food-National Dairy Development Board, Anand	
7.	CSIR-Indian Institute of Toxicology Research, Lucknow	Toxicological evaluation/risk assessment of nutraceuticals, functional foods and novel/emerging foods/food ingredients
Private laboratories		
8.	Trilogy Analytical Laboratory Pvt. Ltd., Hyderabad	Mycotoxins in cereals and pulses, spices and condiments and related PT activities
9.	Edward Food Research and Analysis Centre Limited, Kolkata	Veterinary drug residues, antibiotics and hormones
10.	Vimta Labs Limited, Hyderabad	Water, alcoholic and non-alcoholic beverages
11.	Fare Labs Pvt. Ltd., Gurugram	Oils and fats
12.	Neogen Food and Animal Security (India) Private Limited, Cochin	Food allergens

Conclusion

Seafood is a very perishable product and the risk of contamination of seafood products by biological hazards is very high. Processing and preservation is necessary to assure the prolonged shelf life and safety of seafood. Increasing demands from legislation and from the consumer for better quality and safer products have to be taken into account. Seafood now has to be high quality, nutritious, safe and have the convenience of an extended shelf life. To meet these criteria, seafood processing had to assimilate all the new advances in food science and technology and in quality and safety assurance. Advanced quality and safety methods, such as modern and rapid techniques for assessing quality and safety, species identification techniques and risk assessment tools, all have significant applications in the seafood sector.

Food testing and analysis is an essential part of the food safety ecosystem to assure that the food is safe to consume. This includes strengthening the network of food testing laboratories, assuring quality of food testing, investing in human resources, carrying out surveillance activities and educating consumers. As an essential part of the food safety ecosystem, the Food Safety and Standards Authority of India has created a network of 232 laboratories to fulfil its mandate on food testing and analysis. The network comprises of 142 accredited primary food-testing laboratories from both government and private sphere, 72 state food testing laboratories and 18 referral laboratories of which two are under the direct control of FSSAI. FSSAI's role in food quality is important for smooth functioning. As a resultant of this, every customer receives an equal level of assurance of food safety.

Reference/Website

1. https://www.fssai.gov.in/
2. https://cift.res.in/national-reference-laboratory
3. Huss, H.H., 1988. *Fresh fish--quality and quality changes: a training manual prepared for the FAO/DANIDA Training Programme on Fish Technology and Quality Control* (No. 29). Food & Agriculture Org..

Chapter 19

FSSAI regulations on packaging and labelling requirements

Dr. Remya S.
Scientist, Scientist, Quality Assurance & Management Division, ICAR-CIFT
Email: remya03cof@gmail.com

Food packaging

Food, the most basic necessity of life, has also developed into a lucrative business. Since people no longer have time to cook due to their busy lifestyles, packaged food is gaining popularity. Proper packaging plays a crucial role in preservation of quality and delivery of safe, wholesome food products to the end user. Packaging has been with humans for thousands of years in one form or the other. Packaging dates back to when people first started moving from place to place. Originally, skins, leaves, and bark were used for food transport. Mesolithic humans used baskets, and neolithic humans used metal containers and discovered pottery. Four thousand years ago, sealed pottery jars were used to protect against rodents, and in 1550 BC, glass making was an important industry in Egypt. Tin-plating iron became possible in AD 1200, and as steel replaced iron this method became useful after AD 1600. In 1825, Oersted first extracted aluminum. More recently, plastics were developed, particularly the first commercial plastics in the United States around 1935–1942. Over the last three decades, packaging has grown in volume and importance into one of the most significant areas of food production.

Purpose of packaging

Packaging is the art and science of encasing food products to safeguard them during distribution, sale, and storage. It is also the process of designing and evaluating packages. Product packaging design not only lends aesthetic appeal, but also helps your products stand out from those of others. Packaging performs five main functions (5Ps): product containment, preservation and quality, presentation and convenience, protection, and provide storage history.

1. **Product containment**: The primary purposes of packaging are containment and protection. Containment refers to holding goods in a form suitable for transport, whereas protection refers to safekeeping goods in a way that prevents significant quality deterioration.

2. **Preservation by maintaining quality**: The second function of packaging is to control the local environmental conditions to enhance storage life and safety.
3. **Presentation and convenience**: It is important to display the product in an attractive manner to the potential buyer. For a package to be effective, it must present the product well and should do its own publicity. In many cases, packaging provides convenience to the consumers. Eating styles, such as ready-to-eat meals, snacks, and microwaveable ready meals, have been changed over the years, which need innovation in packaging. For children, the packaging might represent innovation or fun. Other conveniences could be ease of opening, smaller portions and tamper-proof methods.
4. **Protection during distribution and processing**: The fourth function is to protect the product during transit to the consumer. Packaging can handle better when there are challenges in food distribution chain, such as heat, humidity, or dew. It is important to be aware of the distribution challenges and designing of package to suit it.
5. **Provide storage history**: Time-temperature indicator (TTI) is effective for predicting microbial concentrations and other parameters of food quality during shipping and storage. It helps in ensuring proper handling and provides a gauge of product quality for sensitive products in which temperature control is imperative to efficacy and safety. TTIs are tags that can be applied to individual packages or shipping cartons to visually indicate whether a product has been exposed to time and temperature conditions that adversely affect the product quality. TTI could be used in chilled foods to identify the temperature abuse during storage and distribution.

Types of Packaging Materials

From skins, leaves, and bark, tremendous progress has been made in the development of diversified packaging materials and in the packaging equipment. In general, packaging materials may be grouped into rigid and flexible structures.

- **Flexible materials**: Plastic film, foil, paper and textiles are flexible materials.
- **Rigid materials**: Wood, glass, metals and hard plastics are examples of rigid materials.

Plastics

Polymers are the fastest-growing group of materials in food packaging. Their foremost advantage is their wide diversity and extremely broad spectrum of properties. Plastics are relatively cheap, light, easily processed and shaped, and easy to seal. Since no single film can satisfy all packaging requirements, plastic films may be combined by lamination or coextrusion.

- **Polyethylene (PE)**: PE is the result of polymerization of ethylene gas and has the formula $(CH_2)n$. Two main manufacturing processes result in different PE products. The first is called LDPE and the second HDPE.
- **Polypropylene (PP)**: This monomer has the formula $CH_2CH–CH_3$. PP was developed using polymerization catalyst technology.
- **Polyvinyl chloride (PVC)**: This monomer has the formula $CH_2CH–Cl$. The term vinyl means that a halogen has been substituted for a hydrogen atom.

- **Polyvinylidene chloride (PVDC)**: This polymer is similar to PVC, except that there is a double chlorine substitution, giving $CH_2=CCl_2$.
- **Polytetrafluoroethylene (PTFE)**: The formula for this monomer is $CF_2=CF_2$.
- **Polystyrene (PS)**: This polymer results when an ethylene hydrogen is replaced by a phenyl radical ($CH_2CH–C_6H_5$). It is a synthetic rubber, which does not degrade over time.
- **Polyesters (PES)**: Polyesters are plastics formed by the polymerization of esters.
- **Polyethylene terephthalate (PET)**: Ethylene glycol and terephthalic acid yield polyethylene terephthalate (PET).
- **Cellulose**: This was the first transparent film to be used (invented by Du Pont) in packaging and was widely used until the advent of PP. It is biodegradable. A common name is cellophane.
- **Cellulose acetate**: This product is made from cellulose and acetic anhydride.
- **Polyamides (nylons)**: These are made from condensation of a diacid (e.g., adipic acid) and a diamine (e.g., hexamethylene diamine). Polyamides are used for boil-in-the-bag-type products, frozen foods, fish, meat, vegetables, and processed meat and cheese, always in lamination.
- **Polycarbonates**: These are formed from condensation of carbonic acid in the presence of aliphatic or aromatic dihydroxy compounds.
- **Ethylene vinyl alcohol (EVOH)**: This film has high oxygen-barrier properties, but hydroxyl groups make it hydrophilic, which increases its permeability. Thus, it must be sandwiched between materials with good water-barrier properties, such as PP of LDPE, to be effective. However, its oxygen-barrier properties make it a highly desirable film, competing with PVDC for this role.
- **Acrylonitrile (AN)**: This is an excellent gas barrier (like EVOH and PVDC).
- **Pliofilm**: This is a rubber hydrochloride formed by combining polyisoprene (natural rubber) with hydrochloric acid. It is a printable, good-feel, opaque film with good heat-sealing characteristics and grease resistance. Pliofilm is no longer used much as it is not easy to machine and is not very durable.
- **Ionomers**: Surlyn is the brand name of a range of Du Pont ionomer resins (invented by Rees in 1961). An ionomer resin has both ionic and covalent bonds. Surlyn is used for shrink-wrapped meat, cheese blocks, fish, individual candy wrapping, pet food bags, potato chips, snack foods, drink Tetra Pak cartons, margarine tubs, cookies, frozen foods, nuts, etc. as part of a laminate structure, especially as the inner heat-sealing layer.

Metals (Steel, Tin, Aluminum)

Steel, tin, and aluminum are used mainly for canned foods and beverages. The most common use of metals for packaging is in tin-coated steel and aluminum cans. The principal advantages of metal cans are their strength providing mechanical protection, effective barrier properties, and resistance to high temperatures providing stability during processing.

Glass

Glass containers used to be and still are considered a prestigious means of packaging, and serve for the most expensive wines, liqueurs, perfumes, and cosmetics. It is highly inert, impermeable to gases and vapours, and amenable to the most diverse shaping. In its normal state, it has the advantage of transparency, but where required it can be given different desired colours. It has complete as well as selective light protection properties. Its main disadvantages are its fragility, heavy mass and high energy requirement during manufacturing.

Timber, Cardboard, and Papers

Pulp products are widely used in food packaging in the form of different kinds of paper, paperboard, laminates, and corrugated board. The main advantages of paper are its low cost, low mass, relatively high stiffness and excellent printability. The main disadvantage is its high sensitivity to moisture, reflected in close dependence on the relative humidity of the environment. The basic raw material for papermaking is cellulose. Use of wood in packaging today is rather limited, confined primarily to crates, large boxes and pallets. Its major advantage is its strength, but it is quite expensive and cheaper alternatives, such as corrugated board, have been found adequate for many applications. Even pallets, which used to be made exclusively from wood, are made today in part from foamed plastics.

Ceramics

The term ceramic describes any nonmetal nonorganic material produced by high temperatures, such as glass and pottery. The most common use of ceramics in the food industry is, of course, pottery. The chemical composition of most ceramics is silica (SiO_2), alumina (Al_2O_3), and water. Glass is almost pure silica, whereas clays have large amounts of alumina present.

Metallized Films

Aluminum-metallized films are extensively used in food packaging applications. Compared with films containing aluminum foil, metallization has the following advantages: (1) lower environmental impact due to a significant reduction in the amount of raw material used and the recyclability of metallized film scrap as part of the base material, (2) greater flexibility and resistance to flexion, and (3) impressive presentation.

Food Labelling

A label displays information regarding the product, which is typically printed on the packaging. It is a piece of paper, polymer, cloth, metal, or other material affixed to a container or article. A label may also be printed directly on the container or article. A label not only describes the product and its uses, but also provides instructions and crucial precautionary measures (if any) that need to be taken care of. It essentially informs consumers of the properties of a product. Food Labelling hence serves as a primary link of communication between the manufacturer and consumer and covers both food safety and information of consumer interest.

Food Packaging Symbols

This symbol is often used on containers, such as Tupperware, to show that the product is suitable for food use. It may or may not have the word "food" below the cup and fork.

Recycling – this logo is used internationally to show that the product can be recycled. This is not an indication that the packaging has been made from recycled material. A number in the middle of this image (if shown) is to indicate the percentage of recycled material that makes up that product.

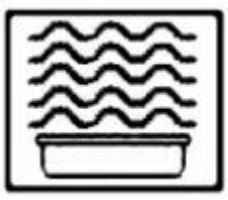
Plastic recycling – another widely used symbol to show that the plastic used in the packaging can be recycled. The PET refers to Polythene Terephthalate which is commonly used in this application. The number inside (1 – 7) defines the resin used in making the packaging.

Compostable – this symbol is a registered trademark of European Bioplastics and is used to show that the packaging is certified to be compostable. Only products that have met the EU standard EN 13432/14955 can use this logo.

Vegetarian –The product in the food packaging is suitable for vegetarians. There is an alternative logo that uses a tick rather than leaves, although the meaning stays the same.

Gluten Free – this states that the product does not contain gluten or any other wheat extracts. This will typically be very clearly labelled on products that match this description.

Allergy Advice – often products that contain ingredients that are common allergies will include this symbol. One of the most common ones to see is this symbol with “may contain nuts” below it.



This is the symbol used to show that the food packaging is suitable for use in a microwave. An alternative symbol is the waves with the word “micro” included below. Always check to make sure this logo is present before trying to microwave it.

Product suitable for freezing – if this image is seen on your food packaging, then you are able to freeze the entire product without having to remove the wrapping first.

FSSAI guidelines on packaging and labelling of food products

Food Safety and Standards Authority of India (FSSAI) is an autonomous body established by the Government of India under the Ministry of Health & Family Welfare. It usually sets standards for food so that there is no chaos in the minds of consumers, traders, **manufacturers** and investors. Since the FSSAI is the authority on all food-related things in India, FSSAI registration and observance of FSSAI rules is a must.

Food safety and standards (packaging and labelling) regulations, 2011

Packaging: General Requirements

1. A utensil or container made of the following materials or metals, when used in the preparation, packaging and storing of food shall be deemed to render it unfit for human consumption: —

a. containers which are rusty;
b. enameled containers which have become chipped and rusty;
c. copper or brass containers which are not properly tinned
d. containers made of aluminium not conforming in chemical composition to IS:20 specification for Cast Aluminium & Aluminium Alloy for utensils or IS:21 specification for Wrought Aluminium and Aluminium Alloy for utensils.

2. Containers made of plastic materials should conform to the following Indian Standards Specification, used as appliances or receptacles for packing or storing whether partly or wholly, food articles namely: —

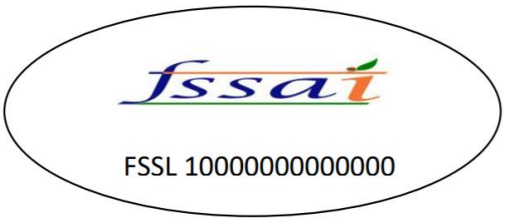
(i) IS: 10146 (Specification for Polyethylene in contact with foodstuffs);
(ii) IS: 10142 (Specification for Styrene Polymers in contact with foodstuffs);
(iii) IS: 10151 (Specification for Polyvinyl Chloride (PVC), in contact with foodstuffs);
(iv) IS: 10910 (Specification for Polypropylene in contact with foodstuffs);
(v) IS: 11434 (Specification for Ionomer Resins in contact with foodstuffs);
(vi) IS: 11704 Specification for Ethylene Acrylic Acid (EAA) copolymer;
(vii) IS: 12252 - Specification for Poly alkylene terephthalates (PET);
(viii) IS: 12247 - Specification for Nylon 6 Polymer;
(ix) IS: 13601 - Ethylene Vinyl Acetate (EVA);
(x) IS: 13576 - Ethylene Metha Acrylic Acid (EMAA);
(xi) Tin and plastic containers once used, shall not be re-used for packaging of edible oils and fats; Provided that utensils or containers made of copper though not properly tinned, may be

used for the preparation of sugar confectionery or essential oils and mere use of such utensils or containers shall not be deemed to render sugar confectionery or essential oils unfit for human consumption.

3. General packaging requirements for Canned products,
   I. All containers shall be securely packed and sealed.
   II. The exterior of the cans shall be free from major dents, rust, perforations and seam distortions.
   III. Cans shall be free from leaks.

Labelling: General Requirements

1. Every pre-packaged food shall carry a label containing information as required here under unless otherwise provided, namely, —
2. The particulars of declaration required under these Regulations to be specified on the label shall be in English or Hindi in Devnagri script: Provided that nothing herein contained shall prevent the use of any other language in addition to the language required under this regulation.
3. Pre-packaged food shall not be described or presented on any label or in any labelling manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect;
4. Label in pre-packaged foods shall be applied in such a manner that they will not become separated from the container;
5. Contents on the label shall be clear, prominent, indelible and readily legible by the consumer under normal conditions of purchase and use;
6. Where the container is covered by a wrapper, the wrapper shall carry the necessary information or the label on the container shall be readily legible through the outer wrapper and not obscured by it;
7. License number shall be displayed on the principal display panel in the following format, namely: -



Provided that the existing products of a unit shall comply with the requirement of this clause on and after the six months of commencement of the Food Safety and Standards (packaging and labelling) Amendment Regulation, 2013.

Labelling of pre-packaged foods

In addition to the General Labelling requirements, every package of food shall carry the following information on the label, namely, —

1. **The Name of Food**: The name of the food shall include trade name or description of food contained in the package.

2. **List of Ingredients**: Except for single ingredient foods, a list of ingredients shall be declared on the label in the following manner: —

(a) The list of ingredients shall contain an appropriate title, such as the term "Ingredients";

(b) The name of Ingredients used in the product shall be listed in descending order of their composition by weight or volume, as the case may be, at the time of its manufacture;

(c) A specific name shall be used for ingredients in the list of Ingredients;

(d) Where an ingredient itself is the product of two or more ingredients, such a compound ingredient shall be declared in the list of ingredients, and shall be accompanied by a list, in brackets, of its ingredients in descending order of weight or volume, as the case may be: Provided that where a compound ingredient, constitutes less than five percent of the food, the list of ingredients of the compound ingredient, other than food additive, need not to be declared;

(e) Added water shall be declared in the list of ingredients except in cases where water forms part of an ingredient, such as, brine, syrup or broth, used in the compound food and so declared in the list of ingredients: Provided that water or other volatile ingredients evaporated in the course of manufacture need not be declared; Provided further that in the case of dehydrated or condensed food, which are intended to be reconstituted by addition of water, the ingredients in such reconstituted food shall be declared in descending order of weight or volume as the case may be, and shall contain a statement such as "Ingredients of the product when prepared in accordance with the directions on the label";

(f) Every package of food sold as a mixture or combination shall disclose the percentage of the ingredient used at the time of the manufacture of the food (including compound ingredients or categories of ingredients), if such ingredient–

i. is emphasised as present on the label through words or pictures or graphics; or

ii. is not within the name of the food but, is essential to characterise the food and is expected to be present in the food by consumers, and if the omission of the quantitative ingredient declaration will mislead or deceive the consumer.

