Participatory Training of Trainers

A New Approach Applied in Fish Processing

Dr. A K M Nowsad Alam

BFRF Bangladesh Fisheries Research Forum

Bangladesh Fisheries Research Forum

This book describes a new training approach, a self-facilitated highly participatory training of trainers (ToT), that is brought into the field and made effective avoiding subjective type approach of delivery. Along with application of various participatory learning methods, the core trainer, extension workers and the primary producers are brought into one platform to initiate a three-way dialogue. Due to such 3-way interactions, a central knowledge pool is developed, from where the primary producers get appropriate technologies by sharing experience and exposing field problems. Side by side, in course of identifying the risks and critical control points of conventional methods, extension workers provide required inputs to the knowledge pool for the improvement of traditional knowledge. The core trainer as well develops his technical skill with the expense of experience and makes the training method and manual more effective and useful.

The new ToT is applied in fish processing. Beside the principles and applications of the new ToT, this book also covers the best possible options for appropriate fish processing technologies, particularly suited for small-scale processors to reduce huge post-harvest loss. These include post-harvest handling and distribution, icing, sun-drying, smoking, salting, fermenting, packaging and quality control of fish and fish products. Adaptable improved techniques of fish handling, preservation and processing and low-cost, sustainable and user/environment friendly technologies developed by the participatory stakeholder-based methods have also been included.

This new ToT technique can be applied in the training of extension personnel and primary beneficiaries of any disciplines of agricultural extension. In order to conduct such training, an appropriately designed training manual with adequate facilitation and information sheet is required. Other essential requirements are primary stakeholder/beneficiary group in proximity and one or two dedicated core trainers, who are willing to devote themselves to develop a useful training manual and to facilitate the course.

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A NEW APPROACH APPLIED IN FISH PROCESSING

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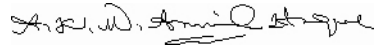
Foreword

I feel privileged to write the foreword of this book "Participatory Training of Trainers- A New Approach Applied in Fish Processing" authored by Dr. A K M Nowsad Alam who has long been working at the field with the stakeholders on post-harvest loss reduction of fish in Bangladesh. Bangladesh Fisheries Research Forum has already initiated supports for the development of post-harvest sector through value chain analysis and market assessment of aquatic products. Partial support for publishing of this book by the Forum is one step forward to fulfil the commitment of contributing towards the development of post-harvest fisheries.

Artisanal fisheries sub-sector in Bangladesh is known to suffer from serious post-harvest loss every year mainly due to ignorance and negligence of the people in different stages from the harvest to retail distribution. Export-oriented fish processing is well taken care of due to strict regulations imposed by the government and foreign countries. But the quality of fish for local consumption and the personal hygiene of the fish handlers itself are not adequately addressed. In order to reduce huge post-harvest loss in fisheries and improve personal hygiene and sanitation, the first step would be to create technically sound skilled extension personnel and field workers who would educate the beneficiaries at the rural level and be used as legal avenue through which the transfer of technology is made easy.

This book describes a new training approach that was developed and introduced for conducting training of trainers (ToT) for the GO-NGO extension workers of Cox's Bazar, where most of the marine fish are landed and processed through small-scale processing enterprise. The ToT was brought into the field and made effective avoiding classroom based approach of delivery. A self-facilitated fully participatory training technique was applied. Beside the principles and applications of the new ToT, this book covers the best possible choice of appropriate fish processing technologies particularly suited for small-scale processors. These include post-harvest handling and distribution of fish, icing, sun-drying, smoking, salting, fermenting, packaging of fish and quality control of domestic fish products. Adaptable improved techniques of fish handling, preservation and processing and low-cost, sustainable and user/ environment friendly technologies developed by participatory stakeholder-based methods have also been included in this book. I believe that the new ToT technique and improved fish handling and artisanal fish processing methods described here will be of immense value to the trainers and extension workers of post-harvest handling and fish processing and help the fishers/small-scale processors as well as the development partners, students, researchers and teachers in minimizing post-harvest loss of fish and ensuring quality of the products.



Professor Dr. A. K. M. Aminul Haque
National Professor
Dhaka, Bangladesh
15 March 2007

Preface

This new training approach along with the facilitation and information sheets compiled in this book was developed and introduced for conducting training of trainers (ToT) for the GO-NGO extension workers of Cox's Bazar attached to a GOB/UNDP/FAO Project: *Empowerment of Coastal Fishing Communities for Livelihood Security* (BGD/97/017). Through that project, the local extension workers were engaged in improving the fish processing situation in the coastal areas and helping artisanal fishers and fish processors in developing and operating sustainable fish processing enterprise.