Provided that where the ingredient has been used as flavouring agent, the disclosure of such ingredient is not required:

Provided further that where the drained net weight is indicated on the label as required or in case of such food products where specific provisions are stipulated under these Regulations or where a pictorial representation of a serving suggestion is made for consumer information and use, the disclosure of such ingredient is not required.

Provided further that in case of any bottle containing liquid milk or liquid beverage having milk as an ingredient, soft drink, carbonated water or ready-to-serve fruit beverages, the declarations with regard to addition of fruit pulp and fruit juice shall invariably appear on the body of the bottle.

3. **Nutritional information** – Nutritional Information or nutritional facts per 100 gm or 100ml or per serving of the product shall be given on the label containing the following: —

(i) energy value in kcal;

(ii) the amounts of protein, carbohydrate (specify quantity of sugar) and fat in gram (g); (iii) the amount of any other nutrient for which a nutrition or health claim is made:

Provided that where a claim is made regarding the amount or type of fatty acids or the amount of cholesterol, the amount of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in gram (g) and cholesterol in milligram (mg) shall be declared, and the amount of trans fatty acid in gram (g) shall be declared in addition to the other requirement stipulated above;

(iv) Wherever, numerical information on vitamins and minerals is declared, it shall be expressed in metric units;

(v) Where the nutrition declaration is made per serving, the amount in gram (g) or millilitre (ml) shall be included for reference beside the serving measure;

Provided that the food claimed to be enriched with nutrients, such as, minerals, proteins, vitamins, metals or their compounds, amino acids or enzymes shall give the quantities of such added nutrients on the label.

Provided that — (i) the nutritional information may not be necessary, in case of foods such as raw agricultural commodities, like, wheat, rice, cereals, spices, spice mixes, herbs, condiments, table salt, sugar, jaggery, or non –nutritive products, like, soluble tea, coffee, soluble coffee, coffee-chicory mixture, packaged drinking water, packaged mineral water, alcoholic beverages or fruit and vegetables, processed and pre-packaged assorted vegetables, fruits, vegetables and products that comprise of single ingredient, pickles, papad, or foods served for immediate consumption such as served in hospitals, hotels or by food services vendors or halwais, or food shipped in bulk which is not for sale in that form to consumers.

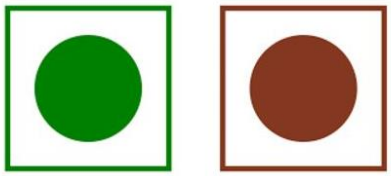
(ii) The compliance to quantity of declared nutrients on the label shall be according to the established practices.

4. Declaration regarding Veg or Non veg –

(i) Every package of "Non-Vegetarian" food shall bear a declaration to this effect made by a symbol and colour code as stipulated below to indicate that the product is Non-Vegetarian Food. The symbol shall consist of a brown colour filled circle having a diameter not less than the minimum size specified in the regulation, inside a square with brown outline having sides double the diameter of the circle.

(ii) Where any article of food contains egg only as Non-Vegetarian ingredient, the manufacturer, or packer or seller may give declaration to this effect in addition to the said symbol.

(iii) Every package of Vegetarian Food shall bear a declaration to this effect by a symbol and colour code as stipulated below for this purpose to indicate that the product is Vegetarian Food. The symbol shall consist of a green colour filled circle, having a diameter not less than the minimum size specified, inside the square with green outline having size double the diameter of the circle.



5. Declaration regarding Food Additives-

(i) For food additives falling in the respective classes and appearing in lists of food additives permitted for use in foods generally, the following class titles shall be used together with the specific names or recognized international numerical identifications:

Acidity Regulator, Acids, Anticaking Agent, Antifoaming Agent, Antioxidant, Bulking Agent, Colour, Colour Retention Agent, Emulsifier, Emulsifying Salt, Firming Agent, Flour Treatment Agent, Flavour Enhancer, Foaming Agent, Gelling Agent, Glazing Agent, Humectant, Preservative, Propellant, Raising Agent, Stabilizer, Sweetener, Thickener:

(ii) Addition of colours and/or Flavours—

6. Name and complete address of the manufacturer

7. Net quantity

8. Lot/Code/Batch identification

9. Date of manufacture or packing

10. Best Before and Use By Date

11. Country of origin for imported food

12. Instructions for use

Food Safety and Standards (Labelling and Display) Regulations

Food Safety and Standards Authority of India made the Food Safety and Standards (Packaging and Labelling) Regulations, 2011, but later to make the national labelling regulations more robust and effective, FSSAI was in the process of comprehensive revision of Food Safety and Standards (Packaging and Labelling) Regulations, 2011 with the objective of having three different regulations dealing separately to packaging, labelling and Advertisement & claims requirements. In this series, two regulations namely "FSS (Packaging) Regulations and FSS (Advertising and Claims) Regulations have been finalised and notified in the year 2018.

The Food Authority has thus divided the packaging and labelling regulations into two regulations, -

(i) the Food Safety and Standards (Packaging) Regulations, 2018; and

(ii) the Food Safety and Standards (Labelling and Display) Regulations, 2019.

- According to the Regulations, the packaged food companies will need to declare nutritional information such as calories (energy), Saturated fat, trans-fat, added sugar and sodium per serve on the front of the pack.
- The idea behind the new labelling regulations is to enable citizens to know more about the composition of food products, so that they can make informed choices.
- The food labels will also declare, per serve percentage contribution to RDA (recommended dietary allowance) on the front of the pack.
- In a bid to encourage consumers make healthier food choices, these regulations propose to make it mandatory to display red colour-coding on front-of-the-pack labels on packaged food products that have high-fat, high-sugar and high-salt content levels.
- This requirement would be implemented in phased manner for a period of three years.
- In present time, the industry practice is to put manufacturing date and expiry date at two different places over the pack and it became difficult for consumer to see both at a glance.
- Hence, the new regulations propose that Date Marking including date of manufacturing and date of expiry must be at one place to make it easily.
- Food allergen labelling is an important tool to reduce risk of exposure and prevent anaphylaxis for individuals with food allergies. Hence, the new regulations prescribe the Provision for labelling of food allergen and also allows to use of standardized precautionary and safety symbols.
- Other key features of these regulations are:
    - Mandatory labelling requirements like information relating to allergens and logo of veg, non-veg food etc. for the prepared food as well.
    - Nutritional information may additionally be provided in the form of Barcode/Global Trade Identification Number (GTIN).
    - New logo for Vegetarian food, which consists of a green colour filled triangle inside a square with green outline to help the colour-blind people.
    - Every package of food material which is not meant for human consumption shall bear a [X] symbol so as to clearly distinguish the non-food grade items to food items.
    - An internal mechanism to address the problem arising out of implementation/interpretation of the regulations.

These Regulations will supersede the Food Safety and Standards (Packaging and Labelling) Regulations, 2011. The above-mentioned draft regulations were published and the copies of the said Gazette were made available to the public on 2nd July, 2019. The objections and suggestions received on the said draft regulations have been considered by the Food Safety and Standards Authority of India and made food safety and standards (labelling and display) regulations, 2020.

Food Safety and Standards (Packaging) Regulations, 2018

General Requirements

- Every food business operator shall ensure that the packaging material used shall be in accordance with these regulations: Provided where Indian Standards are not available, then relevant International Standards may be complied with.
- Any material which comes in direct contact with food or likely to come in contact with food used for packaging, preparation, storing, wrapping, transportation and sale or service of food shall be of food grade quality.
- Packaging materials shall be suitable for the type of product, the conditions provided for storage and the equipment for filling, sealing and packaging of food as well as transportation conditions.
- Packaging materials shall be able to withstand mechanical, chemical or thermal stresses encountered during normal transportation. In case of flexible or semi-rigid containers, an overwrap packaging may be necessary.
- Food products shall be packed in clean, hygienic and tamper-proof package or container.
- The sealing material shall be compatible with the product and the containers as well as the closure systems used for the containers
- Tin containers once used, shall not be re-used for packaging of food
- Plastic containers of capacity 5 litre and above and Glass bottles, which are reused for packaging of food, shall be suitably durable, easy to clean or disinfect
- Printing inks for use on food packages shall conform to IS: 15495
- Printed surface of packaging material shall not come into direct contact with food products
- Newspaper or any such material shall not be used for storing and wrapping of food
- In case of multilayer packaging, the layer which comes in direct contact with food or layers likely to come in contact with food shall meet the requirements of packaging materials specified in Schedule I, II and III of these regulations.
- The materials listed in Schedule I, II and III of these regulations shall be compatible with their intended use as a packaging material so as not to alter the quality and safety of the food product.
- Every food business operator shall obtain the certificate of conformity issued by NABL accredited laboratory against these regulations, for the packaging material, which comes in direct contact with food or layers likely to come in contact with food to be used.

Specific Requirements for Primary food packaging

- Paper and board materials intended to come in contact with food products
- Glass containers intended to come in contact with food products
- Metal and Metal Alloys intended to come in contact with food products
- Plastic materials intended to come in contact with food products

Migration: Plastic materials intended to come in contact with food products

All packaging materials of plastic origin shall pass the prescribed overall migration limit of 60 mg/kg or 10 mg/dm2 when tested as per IS 9845 with no visible colour migration.

Plastic materials and articles shall not release the substances in quantities exceeding the specific migration limits (mg/Kg) as given below.

- Barium 1.0
- Cobalt 0.05
- Copper 5.0
- Iron 48.0
- Lithium 0.6
- Manganese 0.6
- Zinc 25.0

Schedule – IV: List of suggestive packaging materials

Fish and fish products or Seafood

- Glass jars with plastic (PP or High-density polyethylene (HDPE) caps
- Metal Containers with metal lid (lacquered tin containers)
- Polyethylene terephthalate (PET) punnets or containers with plastic caps
- Plastic-based multi-layered flexible laminates heat sealed pouches
- Plastic tray with overwrap

Food safety and standards (labelling and display) regulations, 2020

These regulations prescribe the labelling requirements of pre-packaged foods and display of essential information on premises where food is manufactured, processed, served and stored.

Labelling of pre-packaged foods: General Requirements

1. Every pre-packaged food shall be labelled with information as required under these regulations unless otherwise provided.
2. When a food product is sold through e-commerce or any other direct selling means, the mandatory requirements of the label as given in these regulations shall be provided to the consumer through appropriate means before sale.
3. Pre-packaged food shall not be described or presented on any label or in any labelling in a manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect.
4. Any information or pictorial device written, printed, or graphic matter may be displayed on the label provided that it is not in conflict with the requirements of these regulations.
5. The particulars of declaration required under these Regulations printed on the label shall be in English or Hindi.
6. Label on pre-packaged foods shall be applied in such a manner that it will not become separated from the container.
7. Contents on the label shall be clear, unambiguous, prominent, conspicuous, indelible and readily legible by the consumer under normal conditions of purchase and use.
8. Where a package is provided with an outside container or wrapper and such container or wrapper is displayed for retail sale, it shall also contain all the declarations which are required

to appear on the package except where such container or wrapper itself is transparent and the declarations on the package(s) are easily readable through such outside container or wrapper.

Labelling Requirements

Every package shall carry the following information on the label, namely, -

(1) The Name of Food: Every package of food shall carry name of the food, which indicate the true nature of the food contained in the package, on the Front of Pack:

(a) Where a food is specified by certain essential composition under Food Safety and Standards Regulations made under the Act, that establishes its identity the name provided therein shall be used;

(b) In the absence of such name, either a common or usual name or an accompanying description of true nature of food shall be used;

(c) It may additionally have a "coined", "fanciful", "brand" or "trade name" subject to compliance of Food Safety & Standards (Advertising and Claims) Regulation 2018.

(2) **List of Ingredients**: Except for single ingredient foods, a list of ingredients shall be declared on the label.

(3) **Nutritional information**: Nutritional Information per 100 g or 100 ml or per single consumption pack of the product and per serve percentage (%) contribution to Recommended Dietary Allowance calculated on the basis of 2000 kcal energy, 67 g total fat, 22 g saturated fat, 2 g trans-fat, 50 g added sugar and 2000 mg of sodium (5 g salt) requirement for average adult per day, shall be given on the label.

(**4) Declaration regarding Veg or Non veg**

Non-Vegetarian Food: The symbol shall consist of a brown colour filled triangle inside a square with brown outline.

Vegetarian Food: The symbol shall consist of a green colour filled circle, having a diameter not less than the minimum size specified, inside the square with green outline having size double the diameter of the circle.

(5) Declaration regarding Food Additives

(6) Declaration of name and complete address

(7) FSSAI logo and license number: The FSSAI logo and license number under the Act shall be displayed on the label of the food package in contrast colour to the background as below:

Lic. No. XXXXXXXXXXXXX

Fortified food and organic food shall be marked with the logo as specified in the schedule of these regulations. FSSAI may specify logo for any other food as decided from time to time.

1. Every package of fortified food shall carry the words "fortified with …… (name of the fortificant)" and the logo, as specified below, on the label. It may also carry a tag line "Sampoorna Poshan Swasth Jeevan" under the logo.

Fortified with....
SAMPOORNA POSHAN
SWASTHA JEEVAN

.... से फोर्टिफाइड

सम्पूर्ण पोषण स्वस्थ जीवन

2. Every package of certified organic food as per Food Safety and Standards (Organic Foods) Regulations, 2017 shall carry the logo as specified below:

(8) Net quantity, Retail Sale Price and Consumer Care details
(9) Lot/Code/Batch identification
(10) Date Marking: "Date of manufacture or packaging" and "Expiry/Use by" shall be declared on the label. However, expression "Best before" may also be used as optional or additional information.
(11) Labelling of Imported Foods
(12) Country of Origin for Imported Foods
(13) Instructions for use

(14) Declaration regarding Food allergen

(15) Every package of food material sold in retail, but which is not meant for human consumption shall bear a declaration to this effect by a symbol. The symbol shall consist of a black colour cross inside a square with black outline having the sides of square
not less than the minimum size specified.

Principal display panel. - (1) The information required under these regulations shall be given on the principal display panel of the package or container and such information may be given in following manner, - (a) All information should be grouped together and given at one place. Or (b) The pre-printed information be grouped together and given in one place and, Online information or those not pre-printed be grouped together in another place.

Labelling Requirements of non-retail container

(1) Every packaged food meant for non-retail sale shall provide the following mandatory information either on the container or pasted on the label thereto:

(a) Name of the food;

(b) Net Quantity;

(c) FSSAI Logo and License number;

(d) Date marking;

(e) Lot No.

(f) Name and address of the manufacturer or packer (including country of origin for imported packages)

(2) The following information if not provided on the label shall be provided in the accompanying documents:

(a) List of ingredients

(b) Declaration regarding Veg or Non-Veg

(c)Nutritional information

(3) The following labelling requirements are exempted if they are provided in a Barcode/Global Trade Identification Number (GTIN); -

(a) Address of the brand owner whether or not, he himself is the manufacturer, marketer, packer or bottler, as the case may be,

(b) the license number of the manufacturer or marketer or packer or bottler, as the case may be, if different from the brand owner.

(4) Every package meant for non- retail sale shall bear a statement "NOT FOR RETAIL SALE"

Labelling of packaged Food Additives for Retail Sale

(1) Every package of a food additive meant for retail sale to the consumer shall be labelled in accordance with the Food Safety and Standards (Labelling and Display) Regulations, 2020.

(2) Additionally, the label of every package of food additive shall provide the following information under these regulations:

(a) Name of Food Additive

(b) Other Mandatory Declarations:

(i) Every package of a food additive sold in retail or non-retail sale shall be marked prominently with the words "FOR USE IN FOOD".

(ii) In the case of mixtures of flavourings, the name of each flavouring present in the mixture need not be given but a common or generic expression "flavour" or "flavouring" may be used, together with a true indication of the nature of the flavour.

The expression "flavour" or "flavouring" shall be qualified by the words "natural", nature-identical", "artificial", or a combination of these words, as appropriate. Provided that this qualifier does not apply to flavour modifiers.

Conclusion

Food labelling and food packaging help the consumers in differentiating between various foods and finding out the best products matching their requirements. There is a significant demand for getting FSSAI license or registration in India in order to run a food business. It's crucial for all the food business operators carrying out their business in India to abide by the FSSAI's Food Packaging and Labelling Regulations.

Reference/Website

https://www.fssai.gov.in/

Chapter 20

FSSAI registration and licensing procedure

Dr. Sanu Jacob
Director (Lab Training and Surveillance),
Food Safety and Standards Authority of India
Email: sanu.jacob@fssai.gov.in

Introduction

Food is any substance or a product obtained from nature, which contains nutritive and non-nutritive components that help to maintain or improve the health of an individual if consumed in optimal amount. Globalization of food production and procurement makes food chains longer and more complex and increases the risk of food safety incidents. Infections and diseases arising from contaminated/adulterated food remain threats to global public health. The WHO reports shows that every year foodborne diseases cause the death of over 420000 people including many children (WHO Report, 2020). Food safety is linked to the presence of food-borne hazards in food at the point of consumption. Since food safety hazards can occur at any stage in the food chain it is essential that adequate control be in place. Therefore, a combined effort of all parties in the food chain is required to deliver safe food products to the final consumer. Effective and harmonized food safety systems shall manage and ensure the safety and suitability of food in each link of the supply chain.

Although the food industry has the prime responsibility of ensuring safe foods in most societies, the maintenance of a safe food supply is regarded as a responsibility of the government of that country. This responsibility has, over many years, led governments to adopt legislation, standards and regulations for food processing and to impose penalties when a business fails to meet the expectation. As with any legislation, an effective system for detecting failures to comply with the legal requirements increases compliance and hence, in this case, promotes food safety. Governments have an obligation to protect consumer health and this includes protection against food-borne diseases. Food standards are therefore necessary to aid governments in protecting public health. However, the standards can only be effective when they are enforced through an efficient food control system. This therefore requires comprehensive legislation, inspection, food monitoring and food-borne surveillance. An efficient food control system must be supported by competent staff with good laboratory services. Political and institutional support and stability are also important elements.

Food Safety and Standards Authority of India (FSSAI) is an autonomous body established under the Ministry of Health & Family Welfare, Government of India. The FSSAI has been established under the Food Safety and Standards Act, 2006 (under section 4), which is a consolidating statute, related to food safety and regulation in India. FSSAI is responsible for protecting and promoting public health through the regulation and supervision of food safety. Government of India established FSSAI on 5 September 2008 under Food Safety and

Standards Act, 2006. The FSSAI consists of a chairperson & 22 members. The FSSAI is responsible for setting standards for food so that there is one body to deal with and no confusion in the minds of consumers, traders, manufacturers, and investors. Ministry of Health & Family Welfare, Government of India is the Administrative Ministry of Food Safety and Standards Authority of India. The following are the statutory powers that the FSS Act, 2006 gives to the Food Safety and Standards Authority of India (FSSAI).

1. Framing of regulations to lay down food safety standards
2. Laying down guidelines for accreditation of laboratories for food testing
3. Providing scientific advice and technical support to the Central Government
4. Contributing to the development of international technical standards in food
5. Collecting and collating data regarding food consumption, contamination, emerging risks etc.
6. Disseminating information and promoting awareness about food safety and nutrition in India

The FSSAI has its headquarters at New Delhi, and presently has regional offices located in Delhi, Guwahati, Mumbai, Kolkata, Cochin and Chennai. There are 14 national reference laboratories (NRL) including 2 Ancillary NRL (ANRL), 18 referral laboratories, 74 State / UT Govt. laboratories and 189 primary laboratories notified by FSSAI. The number of food testing laboratories in the country as notified by FSSAI may change based on their NABL accreditation status, scope of food testing and MoU as per FSSAI requirement.

The Food Safety and Standards Act (FSS), 2006 is the primary law for regulation of food products in India. The FSSAI appoints food safety authorities on the state level. The main aim of FSSAI is to:

- Lay down science-based standards for articles of food.
- To regulate manufacture, storage, distribution, sale and import of food
- To facilitate food safety.

The FSS Act is an amalgamation of older laws; rules and regulations existed in India for food safety prior 2006. The FSS Act took older food acts into one umbrella, i.e.,

- Prevention of Food Adulteration Act, 1954.
- Fruit Products Order, 1955.
- Meat Food Products Order, 1973.
- Vegetable Oil Products (Control) Order, 1947.
- Edible Oils Packaging (Regulation) Order 1988.
- Solvent Extracted Oil, De-Oiled Meal and Edible Flour (Control) Order, 1967.
- Milk and Milk Products Order, 1992.

Operational procedure at FSSAI

The Food Safety and Standards Authority under the governance of Chairman constitutes of a Central Advisory Committee with scientific panels for specific food safety concerns and involves experts from different fields including public, NGO, governmental, private. The internal structure is primarily under two groups: Execution (headed by Chief Executive Officer) and scientific group (Headed by Chief Scientific Officer) with prime responsibility of standards formulation and risk assessment. The execution group is subdivided into four categories: management; enforcement; product approvals and quality assurance; and administration and finance. The enforcement section is responsible for

approval, registration of units and providing licensing. The surveillance section is responsible for on-going monitoring and surveillance of food products manufactured by various food business operators (FBO) across the country. The product approval and quality assurance section includes the product approval and technology approval in case of novel or new products registration, it also includes the central food laboratories and testing of samples along with the quality assurance activities of codex. The authority also creates awareness among the food business operators and promotes the culture for food safety inside the premises of food operators and across the country. The training and development of food safety officers (FSO) to ensure preventive hazard control based on the principle of HACCP during inspection is a challenge to the FSSAI. Another important activity of the authority is to collect the information related to food safety in relation to consumers, business operators, enforcement organisation or government (Shukla et al., 2014).

Local authorities issue a license and everyone in the food sector need to be registered. Temporary stall holders are exempted from the license but need to get their business registered with the local municipality or panchayat. The FSSA and State Food Safety Authorities have the authority to monitor and regulate food business operators. The Commissioner of Food Safety of each state appoints a Designated Officer (DO) of the level of Sub- Divisional Officer. The DO of a specific district has the responsibility to issue or cancel licenses, prohibit sale of food items that violate specified standards, receive reports and samples of food items from FSO's, and have those items analysed. The act provides for a graded penalty structure where in the punishment depends on the severity of the violation. For example, a fine is imposed for offenses such as manufacturing, selling, storing, or importing substandard or misbranded food. More severe offenses such as manufacturing, distributing, selling, or importing unsafe food that results in injury could incur a prison sentence, which could be extended to life imprisonment if the violation causes death. Even hawkers, vendors, temporary stall holders, and petty manufacturers who make their own food could be fined up to Rs. 25,000/- if they violate specified standards (Ray et al., 2016).

Food licensing and registration

All FBOs or petty food manufacturers in the country should mandatorily to and take license under FSSAI and are recommended for displaying the license number in the premises of the organization. The registration of FBO or petty food manufacturer can be done in any panchayat, municipality or corporation by remitting a fee of 100 rupees. In order to qualify for petty food manufacturer registration the FBO’s annual turnover should not exceed Rupees 12 lakhs per year. Registering authority after being satisfied with the safety, hygiene and sanitary conditions of the premises as contained in Part II of schedule 4 of FSSAI regulation provide registration certificate. After registration, license can be applied under state or central authority if the FBO or petty manufacturer satisfies all criteria under FSSAI. All procedures for registration and licensing are depicted in flow chart 1 and 2. There are two bodies for licensing such as central and state licensing authorities under which each FBO should apply license according to the capacity of production. The state licensing authority functioning under the food safety commissioner of the state which includes designated officers to grant license and food safety officers to carry out inspections and monitoring of the FBO. Similarly the central licensing authority, working under the CEO of FSSAI includes designated officers in FSSAI headquarters to grant licenses and zonal director or other officers to conduct inspections and monitoring of food business.

There are kinds of food licenses issued by the State and Central Government Authority, viz.,

1. State License: To meet this license requirement the FBO should have an annual turnover between 12 lakh to 20 crore Rupees. All grain, cereal and pulses milling units irrespective of their turnover are covered under this license.

2. Central License: To meet this license requirement the FBO should have an annual turnover of over 20 crores rupees, and / or should operate food business in two or more Indian States. Food business covered under Schedule 1 of FSS (Licensing and Registration of Food Businesses) Regulations, 2011 also comes under the purview of Central License.

As per Section 31(1) of FSS Act, 2006 every Food Business Operator (FBO) in the country is required to be registered/licensed under the Food Safety & standards Authority of India. The licensing and registration procedure and requirements are regulated by Food Safety & Standards (Licensing and Registration of food Business) Regulations, 2011.

Food Licensing and Registration System (FLRS) was previously an online system launched by FSSAI to facilitate FBOs in India to apply for License/Registration certificate and track their applications during the course of processing. Thirty five (35) States/UTs have been issuing License/Registration certificate online through FLRS. All Central Licenses are issued online pan India through FLRS system with minimum documentation. The system has eliminated the need for physical interaction between applicants and Licensing Authorities.

All FBOs must obtain a 14-digit registration or license number which must be printed on food packages as well as displayed on the prominent place.

Eligibility Criteria for License/ Registration

Registration

- Petty Manufactures, seller retailer, hawker, itinerant vendor or temporary stall holder;
- Small food businesses with an annual turnover not exceeding Rs 12 lakhs
- Production capacity of food not exceeding 100 kg/ltr per day
- Procurement or handling and collection of milk up to 500 litres of milk per day
- Slaughtering capacity of 2 large animals or 10 small animals or 50 poultry birds per day or less.

Central License

- Dairy units with more than 50,000 litres of liquid milk/day or 2500 MT of milk sold per annum.
- Vegetable oil processing/ production units having installed capacity more than 2 MT per day.
- All slaughter houses equipped to slaughter more than 50 large animals/ 150 small animals/ 1000 or more poultry birds per day.
- Meat processing units equipped to handle or process more than 500 kg of meat per day or 150 MT per annum.
- All food processing units having installed capacity more than 2 MT/day except grains, cereals and pulses milling units.
- 100 % Export Oriented Units.
- All Importers importing food items including food ingredients and additives for commercial use.
- All food business operators manufacturing/ processing/ importingany proprietary food for which NOC has been given by FSSAI.

- Registered/ Head office of FBOs operating in two or more states.
- Food catering services in establishments and units under Central government Agencies like Railways, Airport, Seaport, Defence etc.
- Hotels with 5 Star and above accreditation.

State License

- All FBOs other than those eligible for Registration/ Central License
- All grains, cereals and pulses milling units.

Food Safety Compliance System (FoSCoS)

FSSAI had earlier implemented a Food Licensing and Registration System (FLRS) - an online application to provide licensing and registration functionality. FLRS application enabled the process for FBOs to submit registration/ license applications related to all food businesses and further supported the processing of these applications by the Central/ State licensing authorities. FLRS has been in place from past 9 years. Over the years multiple enhancements and modifications have been done to enhance the usability of application. Having observed certain performance challenges and business process limitations in FLRS, FSSAI recognized the need for an upgrade which led to development of a new application - Food Safety and Compliance System (FoSCoS). During development of FoSCoS, care has been taken to ensure that most of it is similar to FLRS application in functionality and process flows to the extent possible while making it more user friendly and also improving its system performance. FoSCoS is built on open source platform, has a new and advanced User Interface, is intuitive, computationally powerful and technically superior than FLRS.

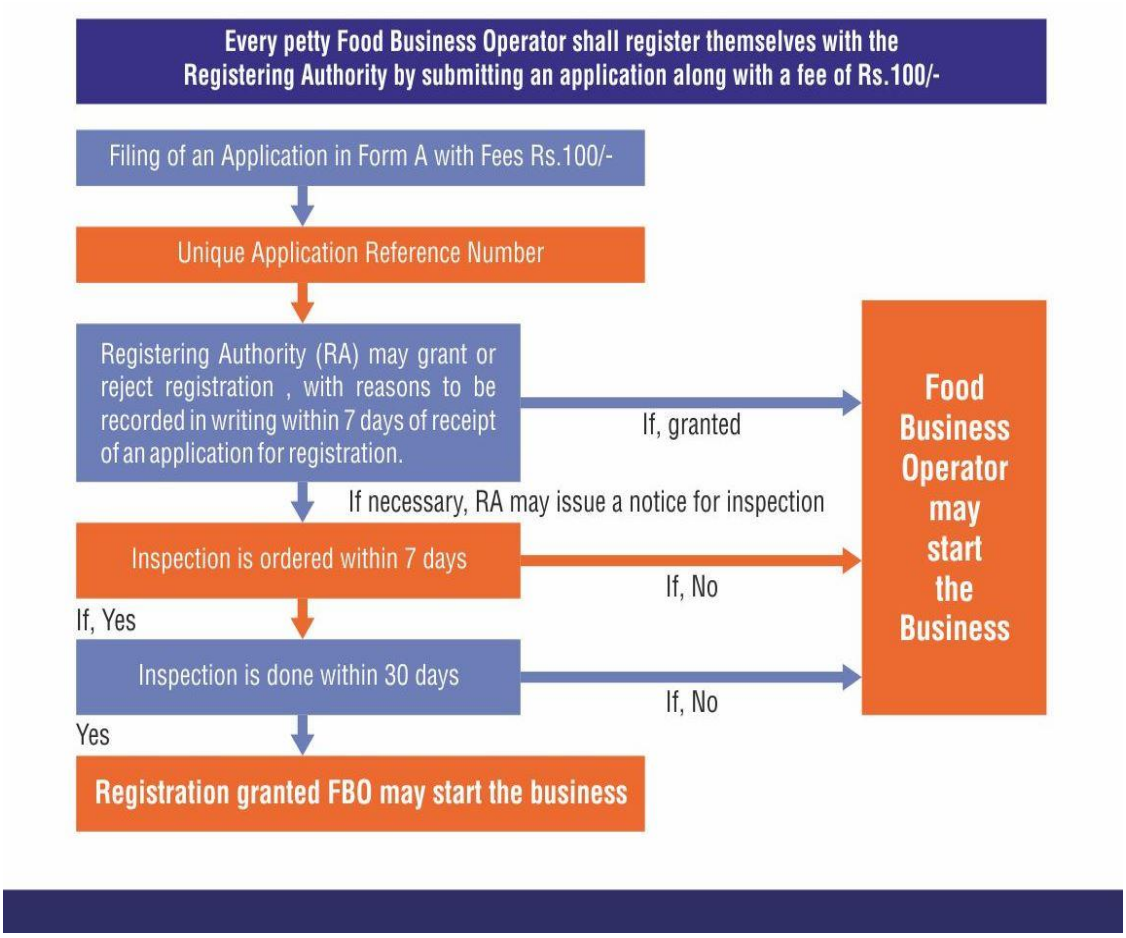
There is a guidance document on FoSCoS available on the website of FSSAI at link: https://foscos.fssai.gov.in/assets/docs/FoSCoSGuidanceDocumentV1.0.pdf to enable and provide guidance to our primary users i.e. Food Business Operators (FBOs), Designated Officers (DOs) and Food Safety Officer (FSOs) about the newly launched application i.e. Food and Safety Compliance System (FoSCoS). This will also further help the users in transition from our legacy application FLRS to FoSCoS from business perspective. FSSAI is providing this guidance document to provide an overall understanding of the new system and describe the key application functions which would be used to apply and process the Registration/License applications.To meet the above objective, process flows and application features of FoSCoS have been enhanced and upgraded for better user experience. Following are the improved key features of FoSCoS:

- Upgradation of hardware and software to ensure enhanced processing speed, least possible downtime, higher user traffic capability and potential for future upgrades.
- Scalable architecture to meet future upgrades, new modules for additional functionalities and integration with other IT systems of FSSAI. FoSCoS shall in future be the one-stop food safety compliance portal.
- Paradigm shift in licensing approach from Text Box approach to Standardized Product approach for manufacturers.
- The Home page has been re-designed to make it more user friendly, intuitive and smart search option for standardized products and eligibility search for any food business is given.
- New online feature for filling annual returns through FoSCoS application.
- FoSCoS has been integrated with FoSCoRIS to ensure seamless operations. FBOs will have access to inspections reports.

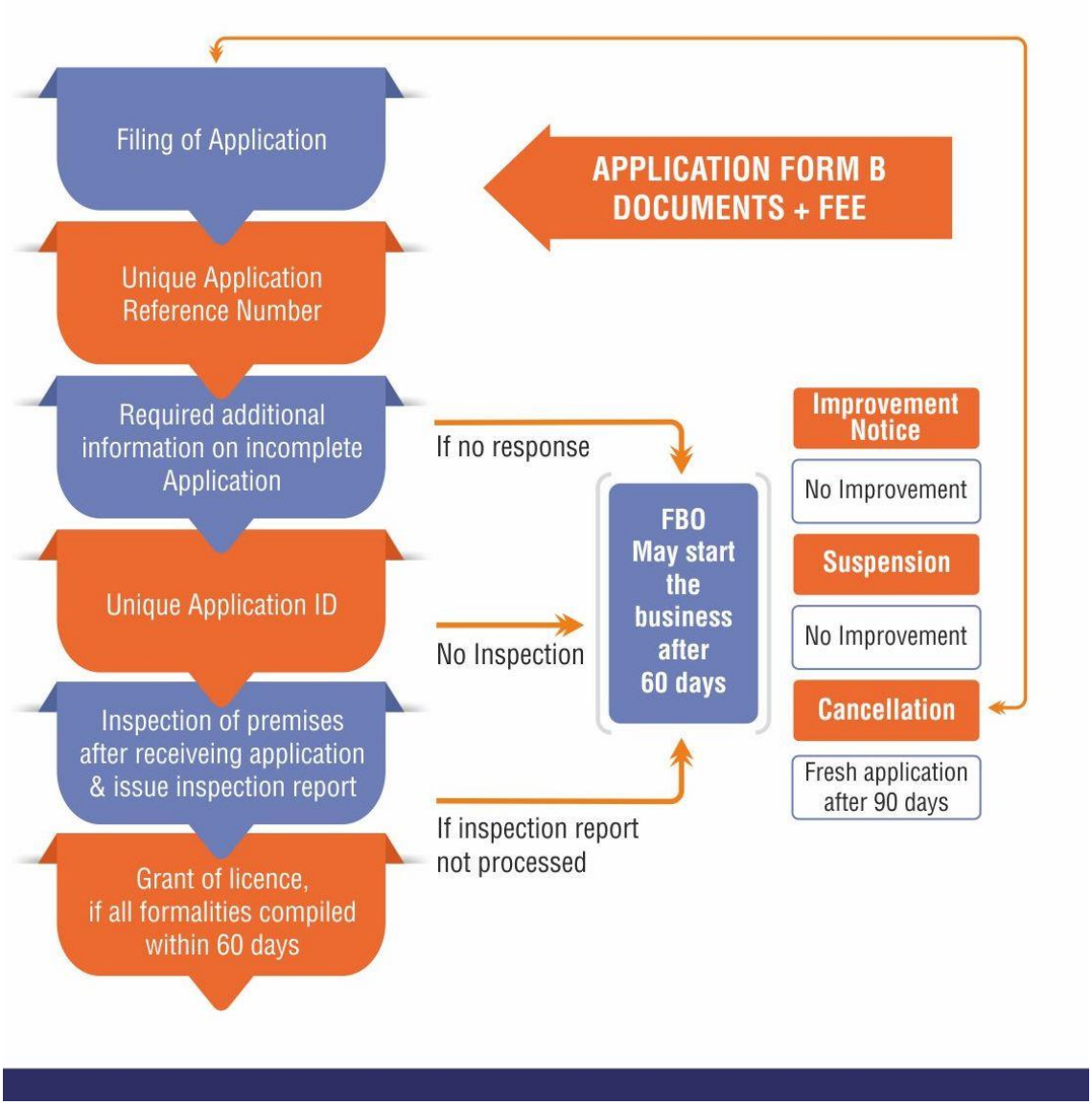
- Rationalization of required documents KoB wise instead of complete set of 29 documents indicated previously in FLRS application.
- Many document-based declarations revised to a check box online declaration.
- Clear segregation of KoBs in FoSCoS application. For e.g. nutraceuticals and novel food category has been added as a separate category of business under manufacturing.
- FoSCoS application has been enabled to seed business specific details such as PAN no., CIN no. and GSTnumbers to ensure 3600 profiling and validation of FBO

Currently, FoSCoS has been made live in 36 States/UTs. The detailed procedure and guidelines are available at https://foodlicensing.fssai.gov.in/index.aspx and https://foscos.fssai.gov.in

Procedure for registration of petty food manufacturer



Procedure for the application of license for food business



Suspension or cancellation of Registration Certificate or license

The registering or licensing authorities have right to suspend or cancel the license of food business if needed. According to section 32 of FSS act authority can suspend any registration or license in case of failure of any food firm to comply with the conditions within a period of improvement after giving a reasonable opportunity for the food business operator (FBO) to be heard. Following the suspension process the registering or licensing authority will have a direct inspection of food business premises within 14 days of the suspension order. The authority may cancel the registration or license if the FBO fails to meet the needs or conditions of improvement notice which lead to the suspension order. In addition to that the authority can also cancel the registration in special cases considering the public health

concerns. The FBO can apply a new license after three months from the cancellation of the license of food firm.

Validity and renewal of license

The registration or license granted by food authority valid for a period of 1-5 years from the date of issue if a license or registration as per the choice food business unless or otherwise specified. The application of renewal of license or registration should be made before 30 days prior to the expiry of the license; otherwise late fee of 100 should be remitted within the expiry of license. If the FBO failed to renew the license it will expire and he should stop all activities in the premises of food business and need to apply for a new license.

Offences and penalties

With food safety and standards gaining high priority, there is a definite opportunity to transform the food safety landscape in the country. Within the legal framework of the FSSA, there are provisions to enforce the standards by imposing penalties for noncompliance. A list of some of the important penalties are as follows:

Section (s) of FSSA, 2006	Type of Offence (s)	Who is Penalised	Penality may extend upto
50	Penalty for selling food not of the nature or substance or quality demanded	the Seller	Rs. 5 lakh
		the persons covered Section 31 (2) [e.g. petty manufacturer, petty retailer, hawker, small scale or cottage industry etc.]	Rs. 25000/-
51	Penalty for sub-standard food	any person who whether by himself or by any other person on his behalf manufactures for sale or stores or sells or distribute or imports any article of food for human consumption which is sub-standard	Rs. 5 lakh
52	Penalty for misbranded food	any person who whether by himself or by any other person on his behalf manufactures for sale or stores or sells or distribute or imports any article of food for human consumption which is misbranded	Rs. 3 lakh
53	Penalty for misleading advertisement	any person who publishes, or is a party to the publication of a misleading advertisement	Rs. 10 lakh
54	Penalty for food containing extraneous matter	On any person who whether by himself or by any other person on his behalf manufacturers for sale or stores or sells or distribute or imports any article	Rs. 1 lakh

		of food for human consumption containing extraneous matter	
55	Penalty for failure to comply with the directions of Food Safety Officer	On Food business operator or importer	Rs. 2 lakh
56	Penalty for unhygienic or unsanitary processing or manufacturing of food	any person who whether by himself or by any other person on his behalf manufacturers or processes any article of food for human consumption under unhygienic or unsanitary conditions	Rs. 1 lakh
57	Penalty for possessing adulterant	manufacture, sales, distribution or import of any adulterant:	
		- Where such adulterant is not injurious to health	Rs. 2 lakh
		- Where such adulterant is injurious to health	Rs. 10 lakh
58	Penalty for contraventions for which no specific penalty is provided	–	Rs. 2 lakh
59	Punishment for unsafe food	Such unsafe food:-	
		does not result in injury	6 Months and Rs 1 lakh
		results in non-grievous injury	1 year and Rs. 3 lakh
		results in grievous injury	6 Years and Rs. 5 Lakh
		results in death	Imprisonment shall not less than 7 years but extended up to lifetime and fine shall not be less than Rs. 10 lakh
60	Punishment for interfering with seized item	Interference, if done without permission of Food Safety Officer	6 Months and Rs. 2 lakh
61	Punishment for false information	Provide any information or produce any document knowing it to be false/ misleading	3 Months and Rs. 2 lakh
62	Punishment for obstructing or impersonating a Food Safety Officer		3 Months and Rs. 1 lakh
63	Punishment for	a person who is required to	6 Months and Rs. 5

	carrying out a business without license	obtain license under the Act	lakh
64	Punishment for subsequent offences	If any person, after having been previously convicted of an offence under this Act subsequently commits and is convicted of the same offence	Twice the punishment which might have been imposed on a first conviction, subject to the punishment being maximum provided for the same offence. If offence is continuing - Further, Daily fine which may extend up to Rs. 1 lakh. License shall be cancelled.
65	Compensation in case of injury or death of consumer	any person who whether by himself or by any other person on his behalf manufacturers or distributes or sells or imports any article of food for causing injury or death of the Consumer	Rs. 5 lakh in case of death. Rs. 3 lakh in case of grievous injury. Rs. 1 lakh, in all other cases of injury.
67	Penalty for contravention of provision of this Act in case of import of articles of food to be in addition to penalties provided under any other Act		In addition to FSS Act, 2006 may also be Liable under provisions of Foreign Trade (Development and Regulation) Act, 1992 and the Customs Act, 1962.

References

Ray. A., Joshi. J. and Gulati. K. 2016. *Regulatory Aspects of Nutraceuticals: An Indian Perspective*. *Nutraceuticals: Efficacy, Safety and Toxicity*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-802147-7.00068-1

Shukla, S., Shankar, R., and Singh, S. P. 2014. Food safety regulatory model in India. *Food Control*, *37*(1), 401–413. https://doi.org/10.1016/j.foodcont.2013.08.015

The Food Safety and Standards Act, 2006 (34 of 2006) 2019. Bare Act with Short Notes. Universal – LexisNexis publisher.

World Health Organization. Health topics: Foodborne diseases. http://www.who.int/topics/food borne diseases/en/ (last accessed: 29 Dec 2020).

Chapter 21

GMP/GHP and GLP practices relevant to fish and marine food processing

Dr. Pankaj Kishore
Scientist, Quality Assurance and Management Division
ICAR-Central Institute of Fisheries Technology, Cochin
Email: pkishore2007@gmail.com

Fish and fishery products are invaluable food commodity for human being. A high-quality protein and vital nutrients available resulting increment in consumption every year. The high nutritional quality and easy digestibility of fish favours almost all living organisms including bacteria. As a result, all organisms compete to consume fish and fishery products. Careless handling can become a source of toxic residues, poisons and different kinds of public health spoilage organisms like *Salmonella* species, pathogenic *Vibrio* species like *V. cholerae*, *V. parahaemolyticus*, *Listeria monocytogenes Staphylococcus aureus* etc. and cause various kinds of infectious diseases and food poisoning.

Various hazards associated with fish and fishery products are concern which must be taken care to avoid health problems. There are several quality assurance programmes evolved to keep fish and fishery products safe. Various kinds of quality standards like Codex standards, USFDA (United States Food and Drug Administration) standards, BSI (British Standards Institution) standards, FSSAI (Food Safety and Standards Authority of India) etc., HACCP (Hazard Analysis Critical Control Points) system of USA, European Commission Norms aimed to ensure safety and quality of fish and fishery products. The chance of failure to ensure both safety and quality, probably due to certain mistakes exempted in calibration, good laboratory practice, good hygienic practices etc. Certain measures need to be taken seriously at different steps in food production system ensures to achieve quality and safety of fishery products.

Quality system in India

Quality control began in India as a pre-shipment inspection before the products were exported to the other country. But, this inspection on quality was only based on random sampling of finished products. When the samples did not satisfy the quality standards, the entire lot of consignments were rejected resulting in great losses. The recent quality monitoring has the major difference, in that quality is monitored all through the steps of processing so that quality could be traced, or the system has traceability. In the initial stages of export of fishery products from India, heavy losses resulted since entire consignments were rejected by some countries due to bacterial contamination and spoilage. These prompted the Government of India to set up a fully equipped fish processing technology laboratory at Cochin (Kerala) in 1957 to initiate research on quality control and thus provide the much needed support for the seafood processing industry. The Govt. of India brought out a scheme

of voluntary pre-shipment inspection in 1963. At the same time, the Export Act (1963) was enacted by the Parliament of India under which Export Inspection Council was constituted under the Ministry of Commerce, Govt. of India. All export goods including the fishery products came under the purview of the Act resulting in compulsory pre-shipment inspection. The Export Inspection Council created the Export Inspection Agency to deal with the pre-shipment inspection of all fishery products as well as other agricultural products.

In any system of food production, possible sources of health risks or hazards arise from one or a combination of the following:

1) Raw materials

2) Production Process

3) Production facility (Plant and Machinery)

4) Personnel involved in Production

5) Cleanliness of direct/indirect food contact surfaces

6) Personnel hygiene

7) Pest control, and

8) Risk/hazard monitoring facilities (Laboratory)

All the possible areas that can contribute to physical, chemical or biological hazards into the food handled in a food processing establishment includes above factors. Therefore, the best method to achieve quality shall be stream lining and critically evaluating each one of the above sources to ensure that health hazards are not introduced at any of the above sources. This exercise needs the support and skill of a team of experts with a thorough knowledge of the raw materials, production processes, hygiene, sanitation and quality assurance. Careful selection of persons responsible for purchase, production, quality, etc. can help in fulfilling this responsibility. The team shall have the skill and expertise to identify possible significant hazards like physical, chemical and biological that can be associated with the raw materials, processing steps, plant and workers. The team shall also be in a position to provide suitable remedial measures to exclude possible hazards from each and every source.

The CODEX of GMP/GHP includes specific aims and objectives:

• To identify the essential principles of food hygiene, applicable throughout the food chain (including primary production through to the final consumer), to achieve the safety of food and suitability for human consumption

• To recommend a HACCP-based approach as a means to enhance food safety

• To indicate how to implement its principles

• To provide a guidance for specific codes which may be needed (for all sectors of the food chain) and to amplify the hygiene requirements specific to those areas.

Good Manufacturing Practice (GMP)/Good Hygienic Practices (GHP)

GMP/GHP is defined as all practices regarding conditions and measures necessary to ensure safety and suitability (quality) of food at all stages of the food chain. This is largely the procedure laid down for achieving safety from plant, machinery and other infrastructure used in the production. The important elements of Good Manufacturing Practice are listed below:

1) Plant design, construction and layout:

In any production plant, there will be raw materials and finished products as well as one or many intermediate products. The plant design shall be such that the movement of edible materials from raw materials stage to the finished products stage is unidirectional and opposite to the movement of waste materials like solid wastes and liquid effluents. Another aspect of the plant design and construction is the nature of the materials used for the construction and the type of construction. All materials used shall be water resistant, washable and with a smooth surface. Further, the construction shall be such that there is no sharp corners, and all wall to wall, wall to floor and wall to roof joints are round and smoothened. The design shall take care to provide fly proofing of all external openings like doors, windows, ventilators, chute doors and drain outlets. In fact, the safety at drain outlets shall be such that there is no chance for any solid particles to go out as well as no fly can enter into the food handling areas. The plant will also need several electrical and mechanical fittings. All such items shall be washable and laid out in such a way that there is no scope for pest/microbial harbourage.

2) Machinery design, construction and layout

Like plant, machinery too shall be designed, constructed and installed to facilitate unidirectional movement of food materials and that the machinery is water resistant, washable and subitizable. All the machinery shall also be in a position to achieve criteria for good manufacturing practice. For example, the machinery for quick freezing shall be in a position to freeze the food in such a way that the core of the food attains $-18\pm2^{o}C$ in 90 minutes. Similarly, equipments for cooking shall be able to attain the validated cooking temperature and time without causing under or over cooking. Selection and installation of processing machinery in this way will exclude all possible health risks from machinery.

3) Provision for pest control

The provision for pest control is often a neglected item. Pest can be the cause for both dirt and contamination with microbes of public health significance. Exclusion of pests is best done by providing fly proof netting for all windows and ventilators as well as providing automatic air curtain and self-closing shutters for all doors and chutes directly opening to outside. There shall also be fly proof netting for drain outlets. Further, to take care of any pest by-passing these facilities, there can be electrical fly catchers and rodent traps at strategic locations. Effective operation of these facilities will make food-handling areas free from pests.

For pest control, there shall not be any chemical based pest control procedures. In rodent traps, the baits shall be only food items like dried and baked coconut or fish. Poison baits shall never be used for rodent control in food processing plants. In case, there is any unusual fly population, fumigation with formaldehyde followed by defumigation with ammonia can be followed. However, there shall not be a regular schedule for fumigation as it may introduce unwanted chemical residues into the food material handled in the plant.

4) Personnel Involved in Production

Workers or plant personnel are the most dynamic source of various type of microbial contamination in any food-processing establishment. In case of food materials from land and inland water bodies, there is every chance of occurrence of organisms of public health significance. But in case of seafood, the occurrence of Public Health Indicator organisms is a sure indication of poor hygiene and sanitation. To exclude such contamination from workers, all personnel in the production unit shall follow good hygiene practice.

a) Medical Fitness of workers- Medical examination to certify the workers is an exercise to be done without failure once in a year. Workers must be examined by a qualified medical

practitioner to rule out that the worker is not suffering from any disease. A doctor can do this by physical examination and certain investigations on blood, urine and stool. These tests exclude the possibility of the worker as a carrier of certain pathogens especially *Salmonella* and *Vibrio cholerae*, and it will ensure that the worker is fit to handle food materials.

b) Use of clean uniform including gum boots, head cover, face mask and gloves

c) Removal of ornaments and other beauty aids

d) Scrubbing of hands with soap and clean water

e) Sanitized footwear using a foot dip containing 100 ppm

f) Hand sanitizing by dipping the full palm of both hands in 20 ppm of chlorine water

5) Cleanliness of Direct/Indirect Food Contact Surfaces

The cleanliness of direct and indirect food contact surfaces is responsible for contamination of food. There shall be identification and listing of all food contact and non-contact surfaces followed by a cleaning procedure and cleaning schedule. All these operations are popularly known as “Standard Sanitation Operation Procedure” (SSOP).

The following are the main elements of SSOP:

- Safety of the water that comes into contact with food or food contact surfaces, or is used in the manufacture of ice
- Condition and cleanliness of food contact surfaces, including utensils, gloves and outer garments
- Prevention of cross-contamination from insanitary objects to food; food packaging material; and other food contact surfaces including utensils, gloves and outer garments; and from raw product to cooked product
- Maintenance of hand washing, hand sanitizing and toilet facilities
- Protection of food, food packaging material and food contact surfaces from adulteration with lubricants, fuel, pesticides, cleaning compounds, sanitizing agents, condensate and other chemical, physical and biological contaminants
- Proper labelling, storage and use of toxic compounds
- Control of employee health conditions that could result in the microbiological contamination of food, food packaging materials and food contact surfaces
- Exclusion of pests from the food plant

6) Risk/Hazard Monitoring Facilities

The success of all the above processes and procedures in a food plant will depend on the facilities of the laboratory. In fact, the laboratory shall have all test methods and testing equipment in par with the national and international requirements.

7) Traceability and recall procedures

A system for tracing all raw materials and finished products is a necessary component in a prerequisite programme. No process is fail-safe and traceability that includes lot identification is essential to an effective recall procedure. A crisis response plan should be in place to handle any incidents.

Appropriate records of processing, production and distribution should be kept and retained for a period that exceeds the shelf life of the product. Where there is a health hazard, products produced under similar conditions may be withdrawn. The need for public warning should be considered. Once retrieved, products must be held under supervision until the manner of product disposition e.g. rework or destruction has been determined.

8) Training

All employees should receive documented training on personal hygiene, GHP, cleaning and disinfection procedures, product handling and protection, the HACCP-system and process control. Periodic refresher training should be part of the overall training programme. Training in basic food hygiene is fundamentally important. All personnel should be aware of their roles and responsibilities in protecting fish and the fish products from contamination and deterioration.

Good Laboratory Practices (GLPs)

Good Laboratory Practices (GLPs) define the rules and criteria for a quality system concerned with the organizational process and the conditions under which non-clinical health and environmental safety studies are planned, performed, monitored, recorded and reported.

General Principles of the good laboratory practices-

a) Management's Responsibilities

Most of the responsibilities of test facility management are of a general nature, such as the requirements that test facility management has to ensure the availability of qualified personnel and of appropriate facilities and equipment for the timely and proper conduct of the study. Furthermore, it has to ensure that health and safety precautions are applied according to national and/or international regulations; appropriate Standard Operating Procedures are established and followed, etc.

b) Laboratory Head's Responsibilities

The study director continues to be the single point of study control and has the responsibility for the overall conduct and reporting of the study. He/she should agree to the study plan and ensure that the procedures specified in the study plan are followed.

c) Personnel Responsibilities

Personnel should exercise safe working practice and health precautions; the chemicals should be handled with suitable caution until their hazard(s) has been established. Personnel known to have a health or medicinal condition that is likely to have an adverse effect on the study should be excluded from operations that may affect the study.

d) Facilities

The GLP Principles mandate in general that test facilities should be of suitable size, construction and location to meet the requirements of the studies performed therein, and an adequate degree of separation should be provided between the different activities to ensure the proper conduct of each study.

e) Apparatus, material, and reagents

Apparatus should be suitably located, be of appropriate design and adequate capacity, and should be periodically inspected, cleaned, maintained and calibrated according to SOPs. Apparatus and materials should not interfere with the test systems, and reagents should be properly labelled.

f) Test Systems

All the methods used by the lab shall be approved methods by national or international agencies, like BIS standards (Bureau of Indian Standards), EU (European Union) Norms, US FDA (United States Food and Drug Administration) Guides and Codex. Under no circumstances, unapproved procedures shall be used for monitoring any process/quality parameter.

In case of physical/chemical test systems, the used apparatus should be properly located and have appropriate design and capacity. Reference substances should be used to ensure the integrity of the test systems and considering biological test systems the housing, handling and care of animals, plants, microbial as well as other cellular and sub-cellular systems should be carried out under proper conditions to ensure the quality of the data.

- Test and Reference Substances

All the records referring to test and reference substances should be maintained; handling, sampling, and storage procedures as well as the test and reference substances should be identified. The stability of test and reference substances under storage and test condition should be known.

Standard Operating Procedures

Standard Operating Procedures (SOPs) should be elaborated for test facilities, and there should be immediately available SOPs for each separate laboratory unit.

- Performance of the Study

Prior to initiation of a study, a study plan should exist. It should be retained as raw data, and the study should be conducted according to it. The proper form and content of a study plan is specified in the Principles of GLP.

- Reporting of Study Results

For each study a final report should be prepared by using the International System of Units (SI). It is the task of the Study Director and perhaps of principal scientists from co-operating disciplines to sign and date the final report.

- Storage and Retention of Records and Material

The proper way of storing and retention of any records and material (e.g. study plans, raw data, final reports, samples and specimens, etc.) must be in place.

Conclusion:

The increasing demand of consumers for fish and fishery products, and the internationalization of the food supply generally have created an increased need for regulatory inspection and control of imported foods. The establishment of GMP in a plant will make organized and documented system for whole production along with Improvement of the quality of products. The final product will meet consumer requirements and improves the efficiency. Proper management of waste will protect the environment. GLP sets good practice to perform work in compliance with standardize procedures worldwide. The food production chain must be included in the planning and implementation of comprehensive food safety efforts. Government officials should develop and support partnerships and joint activities with the food industry and with consumers in pursuit of the goal of delivery of safe food to consumers.

References

- FAO, 2003. Assessment and Management of Seafood Safety and Quality, Eds: H.H. Huss, L. Ababouch and L. Gram, Fisheries Technical Paper 444, Food and Agriculture Organization of the United Nations, Rome.
- FDA, 2005. Food Current Good Manufacturing Practice Modernization Report (2005), Food and Drug Administration, Rockville, MD, USA.
- Gopakumar, K. 2002. Textbook on Fish Processing Technology, Indian Council of Agricultural Research, New Delhi.
- IS 16021:2012 Indian Standard on GOOD MANUFACTURING PRACTICES (GMP) — Requirements For Organizations In The Food Processing Sector, Bureau of Indian Standards, New Delhi, India.

Chapter 22

Regulations and standards for maintaining safety and quality of fish products - FSSAI and International standards

Dr. Satyen Kumar Panda
Principal Scientist
Quality Assurance and Management Division
ICAR-Central Institute of Fisheries Technology, Cochin
Email: satyenpanda@gmail.com

Fish has been an important component of Indian food basket that contributes to the overall food and nutritional security of India. Considering its immense contribution to livelihood security and export earnings, fisheries sector has rightfully gained prominence under government initiated programmes. With an ambitious goal of exporting 1 lakh crore rupees worth seafood by 2024-25 and increasing domestic fish consumption, this sector is facing an uphill task of compliance with regulatory food safety requirements and institutionalizing safety norms across the whole value chain.

Major food safety issues in this sector have been high levels of human pathogenic bacteria in primary production, parasitic infections, residues of agro-chemicals, veterinary drugs and heavy metal contamination. Inappropriate aquaculture practices, environmental pollution and cultural habits of food preparation and consumption also contribute to build-up of hazards in fishery products.

In absence of etiological data linked to seafood, the export rejection figures provides an indirect account of food safety hazards associated with seafood. Import refusals and rejections from countries like USA, Japan, Russia and EU are on the rise because of presence of biological and chemical hazards in seafood, leading to heavy economic loss by seafood industries. The most common import refusal of seafood by USA is due to presence of *Salmonella*, Listeria, filth or illegal veterinary drugs. The RASFF portal of EU indicates alert notifications due to presence of veterinary drug residues, heavy metals, histamine, foreign bodies, biotoxin, defective packaging, incorrect labelling, improper health certificate, unapproved colour and additives and organoleptic aspects. In recent months most of the rejections from Japan had been due to presence of furazolidone (AOZ) and Ethoxyquin in shrimp. Seafood rejections from Russia are mostly due to presence of high load of mesophilic bacteria, coliforms, pathogens and presence of crystal violet.

Genesis of Food Safety Standards and Regulations

Food safety standards can be classified as regulatory, voluntary, Government/Statutory, private, domestic, international or benchmarked depending upon its scope and range of application. Most of these standards have evolved based upon sanitary and phyto-sanitary (SPS) requirements, economic interest, risk analysis or as precautionary approach. The precautionary approach mostly relies on perception i.e. equivalent level of protection, appropriate level of protection (ALOP) or as low as reasonably achievable (ALARA).

In international trade, sanitary and phytosanitary measures are envisioned to be based on sound scientific principles that ensure food safety and do not anyway compromise the production potential and resources of a particular country. These measures should not be linked to prevent market access based on non-scientific reasons, and are requirements but not sufficient condition of trade. As per the Annex A of WTO Agreement, Sanitary and phytosanitary measures are applied to (i) protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms (ii) to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs (iii) from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests and (iv) to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests. WTO encourages members to use accepted International standards by Codex Alimentarius Commission, OIE (World Organization for Animal Health) and IPPC (International Plant Protection Convention). Countries may introduce or maintain SPS measures that provide higher level of protection than the current international or Codex standards.

Food Safety and Standards Authority of India (FSSAI)

The Food Safety and Standards Authority of India was established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption. Various central acts including the erstwhile Prevention of Food Adulteration Act (1954) were merged under this act.

Food Safety and Standards Act, 2006

- To consolidate laws relating to food
- To establish Food Safety and Standards Authority of India for
  - Laying down science based standards for articles of food
  - To regulate their manufacture, storage, distribution, sale and import of food
  - To ensure availability of safe and wholesome food for human consumption

Salient Features of FSS Act, 2006

- Defines the concept of substandard and unsafe food
- Emphasizes the need of risk assessment, not trade restrictive
- Provisions related to functional and novel food
- Prescribes graded penalties for offences and violations
- Improvement notices

The Food Safety and Standards Regulations (FSSR) came into force in 2011, which is divided to following sections:

- Food Safety and Standards (Licensing and Registration of Food businesses) regulation, 2011
- Food Safety and Standards (Food product standards and Food Additives) regulation, 2011
- Food Safety and Standards (Prohibition and Restriction on sales) regulation, 2011
- Food Safety and Standards (Packaging and Labelling) regulation, 2011
- Food Safety and Standards (contaminants, toxins and residues) regulation, 2011
- Food Safety and Standards (Laboratory and Sampling Analysis) Regulation, 2011
- Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel Food) Regulations, 2016
- Food Safety and Standards (Food Recall Procedure) Regulation, 2017
- Food Safety and Standards (Import) Regulation, 2017
- Food Safety and Standards (Approval for Non-Specific Food and Food Ingredients) Regulation, 2017
- Food Safety and Standards (Organic Food) Regulation, 2017
- Food Safety and Standards (Alcoholic Beverages) Regulation, 2018
- Food Safety and Standards (Fortification of Food) Regulation, 2018
- Food Safety and Standards (Food Safety Auditing) Regulation, 2018
- Food Safety and Standards (Recognition and Notification of Laboratories) Regulation, 2018
- Food Safety and Standards (Advertising and Claims) Regulation, 2018
- Food Safety and Standards (Packaging) Regulation, 2018
- Food Safety and Standards (Recovery and Distribution of Surplus food) Regulation, 2019
- Gazette Notification no. F. No. 15(1) 2016/School Children Regulation/Enf/FSSAI dated 04.09.2020 on the Food Safety and Standards (Safe food and balanced diets for children in school) Regulations, 2020
- Food Safety and Standards (Foods for Infant Nutrition) Regulations, 2020
- Food Safety and Standards (Labelling and Display) Regulations, 2020.

Vertical standards as per FSSR

The vertical standards of fish and fishery products are mentioned in section 2.6 of Food Safety and Standards (Food product standards and Food Additives) regulation, 2011. The various commodities covered in this section includes: Frozen shrimp; Frozen lobsters; Frozen squid and parts of squid; Frozen finfish; Frozen fish fillets; Dried shark fins; Salted fish/dried salted fish; Canned Fishery Products; Frozen cephalopods; Smoked fishery products; Ready –to-Eat Finfish or Shell Fish Curry in Retortable Pouches; Sardine Oil; Edible Fish Powder; Fish Pickle; Frozen Minced Fish Meat; Freeze dried prawns; Frozen clam meat; Live and Raw Bivalve Molluscs; Sturgeon caviar; Fish sauce; Quick Frozen Fish Sticks (fish fingers), Fish Portions and Fish Fillets - Breaded or Battered; Fresh and Quick Frozen Raw Scallop Products.

The vertical standards provides specific requirements of various categories of fishery products. For example, salted fish/dried salted fish the requirements specified are water activity (0.78, max.), salt content (12%, min.), histamine content (200 ppm) and acid

insoluble ash (1%, max.). For canned fishery products, specifications have been laid down for drained weight, % of water in the drained liquid, disintegrated portion, vacuum, head space, % of Sodium chloride and acidity of brine. For freeze dried shrimps, the maximum moisture content is specified as 2% with 300% extent of rehydration.

Fish Sauce

- **Total Nitrogen Content: Not less than 10g/l**
- **Amino acid N content: Not less than 40% of total N**
- **pH: 4.5-6.5**
- **Salt: Not less than 200g/l**

Fish Pickle

- **Fluid portion (%) by weight, max.: 40**
- **pH: 4.0-4.5**
- **Acidity as acetic acid of fluid portion % by weight, max.: 2.5-3.0**
- **Sodium chloride % by weight, max.: 12**

There are also specific quality related specifications for other categories of products.

Additives in Fishery products as per FSSR

The additive requirements in various categories of fishery products are specified in Table 9.0-9.5 of **Food Safety and Standards** (Food product standards and Food Additives) regulation, 2011. This regulation has been harmonised mostly with Codex General Standards of Food Additives with certain modifications. For example, no additives are permitted in fresh fish and fish products, except sulphites (100 ppm, max in crustaceans).

Microbiological Specifications as per FSSR

The microbiological specifications for 16 categories of fish and fishery products are given in Table 1A and Table 1B of Annex II of **Food Safety and Standards** (Food product standards and Food Additives) regulation, 2011. Two different kinds of criteria are followed in FSSAI regulations

Food safety criterion: a criterion defining the acceptability of a product or a batch of foodstuff applicable to products ready to be placed on the market or which are already in the market.

Ex.: Aerobic Plate Count; Coagulase Positive Staphylococci, Yeast and Mold Count

Process hygiene criterion: A criterion indicating the acceptable functioning of the production process. It sets an indicative contamination value above which corrective actions are required in order to maintain the hygiene of the process in compliance with food law

Ex.*: Escherichia coli, Listeria monocytogenes, Vibrio cholerae* (O1 and O139), *Clostridium botulinum*

Non-compliance for process hygiene criteria leads to corrective action in processing or handling, whereas that for food safety criteria leads to rejection or withdrawal from market.

Limit of heavy metal, other contaminants and toxins as per FSSR

Limit of heavy metals such as lead, cadmium, mercury, arsenic, chromium and tin are specified in **Food Safety and Standards** (contaminants, toxins and residues) regulation, 2011.

Lead	Cadmium	Mercury
Finfish: 0.3 ppm Crustaceans: 0.5 ppm Cephalopods: 1.0 ppm Bivalve Molluscs: 1.5 ppm Canned Fish: 5.0 ppm	Finfish: 0.3 ppm Crustaceans: 0.5 ppm Cephalopods: 2.0 ppm Bivalve Molluscs: 2.0 ppm	Non-predatory Fish: 0.5 ppm Predatory Fish (Tuna, Marlin, Sword Fish, Elasmobranch): 1.0 ppm Crustaceans: 0.5 ppm Cephalopods: 0.5 ppm Bivalve Molluscs: 0.5 ppm **Methyl Mercury** (Calculated as the element): 0.25 ppm

Arsenic	Chromium	Tin
Finfish: 76 Crustaceans: 76 ppm Molluscs: 86 ppm	All fishery products: 12 ppm	Canned Fish: 200 ppm

The limit of Polychlorinated biphenyls (Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180) for inland and migratory fish is 2.0 ppm, whereas it is 0.5 ppm for marine fish, crustaceans and molluscs. The limit of Benzo(a) pyrene in smoked fishery product is 5 ppb.

FSSR also specifies limit for marine biotoxins (paralytic shellfish poisoning, Diarrhetic Shellfish Poison, Amnesic shellfish poison, Azaspiracid shellfish poison and Brevetoxin) for bivalve molluscs.

In FSSR, 144 species of fishes belonging to 10 families (Carangidae, Chanidae, Clupeidae, Coryphaenidae, Engraulidae, Istiophoridae, Mugilidae, Pristigasteridae, Scombridae and Xiphiidae) are notified as potential species to cause Histamine fish poisoning. The limit of histamine is specified for 11 categories of fishery products. The limits are in the range of 100-200 ppm for most of the products, except for dried, fermented and fish pickles where limits are in the range of 200-400 ppm.

Although there are no approved use of pesticides in aquaculture, pesticide contamination is a greater issue as water serves as sink for all contaminants. The current FSSR specifically mentions carbaryl (0.2 ppm) and quinalphos (0.01 ppm). For all other pesticides a default tolerance level of 0.01 ppm is followed.

For veterinary drugs (including antibiotic residues), a separate list of prohibited compounds is given in FSSR. Maximum residue limits are given for Ampicillin: 0.01 ppm in Fish, Amoxicillin: 0.05 ppm (Fish Fillet and Muscle), Cloxacillin: 0.01 ppm (All fish), Chlortetracycline/Oxytetra cycline/Tetracycline: 0.2 ppm (Prawn and Shrimp), Flumequine: 0.5 ppm (Trout), Sulfadiazine: 0.01 ppm (All fish) and Sulfanilamide: 0.01 ppm (All fish).

International Regulations

Fish and fishery products are one of the highly traded commodity across the globe (US$163 billion). Around 37% of global fish production enters international trade, out of

which 75% imported by developed nations and 50% are exported by developing nations. Keeping in view the food safety requirements of different countries many international regulations are in place.

Codex Alimentarius Commission

CAC has the mandate to formulate food standards, code of practice, guidelines and recommendations to protect health of consumers, Ensure fair practices in food trade and to promote coordination of all food standards work undertaken by international governmental and non-governmental organizations. There are more than 22 codex standards for fish and fishery products, apart from code of practices, and specific guidelines.

European Union

European Union is the biggest importer of fish and fishery products in the world. The food safety regulations set by EU is harmonised, gets periodically updated, transparent and based on principles of risk assessment. The key elements of EU requirements for import of seafood are (a) certification by a competent authority (b) compliance to hygiene and public health requirements in terms of structure of vessels, landing sites, processing establishments and on operational processes, freezing and storage (c) certified production area for bivalves (d) national control plan on heavy metals, contaminants, residues of pesticides and veterinary drugs (e) approval of establishments. The legal acts of EU are managed through regulations, directives, decision, recommendations and opinions.

USA

In USA both Federal and State Regulatory agencies are involved in ensuring safety and quality of seafood. Multiple federal agencies such as USDA, USFWS, NOAA and USFDA are involved in regulatory oversight of seafood for both importation and export. The U.S. Food and Drug Administration (USFDA) is vested with the primary Federal responsibility for the safety of seafood products in the United States. It operates a mandatory safety program for all fish and fishery products under the provisions of the Federal Food, Drug and Cosmetic (FD&C) Act, the Public Health Service Act, and related regulations. The most important regulation enacted by USFDA was "Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products" published as final rule 21 CFR 123 on 18th December 1995 and came into force on 18th December 1997. It required processors to adopt the preventive system of food safety controls known as HACCP (Hazard Analysis and Critical Control Point). Seafood was the first food commodity in the U.S. to adopt HACCP in USA. Food Safety and Modernization Act (FSMA) which came into existence in 2011 strengthens the existing regulatory scenario for imported seafood.

Other countries

Other major importing countries such as China, Japan, Russia, Australia and SE Asian countries have also specific requirements for import of fish and fishery products. Japan uses a positive list system for MRL of agricultural chemicals in foods. The hygienic requirements in Russian regulations are different from other countries as some of the microbiological parameters are expressed as absent in 0.001g or 0.01g. In recent years China has strengthened its SPS measures and has taken a number of precautionary steps to ensure safety to its population.

References

- FSSAI (2020). Food Safety and Standard Regulations (FSSR) Available at https://fssai.gov.in/cms/food-safety-and-standards-regulations.php, accessed on 06.01.2021
- DG SANTE, EU (2021). EU food safety legislation. Available at https://ec.europa.eu/food/safety_en, accessed on 06.01.2021
- FDA (2020). Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition. U.S. Department of Health and Human Services Food and Drug Administration and Center for Food Safety and Applied Nutrition. Available at https://www.fda.gov/media/80637/download, accessed on 06.01.2021

Chapter 23

HACCP implementation for fishery products

Dr. Devananda Uchoi
Scientist, Quality Assurance & Management Division, ICAR-CIFT
Email: uchoidev514@gmail.com

Introduction

In current times, food safety remains a major concern facing the seafood industry, and it is a critical component in ensuring food and nutrition security worldwide. The production and consumption of safe food are central to any society, and they have a wide range of economic, social and, in many cases, environmental consequences. The issue of seafood safety is even more important in view of the growth in international fish trade, which has undergone tremendous expansion in the last three decades, increasing from US$8 billion in 1976 to a record export value of US$ 102.5 billion in 2010 and to a recent record of US$ 164 billion in 2018 (FAO, 2020). In the new millennium, seafood production and distribution are globalized and even more complex. The advent of emerging pathogens and the impacts of climate change on seafood safety are adding to this complexity. The media and consumers have developed a much greater interest in seafood safety issues owing to the continuing incidence of food scares. The advent of the Hazard Analysis and Critical Control Points (HACCP) system in recent decades has provided a single system that has now been adopted by international bodies and trading countries and regions to control seafood safety.

However, there are important foundations to be put in place before implementing the HACCP system. International organizations have defined the importance of so-called prerequisite programmes, and this clearly differentiates the prerequisite programmes from the HACCP system – something that is always not fully appreciated by processors in many countries. Moreover, various bodies have defined what is required in these "pre-HACCP" operations and, while there is overlap, they do differ. This lack of a universally agreed set of operations prior to implementing HACCP has possibly given rise to the lack of consistency in documentation and implementation of these procedures when compared with the very structured approach offered by the 12 steps of the HACCP system. In the present decade, the International Organization for Standardization (ISO) has developed the ISO 22000 family of standards on food safety management systems. It takes the approach of ISO 9001 as a management system, and incorporates the hygiene measures of prerequisite programmes and the HACCP principles and criteria.

The frameworks for ensuring food safety in the international context are provided by: (i) the World Trade Organization (WTO) under two binding agreements (the Agreement on the Application of Sanitary and Phytosanitary Measures [SPS Agreement] and the Agreement on Technical Barriers to Trade [TBT Agreement]); (ii) the Codex Alimentarius Commission (CAC) through various instruments, for example, the Code of Practice for Fish and Fishery

Products and the basics texts on Food Hygiene; and (iii) the FAO Code of Conduct for Responsible Fisheries (the Code), especially under Article 6 (General principles, provisions 6.7 and 6.14) and Article 11 (Post-harvest practices and trade), both of which are of particular relevance to fish trade, safety and quality. The public health significance of seafood-borne illnesses depends on the likelihood and the severity of the illness. The concept of "risk analysis" has become the method for establishing tolerable levels of hazards in foods in international trade and, equally, within national jurisdictions.

In the current international food safety management environment, the risk is expressed as "food safety objectives" in order to achieve what is called an "appropriate level of protection" or ALOP for populations. The consumer's awareness and demand in respect to food safety is growing enormously day by day. Food-borne illness caused by various hazards viz. physical, chemical, biological or allergens across the world lead to make processes for the good human health. Each year, millions of illnesses can be attributed to contaminated food. Hence a food safety action aimed at ensuring that all food is as safe as possible is must. Food safety policies and actions need to cover the entire food chain, from production to consumption. Food safety in the beginning of twenty-first century is an international challenge requiring close cooperation between countries in agreeing standards and in setting up transnational surveillance systems. The behaviour of consumers has been gradually changing. They currently require not only much higher dietary quality, hygiene and health standards in the products they purchase, but they also look for certification and reassurance of products' origins (national or geographical) and production methods. HACCP or Hazard Analysis Critical Control Points is a scientific and systematic approach to identify, assess and control hazards in the food production process. With the HACCP system, food safety control is integrated into the design of the process rather than relied on end-product testing. Therefore HACCP system provides a preventive and thus cost-effective approach in food safety.

HACCP Concept

The Hazard Analysis Critical Control Point (HACCP) system identifies, evaluates and controls hazards that are significant for food safety. HACCP is a team work. It is not a standalone programme. It requires firm commitment from top management level for effective implementation. HACCP does not assure zero risk. It is a systematic tool to minimize risk of food safety hazards. HACCP plan once developed doesn't mean it is the ultimate plan. It needs to be modified whenever required. HACCP is a continuous process and is mainly risk based. HACCP need to be implemented from farm to fork. HACCP programme is a sum total of PRP, OPRP, GMP, SOP, SSOP, GHP and GAP. HACCP do functions based on scientific approach.

It is important to always remember that the establishment of effective HACCP programs involves primarily the application of good common sense and preventive considerations to address situations before they become problems. The emphasis is on forecast rather than reaction, on getting the process right initially rather than correcting it after problems have occurred. It emphasized on identifying potential food safety problems and determining how and where these can be controlled or prevented. Describing what to do and training the personnel, implementation, recording and assurance throughout the food chain are taken care under HACCP system.

The objectives of HACCP

- Prevention of foodborne illness
- Reduction of losses due to product recall

- Protection of reputation
- Reduction of costs of food analysis
- More efficient quality assurance system
- Focuses on identifying and preventing hazards from contaminating food, based on sound science.
- Permits more efficient and effective government oversight, primarily because record keeping allows investigators to see how well a firm is complying with food safety laws over a period, rather than how well it is doing on any given day.
- Helps food companies to compete more effectively in the world market.
- Reduces barriers to international trade.

Importance of HACCP

- Identify potential hazards and apply effective steps to control them in food production.
- All type of hazards such as microbiological, chemical and physical can be reduced to a large extent, thereby enabling industries to produce safe food product for the consumers.
- HACCP helps to gain consumer's trust upon food processing unit which are effectively implementing the principles.
- HACCP does not rely on end product testing.
- Improve food safety, increase market access, protection against liability, drive for continuous improvement and enhance process control.

An effective food safety assurance method is required due to emergence of foodborne pathogens and foodborne diseases which has widespread public health problem. Increased knowledge and awareness of the serious and chronic health effects associated with unsafe food products had made HACCP indispensible in all exporting food processing industries. An effective food safety assurance method such as HACCP is important due to the followings;

- New food technologies and processing methods are introduced now and then
- Increased awareness of the economic consequences of foodborne illness
- Increase in the number of vulnerable people
- Industrialization and mass production
- Urbanization
- Changing lifestyle
- Increase of tourism and international trade in foodstuffs
- Increase of consumer awareness on food safety
- Increase in incidence of food poisoning and toxicity
- Increasing cases of food adulteration and food fraud, etc.

Implementation of HACCP in fish and fishery products

Several stages are involved in implementation of HACCP in any food, including fish and fishery products. These are pre-requisite programme, HACCP plans, preliminary steps and the seven principles.

Pre-requisite programmes

PRP such as SOP, SSOP, GMP, etc. are implemented prior to HACCP plans. PRP focus on employees, facilities and equipment and deals with illness policy, cleaning and sanitizing procedures, garbage removal, pest control, equipment selection, employee hygiene. It also deals with control of harvest operation and the overall plant environment which are not

directly related to food (e.g. water quality, transportation and storage, plant sanitation, employee training, etc.).

The SSOPs should address at least the following eight conditions and practices:

- Safety of water and ice;
- Condition and cleanliness of food contact surfaces;
- Prevention of cross-contamination from unsanitary objects to food;
- Maintenance of facilities for personal hygiene;
- Protection of food, food packaging and food contact surfaces from adulteration;
- Proper labeling, storage and use of toxic compounds;
- Control of employee health conditions;
- Exclusion of pests.

According to the Code of Practice for Fish and Fishery Products (CPFFP), the following aspects should be included in the prerequisite programme:

- Fishing and harvesting vessel design and construction;
- Facility design and construction;
- Design and construction of equipment and utensils;
- Hygiene control programme;
- Personal hygiene and health;
- Transportation;
- Product tracing and recall procedures;
- Training.

1. Fishing and harvesting vessel design and construction

The design and construction of a fishing vessel and of vessels used to harvest farmed fish and shellfish should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination
- Minimize damage to the fish, shellfish and other aquatic invertebrates
- Minimize damage during harvesting of farmed and molluscan shellfish

2. Facility design and construction

The food facility should provide:

- Adequate space for equipment, installations and storage of materials;
- Separation of operations, where needed, to avoid cross-contamination;
- Adequate lightning and ventilation;
- Protection against pests.

The design and construction of a facility should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination

3. Design and construction of equipment and utensils

The design and construction of equipment and utensils should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination
- Minimize damage

4. Hygiene control programme

The hygiene control programme should take into consideration the following points:

- A cleaning and disinfection schedule
- Designation of personnel for cleaning

5. Personal hygiene and health

Personal hygiene and facilities should be such to ensure that an appropriate degree of personal hygiene can be maintained to avoid contamination.

6. Transportation

Vehicles should be designed and constructed:

- Such that walls, floors and ceilings, where appropriate, are made of a suitable corrosion-resistant material with smooth non-absorbent surfaces. Floors should be adequately drained.
- Where appropriate, with chilling equipment to maintain chilled fish or shellfish during transport to a temperature as close as possible to 0 °C or, for frozen fish, shellfish and their products, to maintain a temperature of –18 °C or colder (except for brine frozen fish intended for canning, which may be transported at –9 °C or colder).
- Live fish and shellfish are to be transported at temperatures that the species can tolerate.
- To provide the fish or shellfish with protection against contamination, exposure to extreme temperatures and the drying effects of the sun or wind.
- To permit the free flow of chilled air around the load when fitted with mechanical refrigeration means.

7. Product tracing and recall procedures

Experience has demonstrated that a system for recall of product is a necessary component of a prerequisite programme. Product tracing, which includes lot identification, is essential to an effective recall procedure. Therefore:

- Managers should ensure effective procedures are in place to effect the complete product tracing and rapid recall of any lot of fishery product from the market.
- Appropriate records of processing, production and distribution should be kept and retained for a period that exceeds the shelf-life of the product.
- Each container of fish, shellfish and their products intended for the final consumer or for further processing should be clearly marked to ensure the identification of the producer and of the lot.
- Where there is a health hazard, products produced under similar conditions, and likely to present a similar hazard to public health, may be withdrawn. The need for public warnings should be considered.
- Recalled products should be held under supervision until they are destroyed, used for purposes other than human consumption, or reprocessed in a manner to ensure their safety.

7. Training

Fish or shellfish hygiene training is of fundamental importance. All personnel should be aware of their role and responsibility in protecting fish or shellfish from contamination and deterioration. Handlers should have the necessary knowledge and skill to enable them to handle fish or shellfish hygienically. Those who handle strong cleaning chemicals or other potentially hazardous chemicals should be instructed in safe handling techniques. Each fish and shellfish facility should ensure that individuals have received adequate and appropriate

training in the design and proper application of an HACCP system and process control. Training of personnel in the use of HACCP is fundamental to the successful implementation and delivery of the programme in fish or shellfish processing establishments. The practical application of such systems will be enhanced when the individual responsible for HACCP has successfully completed a course. Managers should also arrange for adequate and periodic training of relevant employees in the facility so that they understand the principles involved in HACCP.

HACCP plans

It is a document prepared in accordance with the principles of HACCP to ensure control of hazards that are significant for food safety in the segment of the food chain under consideration. It is implemented following pre-requisite programmes. Prior to the application of HACCP to a fish or seafood establishment, that establishment should be operating proper prerequisite programmes according to the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP1-1969, Revision 2008/2020). Management awareness and commitment are necessary for the implementation of an effective HACCP system. The effectiveness will also rely upon management and employees having the appropriate HACCP knowledge and skills. Therefore, on-going training is necessary for all levels of employees and managers, as appropriate. If the necessary expertise is not available on-site for the development and implementation of an effective HACCP plan, expert advice should be obtained from other sources, such as trade and industry associations, independent experts and regulatory authorities. HACCP literature and fish and seafood HACCP guides can be valuable and they provide a useful tool for businesses in designing and implementing the HACCP plan.

Preliminary Steps for the introduction of a HACCP System

Gathering the resources and information needed. The application of HACCP principles consists of the following tasks as identified in the logic sequence for the application of HACCP (CAC, 2003/2008).

1. Assemble the HACCP team.
2. Describe product.
3. Identify intended use.
4. Construct flow diagram.
5. Confirm flow diagram.
6. Conduct hazard analysis.
7. Determine CCPs (decision tree).
8. Establish critical limits for each CCP.
9. Establish a monitoring system for each CCP.
10. Establish corrective action.
11. Establish verification procedures.
12. Establish documentation and record-keeping.

An HACCP plan is a final document that describes how a fish or seafood operation will manage the identified CCPs for each product under its particular environment and working conditions. The following are the details on how to apply the above sequence for the preparation of a specific HACCP plan.

1. <u>Assemble the HACCP Team</u>:

A qualified HACCP team should be put together with the view to develop the HACCP plan. It should have expertise in food safety and quality, food technology and quality assurance. If the necessary knowledge and skills are not available at the seafood operation, the team can be assisted by local public health officers, independent experts, and fish inspection or fisheries extension officers. Technical advice provided to small operators by companies that buy raw material for further handling, processing or distribution is a valuable alternative, especially in the case of small-scale aquaculture or artisanal fishing.

The HACCP team should have access to all relevant and necessary information.

For example, A HACCP team of a hypothetical seafood operation can be formed by:

- The safety and quality supervisor, with a degree/training in food science/food safety, good experience in the production/processing operations and a special training in HACCP application in the fish industry.
- The technical supervisor, with a degree/training in food technology, experience in seafood industry and a special training in HACCP application in the fish industry.
- The equipment maintenance supervisor.
- Key personnel such as the retort or double-seam supervisor in a cannery.
- As appropriate, an advisor on fish and seafood safety and quality assurance.

2. Describe the product:

A full description of the product should be drawn up, including relevant safety information such as: harvesting area and technique; raw materials and ingredients used including commercial and Latin name of the fish; factors that influence safety such as composition, physical/chemical parameters, such as water activity (aw), pH, salt content; processing such as heating, freezing, brining or smoking; packaging type; storage conditions and methods of distribution; shelf-life under specified condition should also be recorded. An example of product description for depurated oysters can be as follows: “Live oysters (Crassostrea gigas) harvested from (locality), depurated for at least 44 hours, using UV disinfected water. The depurated oysters are packed in mesh nets and sold live to retailers and to restaurants.

3. Identify the intended use:

The intended use should be based on the expected uses by the end user or consumer. The use and preparation before use greatly influence the safety of the product. Certain products may carry harmful organisms as part of the natural flora. If the processing does not include a killing step, the only possibility to render the product safe is adequate heat treatment (e.g. cooking) during preparation. It is important to identify whether the product is to be used in a way that increases the risk of harm to the consumer, or whether the product is particularly used by consumers who are especially susceptible to a hazard. In specific cases, e.g. institutional feeding, vulnerable groups of the population, such as elderly and infants, must be considered. For example, a description of the intended use can read as follows: The product, canned tuna in olive oil, is destined for export mainly to Europe and the United States of America. It is generally consumed without any cooking, as an appetizer, in a sandwich or after mixing with other food or salads. It is consumed by the public at large, with no specific age restriction.

4. Construct a process flow diagram:

A flow diagram should be constructed by the HACCP team to provide a clear and simple description of all steps involved in the operation. When applying HACCP to a given operation, consideration should be given to steps preceding and following the specific

operation. Receiving and storage steps for raw materials and ingredients should be included. Time and temperature conditions during processing should be mentioned whenever there is a holding step, e.g. in holding vats, buffer tanks or other areas, where there could be a potential delay or temperature abuse.

5. On site verification of the process flow diagram:

The HACCP team should confirm on-site the production operations against the flow diagram and amend it with information, such as correct durations, temperatures, and salt concentration, where appropriate. The site should be inspected during all hours (including night shifts and weekends) of operation to check for correctness and ensure that nothing crucial has been overlooked.

Principles of HACCP

1. Conduct a hazard analysis
2. Determine the CCPs
3. Establish critical limit(s)
4. Establish a monitoring system
5. Establish corrective actions
6. Establish verification procedures
7. Establish documentation

1) Conduct a hazard analysis

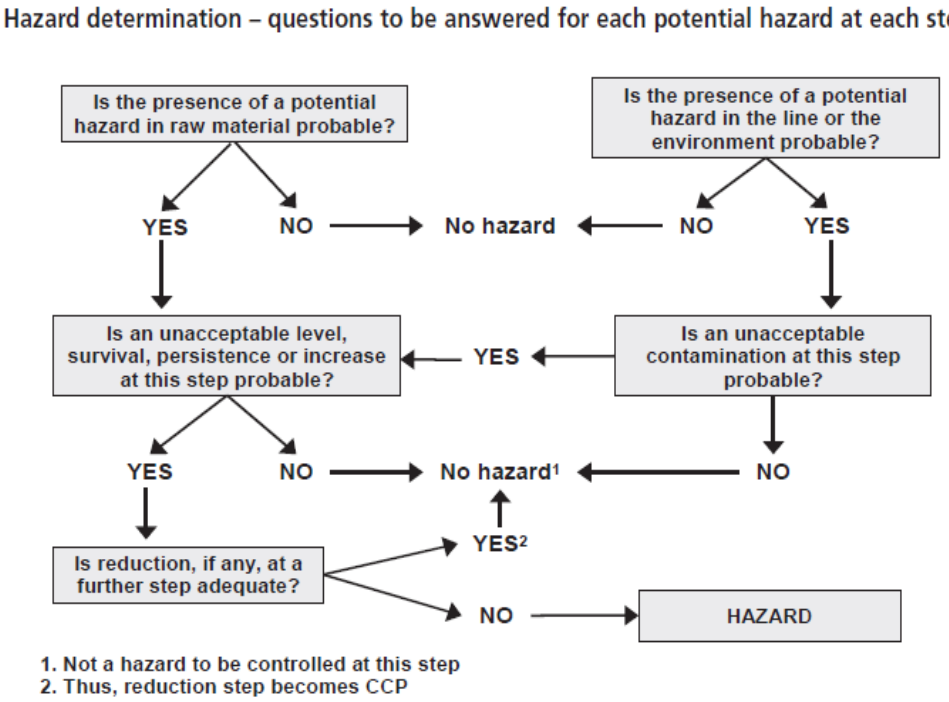
A hazard is defined as a biological, chemical or physical agent in, or condition of, food (e.g. temperature abuse, insufficient thermal process), with the potential to cause an adverse health effect and harm. The HACCP team should list all hazards that may reasonably be expected to occur during production, processing, transportation and distribution until the point of fish consumption. Hazard analysis is the first HACCP principle and the science-based component of HACCP. An inaccurate hazard analysis would inevitably lead to the development of an inadequate HACCP plan. The HACCP team should identify which hazards are of such a nature that their elimination or reduction to acceptable levels is essential for the production of a safe product.

Examples of questions to be considered, when conducting a hazard analysis are as

follows:

- Raw materials and ingredients – do they contain any hazardous agents?
- Intrinsic factors – will the seafood permit survival, multiplication of pathogens or toxin formation?
- Processing conditions – are contaminants or pathogens reduced or destroyed, are there any possibilities for recontamination?
- Packaging – does the packaging affect the microbial population? (e.g. vacuum packaging favours anaerobes)
- Preparation and intended use – will the food be heated or cooked before consumption?
- Intended consumer – is the product destined for the general public or for consumption by a population with higher susceptibility to illness such as infants, elderly people or patients?

A decision tree with a number of questions can be used to determine whether potential hazards are “real”, as demonstrated below:



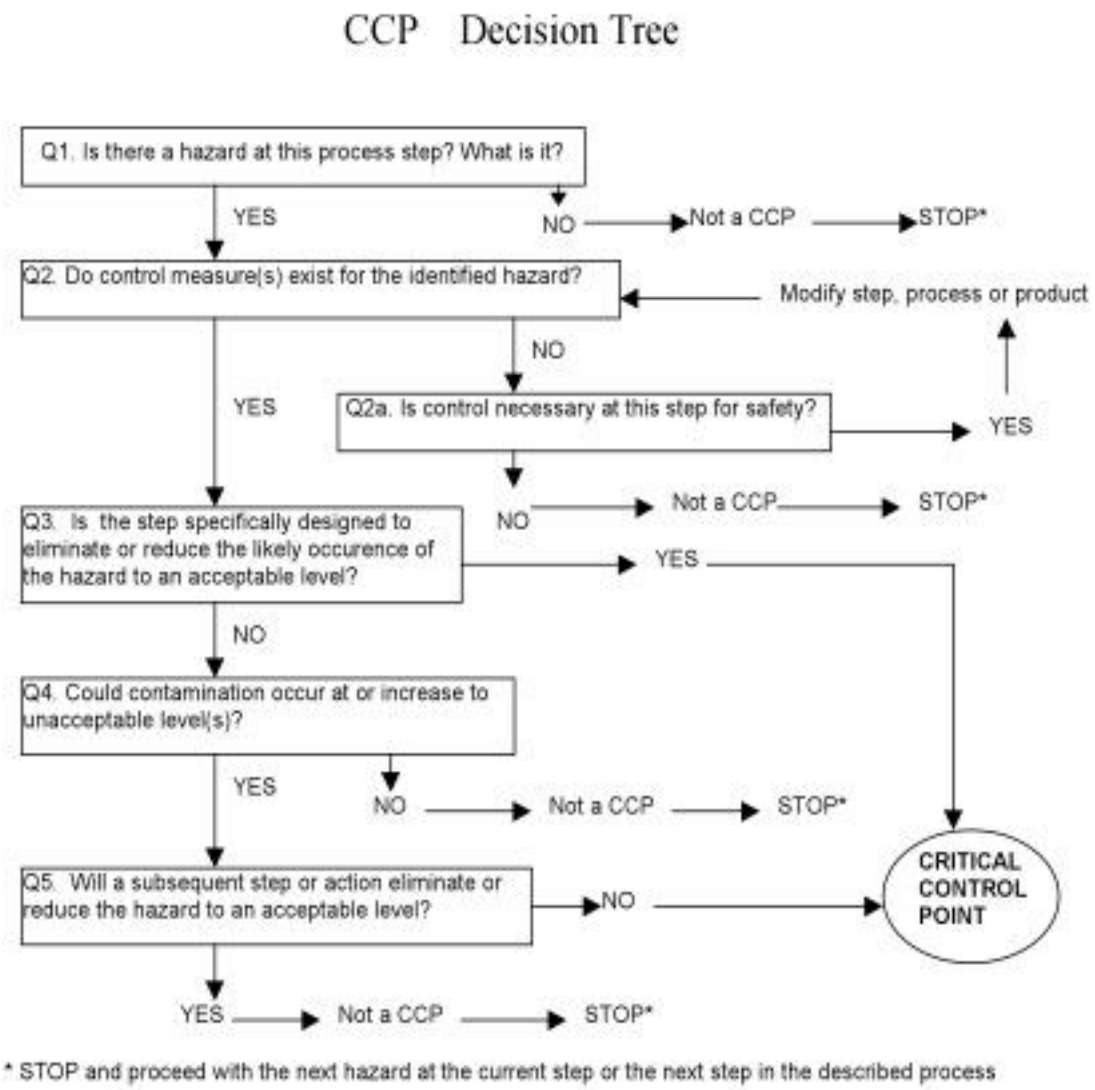
Thus, the basic procedure to use in conducting a hazard analysis is as follows:

- Based on the product description and the flow diagram, all the potential hazards associated with the product and at each production/processing step are determined and listed.
- Make a hazard evaluation: assess severity of health consequences if potential hazards are not controlled; determine likelihood of occurrence of potential hazards if not properly controlled.
- Using information above, determine if this potential hazard is to be addressed in the HACCP plan.
- Describe control measures.

Upon completion of the hazard analysis, the HACCP team must consider what control measures, if any, exist that can be applied for each hazard. More than one control measure may be required to control a specific hazard (or hazards) and more than one hazard may be controlled by a specific control measure. The hazards associated with each step in the production should be listed along with any measure (or measures) that is (are) used to control the hazards. A "hazard analysis worksheet" can be used to organize and document the considerations in identifying food safety hazards.

2) Determine CCPs

A CCP is a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. There may be more than one CCP at which control is applied to address the same hazard. Likewise, several hazards can be controlled at a single CCP. Complete and accurate identification of all the CCPs is fundamental for controlling food safety hazards. The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree.



The application of the decision tree should be flexible depending upon the type of operation under consideration. Other approaches than the decision tree may be used for the determination of CCPs. If a hazard has been identified at a step where control is necessary for safety, and if no control measure exists at that step or at any other, then the product or the process should be modified at that step, or at an earlier or later stage, to include a control measure. This exercise should be conducted at each step and for each hazard to identify CCPs.

The following is an example of the application of the decision tree to decide whether receiving raw material is a CCP for the presence of biotoxins and the presence of salmonella and viruses in live oysters.

Step 1: Receiving live oysters

Hazard 1: Presence of pathogenic bacteria and viruses

Control measure(s): Purchase live oysters only from a licensed harvester who has harvested them from an approved area and has tagged the containers or purchase records properly

Is step 1 a CCP for the considered hazard or not?

Question 1: Do control measures exist for the identified hazard? Yes (measures described above)

Question 2: Does this step eliminate or reduce the likely occurrence of the hazard to an acceptable level? Yes. By applying the control measure described above, we avoid purchase of oysters which cannot be rendered safe for human consumption by depuration

Conclusion: This step is a CCP for obtaining safe live oysters after depuration

Hazard 2: Presence of biotoxins

Control measure(s): Purchase live oysters only from a licensed harvester who has harvested them from an approved area and has tagged the containers or purchase records properly

Is step 1 a CCP for the considered hazard of biotoxins or not?

Question 1: Do control measures exist for the identified hazard? Yes (purchase only from licensed suppliers)

Question 2: Does this step eliminate or reduce the likely occurrence of the hazard to an acceptable level? Yes. By using only licensed harvesters that collect only from approved areas we avoid depurating oysters containing biotoxins.

Conclusion: This step is a CCP for the considered hazard

3) Establish critical limits

Critical limits are defined as criteria that separate acceptability from unacceptability. Critical limits represent the boundaries that are used to judge whether an operation is producing safe products as a result of proper application of the control measures. In other words, critical limits must be met to ensure that a CCP is under control. Critical limits should be scientifically based and refer to easily measurable factors such as temperature, time, chlorine levels, water activity (aw), pH, titratable acidity, salt concentration, available chlorine, preservatives, and sensory quality. These parameters, if maintained within boundaries, will confirm that a given hazard is under control at a given CCP. Microbiological limits, which often require days for their measurement, should be avoided by all means. However, when microbiological limits are necessary, reliable rapid microbiological techniques should be used. The critical limits should meet the requirements of government regulations and/or company standards and/or be supported by other scientific data. It is essential that the persons responsible for establishing critical limits have knowledge of the process and of the legal and commercial standards required for the products.

4) Establish monitoring procedures

Monitoring is defined as the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control. The monitoring procedures will determine whether the control measures are being implemented properly and ensure that critical limits are not exceeded. The monitoring procedures must be able to detect loss of control at the CCP.

The purposes of monitoring include the following:

- To measure the performance level of the system’s operation at the CCP (trend analysis);
- To determine when the performance level of the system results in a loss of control at the CCP, e.g. when there is deviation from a critical limit;

- To establish records that reflects the performance level of the system's operation at the CCP to comply with the HACCP plan.

The monitoring procedures should give information on the following aspects:

What will be monitored (What?)

Monitoring may mean measuring a characteristic of the process or of the product to determine compliance with a critical limit. Monitoring may also mean observing whether a control measure at a CCP is being implemented. Examples include measurement of fish temperature, sensory quality, histamine concentration, and verification of proper application of hygienic practices.

How critical limits and control measures will be monitored (How?)

Deviation from a critical limit should be detected in as short a time as possible to allow prompt corrective action so as to limit the amount of adversely affected product. Again, microbiological testing is rarely effective for monitoring CCPs for this reason. Instead, physical and chemical measurements (e.g. pH, time, temperature, and sensory quality) are preferred, as they can be done rapidly and can often be related to the microbiological control of the process. This correlation between rapid measurements and microbiological control needs to be regularly validated. Equipment used for monitoring procedures should undergo periodic calibration or standardization as necessary to ensure accuracy. Operators should be trained in the proper use of the monitoring equipment and should be provided with a clear description of how the monitoring should be carried out.

Frequency of monitoring (When?)

Wherever possible, continuous monitoring is preferred. Continuous monitoring is possible for many types of physical or chemical methods. Examples of continuous monitoring would include the automatic measurement of free chlorine levels in water, time and temperature of sterilization, and freezing temperature. Where non-continuous monitoring is the chosen system, the frequency of monitoring should be determined from historical knowledge of the process and product. If a problem is detected, the frequency of monitoring may need to be increased until the cause of the problem is corrected.

Who will monitor (Who?)

Careful consideration should be given to assigning responsibility for monitoring. Once assigned, the individual responsible for monitoring a CCP must:

- Be adequately trained in the CCP monitoring techniques;
- Fully understand the importance of the CCP monitoring techniques;
- Have ready access (be close) to the monitoring activity;
- accurately report each monitoring activity;
- Have the authority to take appropriate action as defined in the HACCP plan;
- Immediately report critical limit deviation to supervisor.

Where to monitor (Where?)

Monitoring takes place at each CCP where a given control measure is applied to control a given hazard.

5) Establish corrective actions

As the main reason for implementing HACCP is to prevent problems from occurring, corrective actions should be predefined and taken when the results of monitoring at the CCP indicate a loss of control. Loss of control can cause a deviation from a critical limit for a CCP. All deviations must be controlled by taking predetermined actions to control the non-compliant product and to correct the cause of non-compliance. Product control includes proper identification, control and disposition of the affected product. The establishment should have effective procedures in place to identify, isolate (separate), mark clearly and control all products produced during the deviation period. Corrective action procedures are necessary to determine the cause of the problem, take action to prevent recurrence and follow up with monitoring and reassessment to ensure that the action taken is effective. Reassessment of the hazard analysis or modification of the HACCP plan may be necessary to eliminate further recurrence.

The control and disposition of the affected product and the corrective actions taken must be recorded and filed. Records should be available to demonstrate the control of products affected by the deviation and the corrective action taken. Adequate records permit verification that the establishment has deviations under control and has taken corrective action.

6) Establish verification procedures

Verification is the application of methods, procedures and tests, including random sampling and analysis and other evaluations, in addition to monitoring, to determine compliance with the HACCP plan. The objective of verification procedures is to determine whether the HACCP system is working effectively. Careful preparation and implementation of the HACCP plan does not guarantee the plan's effectiveness. Verification procedures are necessary to assess the effectiveness of the plan and to confirm that the HACCP system adheres to the plan. Verification should be undertaken by an appropriately qualified individual (or individuals) capable of detecting deficiencies in the plan or its implementation. Verification activities should be documented in the HACCP plan. Records should be made of the results of all verification activities. Records should include methods, date, individuals and/or organizations responsible, results or findings and actions taken.

For example, the following verification procedure can be recommended:

Wherever needed but at least weekly, the HACCP team assesses internally all the results of the controls, monitoring and corrective actions and draws conclusions for the subsequent production weeks.

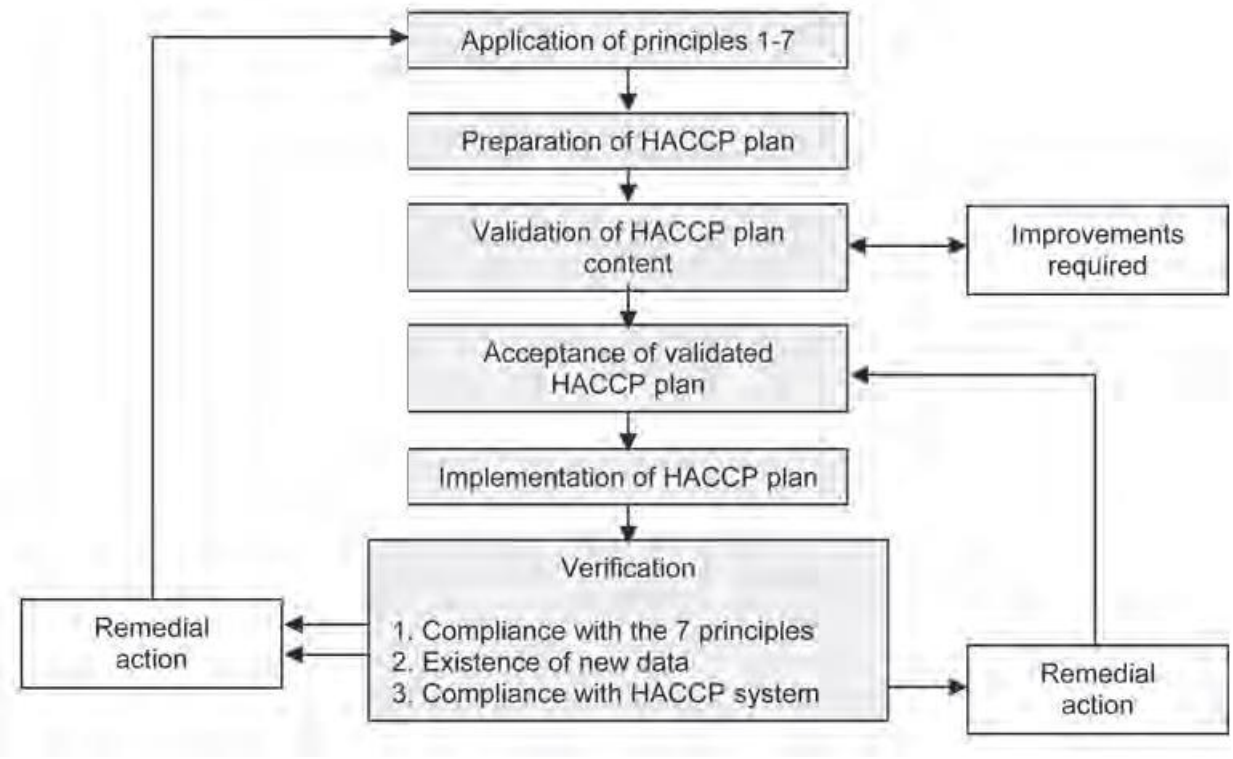
On a longer term, bi-annually or annually for example, the HACCP team can:

- Evaluate the monitoring and corrective actions data to assess performance and analyse the reasons for any loss of control or for complaints from clients and/or control authorities.
- Use the results of this analysis to update the HACCP manual, identify further training and improved practices, performance or maintenance, modify frequency (increase or decrease) of specific monitoring and revise the list of approved suppliers.
- Perform an audit by an external specialist to assess the performance of each control, monitoring or corrective procedure. He/She will examine the different records, including records for monitoring, calibration and maintenance, training, complaints and reports from clients and control authorities. He/she will prepare a report that will be submitted to management and discussed during a meeting with management and the HACCP team. The audit exercise will be also used as an opportunity to introduce

new procedures, monitoring techniques or critical limits to take into consideration new developments, including new regulatory requirements.

Apart from the initial validation, subsequent validation as well as verification must take place whenever there is a change in raw materials, product formulation, processing procedures, consumer and handling practices, new information on hazards and their control, consumer complaints, recurring deviations or any other indication, that the system is not working.

Below chart shows where validation fits into the process of HACCP implementation.



7) Establish record keeping

Records and documentation are essential for reviewing the adequacy of and adherence to the HACCP plan. Several types of records should be considered among those relevant in an HACCP programme:

- Support documentation, including validation records, for developing the HACCP plan;
- Records generated by the HACCP system: monitoring records of all CCPs;
- Deviation and corrective action records, verification/validation records;
- Documentation on methods and procedures used;
- Records of employee training programmes.

Records may be in different forms, e.g. processing charts, written procedures or records, and tables. They can be stored in paper or electronic forms, provided that assurance of record integrity is provided. It is imperative to maintain complete, current, properly filed and accurate records. Failure to document the control of a CCP or implementation of a corrective action would be a critical departure from the HACCP plan.

HACCP application in fermented fish product

In north-east India, fermented fish products are consumed after cooking along with vegetables. In contrary, the fermented fish products of south-east Asian countries are traditionally stored at ambient temperatures and consumed without any cooking. These fermented fish contain a carbohydrate source and in some of these products the level of salt is less than 8 percent water phase salt (WPS)". This level of salt (< 8 percent) allows the fermentative growth of lactic-acid bacteria and a concomitant decrease in pH to < 4.5. In contrast, enzyme hydrolysed fish has a WPS > 8 percent and a final pH of 5–7. Hence, in south-east Asia fermented fish products have been associated with a number of outbreaks of food-borne diseases such as botulism, trematodiasis, salmonellosis and vibriosis. The natural presence of pathogenic bacteria from the aquatic and general environment is not considered a significant hazard in this product owing to the low numbers. However, conditions for growth of some of these organisms (C. botulinum type A and B, Listeria monocytogenes, and Vibrio sp.) are good until the pH decreases to almost 4.5. This takes about 1–2 days at 30 °C in a natural fermentation. Therefore, rapid and adequate acidification is the preventive measure for this significant hazard. For complete safety, temperatures during fermentation should be kept at < 10 °C until the final pH has been reached.

Contamination of fermented fish products with pathogenic bacteria from the animal/human reservoir and with pathogenic viruses are potential hazards, which will be controlled by the prerequisite programme. Most fermented fish products are based on freshwater fish as raw material. However, if marine fish are used, the presence of biotoxin (ciguatera) should be considered a potential hazard. Formation of biogenic amines (histamine) is a health hazard primarily related to marine, scombroid fish species and is not a potential hazard when freshwater fish are used as raw material. Parasites, particularly trematodes, are very common in fish used as raw material for fermented fish. As there is no killing step for these parasites in the normal processing, they are very likely to cause disease and must be regarded as a significant hazard. The preventive measures are food safety education and to bring about changes in the traditional consumption practices of eating non-cooked fermented fish. Until then, fermented fish that is to be eaten without any cooking must have a freezing step included. The concerns for chemical hazards are related to the raw material. The hazard analysis for fermented fish products is summarized in table below.

Hazard analysis of fermented fish

Organism/ component of concern	Potential hazard		Analysis of hazard			Control		
	Contamination	Growth	Severity	Likely occurrence	Significant	Government monitoring programme	PP[1]	Incl. in HACCP plan
Pathogenic bacteria								
indigenous	–	+	high	high	+	–	–	+
non-indigenous	+	+	high	high	+	–	+	–
Viruses	+	–	high	high	+	–	+	–
Biotoxins	+	–	high	high/low[2]	+/–	(+)	–	+
Biogenic amines	–	+	low	high/low[2]	+/–	–	–	+
Parasites	+	–	low	high	+	–	–	+
Chemicals	+	–	medium	high/low[2]	+/–	+	–	+

[1] PP = prerequisite programme.
[2] Depending on fish/bivalve shellfish species, geographical position and season, the likely occurrence may be high or low.

The CCPs in production of fermented fish are:

Receiving step: Check raw materials.

Time/temperature conditions during fermentation: Inhibition of growth of indigenous pathogens.

Freezing step: Control of parasites.

Note: If cooking is done freezing step is not required.

In similar process, HACCP can be implemented in various others fish and fishery products as grouped by Huss (1994) into following categories:

- Molluscan shellfish.
- Raw fish to be eaten without any cooking.
- Fresh or frozen fish and crustaceans – to be fully cooked before consumption.
- Lightly preserved fish products, i.e. NaCl < 6 percent in water phase, pH >5.0. The prescribed storage temperature is < 5 °C. This group includes salted, marinated, cold-smoked and gravad fish.
- Semi-preserved fish, i.e. NaCl > 6 percent in water phase, or pH < 5, preservatives (sorbate, benzoate, nitrite) may be added. The prescribed storage temperature is < 10 °C. This group includes salted and/or marinated fish or caviar, fermented fish (after completion of fermentation).
- Mildly heat-processed (pasteurized, cooked, hot-smoked) fish products and crustaceans (including precooked, breaded fillets). The prescribed storage temperature is < 5 °C.
- Heat-processed (sterilized, packed in sealed containers).
- Dried, smoke-dried fish, heavily salted fish. Can be stored at ambient temperatures.

Conclusion

The safety of seafood products varies considerably and is influenced by a number of factors such as origin of the fish, microbiological ecology of the product, handling and processing practices and preparations before consumption. However, the food safety hazards and risk in seafood products cannot be made nil through any approach, it can only be minimized or reduced to an acceptable level. A large number of hazards are related to the pre-harvest situation or raw-material handling and must be under control by implementation of HACCP when the raw material is received at the processing factory.

References

- Codex Alimentarius Commission. (1997). Hazard analysis and critical control point (HACCP) system and guidelines for its application. *Annex to CAC/RCP*, *1*(1969), Rev-3.
- Ehiri, J. E., Morris, G. P., & McEwen, J. (1995). Implementation of HACCP in food businesses: the way ahead. *Food Control*, *6*(6), 341-345.
- FAO. (2020). The state of world fisheries and aquaculture 2020. Sustainability in action. *Food and Agriculture Organization of the United Nations*.
- HACCP in microbiological safety and quality. International Commission on Microbiological Specifications for Foods (ICMSF), 1989. Boston, Massachusetts, USA, Blackwell Scientific Publications.
- Huss, H. H. (1994). *Assurance of seafood quality* (No. 334). Food & Agriculture Org.
- Pierson, M. D. (2012). *HACCP: principles and applications*. Springer Science & Business Media.
- Reilly, A., & Käferstein, F. (1997). Food safety hazards and the application of the principles of the hazard analysis and critical control point (HACCP) system for their control in aquaculture production. *Aquaculture research*, *28*(10), 735-752.
- Ryder, J., Iddya, K., & Ababouch, L. (2014). Assessment and management of seafood safety and quality: current practices and emerging issues. *FAO fisheries and aquaculture technical paper*, (574), I.

Chapter 24

Soft skills and communication

Mr. Abdul Latheef
Facebook Lead Trainer India Grow Your Business Project
Email: technicscomputer2@gmail.com

What are the Soft Skills?

Soft skills are the more intangible and non-technical abilities that are sought from candidates.

For example: Communication, Teamwork, Problem-solving, Leadership and Responsibility

Soft skills are sometimes referred to as transferable skills or professional skills. As this term implies, these are skills that are less specialized, less rooted in specific vocations and more aligned with the general disposition and personality of a candidate. Soft skills relate to your attitudes and your intuitions. As soft skills are less about your qualifications and more personality-driven, it is important to consider what your soft skills are and how you might show evidence of them before you apply for a job.

This is particularly true of the recruitment process for graduate programmes, where transferable skills and potential often take precedence over professional experience.

Why soft skills are important?

Soft skills are the difference between adequate candidates and ideal candidates. In most competitive job markets, recruitment criteria are not limited to technical ability and specialist knowledge.

Every job role requires some interaction with others, whether they are colleagues or customers, so soft skills will be important to most employers. Earlier in your career, recruiters will be looking for people who have the potential to become leaders. They won't expect you to have all the qualifications and experience from day one, but they will need to know that you have the qualities that will allow you to learn and grow in the role. Here are some examples of the difference made by soft skills:

A doctor is required to have an extensive repertoire of hard skills, especially the ability to diagnose and prescribe treatments for an array of ailments. But a doctor who does not have the soft skills of emotional intelligence, trustworthiness and approachability is not likely to be very highly regarded by their patients.

A salesperson, who may have an unrivalled and exhaustive knowledge of their market, will find it difficult to close a deal and retain their clients if they lack the soft skills of interpersonal skills and negotiation.

A customer services professional with amazing organisational skills will only do well if they are also able to interact professionally with customers, and have empathy and listening skills.

Soft skills are not just important when facing external customers and clients. They are equally important when it comes to interacting with colleagues. Employers value soft skills because they enable people to function and thrive in teams and organizations as a whole. A productive and healthy work environment depends on soft skills. After all, the workplace is an interpersonal space where relationships must be built and fostered, perspectives must be exchanged and, occasionally, conflicts must be resolved.

What are the 10 Keys of Soft Skills?

1. Communication
2. Self-Motivation
3. Leadership
4. Responsibility
5. Teamwork
6. Problem Solving
7. Decisiveness
8. Ability to Work Under Pressure and Time Management
9. Flexibility
10. Negotiation and Conflict Resolution

How to Push Your Soft Skills in Your Resume and at Interview
Can I Learn Soft Skills?

This section is an extensive, but not exhaustive, guide to some of the key soft skills sought by employers.

1. Communication

Communication is one of the most important soft skills. Able communicators can adjust their tone and style according to their audience, comprehend and act efficiently on instructions, and explain complex issues to colleagues and clients alike. A key, often forgotten, communication skill is listening. Whether you are dealing with a customer complaint or working with your colleagues, good listening skills will help you learn and respond correctly to the circumstance you have been presented with.

Equally as important are your verbal and non-verbal skills. Verbal skills are key to fostering relationships that are collaborative and respectful, and, ultimately, productive. This also applies to your written communication.

A lot of business communication is now played out by email, so it's important to know good email etiquette and give instructions clearly and concisely.

2. Self-Motivation

Having a positive attitude and the initiative to work well without around-the-clock supervision is a vital soft skill for any employee. Not only does it demonstrate reliability and commitment, but it also shows that you can fit efficiently into an organizational structure without the need for constant supervision.

To demonstrate your motivation, think about these keys skills:
Positivity
Ambition
Commitment
Initiative

3. Leadership

Leadership is a soft skill you can show even if you're not directly managing others. Those with strong leadership skills will have the ability to inspire others and lead teams to success. This is why it is a particularly sought-after skill.

- People with good leadership skills will have a range of skills that are useful in the workplace, including:
- The ability to make quick and effective decisions, Example : problem-solving or conflict management skills
- The ability to communicate effectively
- An aptitude for both self-motivating and motivating others
- Even if you are applying for an entry-level role, don't be afraid to demonstrate your potential by showing how you have positively influenced others to take a project to success.

4. Responsibility

Responsibility is a seldom talked-about but highly valued soft skill. Colleagues who fail to take responsibility for their work will be less productive and less successful overall.

To demonstrate a high level of responsibility, make sure you can master these skills:

Trustworthiness
Discipline
Motivation
Conscientiousness
Accountability

Taking responsibility means taking ownership of not only your goals but the wider company goals. This will mean taking the initiative to make improvements, accepting responsibility for any failures and really caring about working your way to success.

5. Teamwork

Like leadership, good teamwork involves a combination of other soft skills. Working in a team towards a common goal requires the intuition and interpersonal acumen to know when

to be a leader and when to be a listener. Good team players are perceptive, as well as receptive to the needs and responsibilities of others.

6. Problem Solving

Problem solving does not just require analytical, creative and critical skills, but a particular mind-set; those who can approach a problem with a cool and level head will often reach a solution more efficiently than those who cannot.

This is a soft skill which can often rely on strong teamwork, too. Problems need not always be solved alone. The ability to know who can help you reach a solution, and how they can do it, can be of great advantage.

7. Decisiveness

Decisiveness is characterized by the ability to make quick and effective decisions. It does not mean recklessness or impulsiveness. Decisiveness combines several different abilities:

- The ability to put things into perspective
- Weigh up the options
- Assess all relevant information
- Anticipate any consequences, good and bad
- A decisive employee will take effective and considered action quickly, especially when under pressure.
- They take responsibility for the consequences of their decision and can adapt when mistakes are made. This ensures that opportunities aren't missed by lengthy analysis or debate.

8. Ability to Work Under Pressure and Time Management

Many jobs come with demanding deadlines and, sometimes, high stakes. Recruiters prize candidates who show a decisive attitude, an unfaltering ability to think clearly, and a capacity to compartmentalize and set stress aside.

Time management is closely related to the ability to work under pressure, as well as within tight deadlines. Employees who manage their time well can efficiently prioritize tasks and organize their diaries while adopting an attitude which allows them to take on new tasks and deadlines.

9. Flexibility

Flexibility is an important soft skill, since it demonstrates an ability and willingness to embrace new tasks and new challenges calmly and without fuss. Flexible employees are willing to help out where needed, take on extra responsibilities and can adapt quickly when plans change. Employers are looking for candidates who can show a willing and upbeat attitude, and who are unfazed by change.

10. Negotiation and Conflict Resolution

This is another of those soft skills which employers look for in potential leaders.

To be an adept negotiator is to know how to be persuasive and exert influence, while sensitively seeking a solution which will benefit all parties. Similarly, conflict resolution depends on strong interpersonal skills and the ability to establish a rapport with colleagues and clients alike.

How to Push Your Soft Skills in Your Resume and at Interview

As with hard skills, you should spend some time considering what your soft skills are (it may help to ask people who know you well) and highlight them in your resume and in job interviews. Hard skills can be shown via qualifications, but soft skills are more slippery. It is important to fully research the company you are applying to and identify which of your soft skills are most relevant to the role. Once you have identified the soft skills that are most relevant to the role you are applying for, make sure you prepare to talk about them at interview and include them as keywords in your resume or cover letter. Since soft skills are necessarily abstract, you should reinforce any claims with examples of when you were able to use them to achieve positive outcomes.

These examples can be drawn from professional, personal or academic experiences:

If you've been an undergraduate student, you will probably have experience of juggling various deadlines and extra-curricular responsibilities. If you have previously worked in any job with a customer service element, you may have had to use your communication and conflict resolution skills to manage any complaints. On your resume, the easiest and most essential way to show your soft skills of communication and attention to detail is to proofread ruthlessly and eliminate any typos.

In your interview, demonstrate your interpersonal skills by being professional, making eye contact, shaking hands, listening closely to the questions and answering them fully.

Can I Learn Soft Skills?

Even though soft skills are not as easily learnt as technical ability or passing an exam, they can certainly be developed and improved over time. Improving your soft skills can be tricky as this requires quite a lot of introspection, which can be difficult or uncomfortable if you haven't done it before.

If you want to improve on your soft skills or have some you need to develop to work in a certain role, here are some tips to help:

Participate in self-reflection. In order to improve, you must first be honest about where your shortcomings are. This isn't always easy. If you are struggling, ask a friend or family member to help you identify your true strengths and weaknesses. Look for online training. Once you have identified the areas you need to improve, look for some online courses that will help you learn skills that would be useful in the workplace. Observe others. Look to others who exemplify the soft skills you want to improve. If you have a relationship with them, ask for their advice or coaching.

Practice. All soft skills will improve with practice. Once you have obtained training or coaching, practise using your new-found skills with friends or family before your interview. This will give you the confidence to take these skills into the workplace.

Key Competencies

Technical Skills
Interpersonal Skills
Transferable Skills
Interview Question: "What Are Your Strengths?"
Interview Question: "What Are Your Weaknesses?"
Common Interview Questions

Appendix- 1

Cleaning and sanitizing agents used in fish processing unit

Four categories of cleaning agents:

- Detergents
- Solvent cleaners
- Abrasive cleaners
- Acid cleaners

Detergents - A **detergent** is a surfactant or a mixture of surfactants with "cleaning properties in dilute solutions." These substances are usually alkylbenzenesulfonates, a family of compounds that are similar to soap but are more soluble in hard water. Detergents contain surfactants (surface acting agents) that reduce surface tension between soil and surface so that soil can be penetrated and removed. Types of detergents

- General Purpose (GP)
- Alkaline
- Chlorinated (Chlorinated alkaline);
- Acid
- Enzymes

- General purpose detergents are mildly alkaline and used to clean up fresh soil from floors , walls , ceilings, equipment, utensils, etc .
- Alkaline or Chlorinated Alkaline detergents are recommended for most processing plant applications and are effective then GP's. Alkaline detergents range from moderately alkaline (Caustic). Smoke houses, cooker surfaces may require highly caustic cleaning chemicals and application methods.
- Chlorinated products are usually more aggressive in loosening protein based soils or for surfaces that are difficult to clean due to their shape or size, such as perforated storage crates and waste containers. They are also alkaline and many more corrosive. They should not be used on corrodible material such as Aluminium.
- Acid detergents remove inorganic mineral deposits (scale) and stains such as those associated with hard water.
- Emzymes are specific to a given soil type. These detergents are tailored for protein, oil or carbohydrate based oils. Carbohydrate soils mostly occur where breading, batters or starches are used.
- In situations where exposure to excess alkaline or acid conditions are a problem, such as with waste water discharge restriction or equipment susceptible to corrosion enzyme detergents may be an acceptable alternative.

Solvent Cleaners : Often called degreasers

- Alkaline detergents containing grease dissolving agent.
- Useful for grill back splashes, oven doors, range hoods, etc
- Effective usually at full strength

Acid cleaners

- Used on mineral deposits eg. Scale
- Used in ware-washing machines , steam tables,
- Used for rust stains and tarnish on copper and brass.

Abrasive cleaners

- Contain a scouring agent like silica that help to remove hard – to – remove soil.
- Often used on floors or to remove baked on food in pots and pans.

Types of Sanitizers

Sanitizer	Forms/Description	Advantages	Disadvantages
Chlorine	Hypochlorites Chlorine gas Organic chlorine, e.g., Chloramines	-Kills most types of microorganisms -Less affected by hard water than some -Does not form films -Effective at low temperatures -Relatively inexpensive -Concentration determined by test strips	-May corrode metals and weaken rubber -Irritating to skin, eyes and throat -Unstable, dissipates quickly -Liquid chlorine loses strength in storage -pH sensitive
Iodophors	Iodine dissolved in surfactant and acid	-Kills most types of microorganisms -Less affected by organic matter than some -Less pH sensitive than chlorine -Concentration determined by test strips -Solution color indicates active sanitizer	-May stain plastics and porous materials -Inactivated above 120°F -Reduced effectiveness at alkaline pH -More expensive than hypochlorites -May be unsuitable for CIP due to foaming
Quaternary Ammonium Compounds	Benzalkonium chloride and related compounds, sometimes called quats or QACs	-Non corrosive -Less affected by organic matter than some -Residual antimicrobial activity if not rinsed -Can be applied as foam for visual control -Effective against Listeria monocytogenes -Effective for odor control -Concentration determined by test strips	-Inactivated by most detergents -May be ineffective against certain organisms -May be inactivated by hard water -Effectiveness varies with formulation -Not as effective at low temp. as some -May be unsuitable for CIP due to foaming
Acid-Anionic	Combination of certain surfactants and acids	-Sanitize and acid rinse in one step -Very stable -Less affected by organic matter than some -Can be applied at high temperature -Not affected by hard water	-Effectiveness varies with microorganism -More expensive than some pH sensitive (use below pH 3.0) -Corrodes some metals -May be unsuitable for CIP due to foaming

Sanitizer	Forms/Description	Advantages	Disadvantages
Peroxy Compounds	Acetic acid and hydrogen peroxide combined to form peroxyacetic acid	-Best against bacteria in biofilms -Kills most types of microorganisms -Relatively stable in use -Effective at low temperatures -Meets most discharge requirements -Low foaming; suitable for CIP	-More expensive than some -Inactivated by some metals/organics -May corrode some metals -Not as effective as some against yeasts and molds.
Carboxylic Acid	Fatty acids combined with other acids; sometimes called fatty acid sanitizers	-Kills most types of bacteria -Sanitize and acid rinse in one step -Low foaming, suitable for CIP -Stable in presence of organic matter -Less affected by hard water than some	-Inactivated by some detergents -pH sensitive (use below pH 3.5) -Less effective than chlorine at low temp. -May damage non-stainless steel materials -Less effective against yeasts and molds than some
Chlorine Dioxide	A gas formed on-site and dissolved in solution or by acidification of chlorite and chlorate salts	-Kills most type of microorganisms -Stronger oxidizer (sanitizer) than chlorine -Less affected by organic matter than some -Less corrosive than chlorine -Less pH sensitive than some	-Unstable and cannot be stored -Potentially explosive and toxic -Relatively high initial equipment cost
Ozone	A gas formed on-site and dissolved in solution	-Kills most type of microorganisms -Stronger oxidizer (sanitizer) than chlorine and chlorine dioxide	-Unstable and cannot be stored -May corrode metals and weaken rubber -Potentially toxic -Inactivated by organic matter (similar to chlorine) -pH sensitive -More expensive than most
Hot Water / Heated Solutions	Water at 170 - 190°F	-Kills most types of microorganisms -Penetrates irregular surfaces -Suitable for CIP -Relatively inexpensive	-May form films or scale on equipment -Burn hazard -Contact time sensitive; inappropriate for general sanitation