Small-scale artisanal fisheries of Bangladesh contribute about 94% of the total marine catch. It is a major employment provider to a large number of resource poor and most disadvantaged coastal communities. It also significantly contributes to the national food and nutritional security by satisfying the local consumer demand for fresh fish and fish meal for poultry and aquaculture industry. However, in spite of its significant role in the socio-economic wellbeing and food and nutritional security of the country, the condition of poor fishers has been going from bad to worse. As a result, there is ever increasing fishing pressure, restoring to use of destructive fishing methods and gears which, in turn, creates intense negative impact on the coastal fishery resources and biodiversity. Many species of marine shrimp and fish stocks have already shown a declining trend.

In order to secure the lives and livelihood of such resource poor, disaster prone and highly disadvantaged coastal fishing communities, the Department of Fisheries (DoF) of the Government of Bangladesh (GoB) and the Food and Agriculture Organization of the United Nations (FAO) adopted the above project. The objective of the project was to promote livelihood security of the poor coastal fishing communities through creating an enabling environment so that they have increased access to assets, essential support services and resources. While achieving these objectives, the fishers were made aware of the need for maintaining the health of the coastal fisheries environment by restoring to sustainable management practices and harnessing the potential of coastal fisheries through their active participation in planning and implementation.

Along with different interventions for various project components, extensive measures were taken to reduce post-harvest loss of fish through good practices (improved handling, adequate sanitation and appropriate processing of fish). Available data supported with project baseline survey on fish processing indicated that about one third of the total marine catch had been spoiled every year, due to either lack of knowledge or negligence of the fishermen, fish processors and fish traders. To minimize such huge loss, and side by side, to increase the family income of the fishers and small-scale processors of the command area, various steps like awareness creation and development among the beneficiaries and other stakeholders, capacity building and training for both target beneficiaries and Upazila and field level extension personnel, etc. were taken. As a first step of development of this sector, all Upazila and field level GO/NGO extension workers were brought under intensive training programme. Training of trainers (ToT) was brought into the field and made effective avoiding classroom based approach of delivery. A self-facilitated fully participatory training technique was developed and introduced that could be equally adopted to all disciplines of agricultural extension. This book describes the details of this new ToT technique applied in fish processing. Along with the principles and applications of the new ToT, this book also covers the best choice of appropriate fish processing methods and techniques particularly suitable for small-scale processors of

Bangladesh, covering post-harvest handling, icing, sun-drying, smoking, salting, fish fermenting, packaging of fish and quality control of fish and fish products. Besides, improved techniques of fish handling, preservation and processing and low-cost, sustainable and user/ environment friendly technologies developed by the author (Fish Processing Expert of the Project) have also been included in this book. Some basic information on composition and post-mortem changes of fish are, however, included to minimize the knowledge gap of advanced learners who are really intended to improve the handling and preservation of fresh fish. The new ToT technique and appropriate fish handling and artisanal fish processing methods described in this book would, I believe, help the fishers/small-scale fish processors including the extension workers, development partners, students, researchers and teachers of the discipline.

Dr. A K M Nowsad Alam
Mymensingh, Bangladesh
25 April 2007

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The author is indebted to Dr. Dilip Kumar, Director, Central Institute of Fisheries Education (Deemed University), Mumbai, India, formerly, Fishing Community Development Adviser and Team Leader of the Empowerment of Coastal Fishing Communities for Livelihood Security Project (GoB/UNDP/FAO: BGD/97/017) for valuable guidance and suggestions in designing and conducting training of trainers and for encouragement in writing this book.

Particular thanks are due to Mr. Ivor Clucas, former Fish Processing Technologist of the Natural Resources Institute, UK for correcting and editing on the draft of this book.

The author expresses his deepest sense of gratitude to the National Professor, Dr. A. K. M. Aminul Haque, former Vice-chancellor of Bangladesh Agricultural University to kindly writing a foreword to this book.

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Introduction

To establish an effective training network within the beneficiaries of a FAO project: BGD/97/017 (*Core Trainer–Upazila Fisheries Officers–Assistant Upazila Fisheries Officer–Field Extension Workers–NGOs/Service Providers–Target Community)* and to smoothing feed-back flow at each level, a comprehensive training was introduced in Cox's Bazar, where most of the country's marine fish are landed and processed through small-scale fish processing. Extension Officers, after trained by the core trainer, conducted series of training for the field level extension workers and NGO personnel/service providers who had direct contacts with the target community. Field extension workers and service providers further trained the beneficiaries at field level. In many occasions, Upazila level Extension Officers conducted demonstration training directly for the primary target people. Through such chain extension process, all stakeholders of fish processing had been brought under a network of training and made the information and feed-back flow easier, smoother and effective. For the training of trainers (ToT), a new approach based on exercise-oriented delivery and field based demonstration of the topics was designed that enabled the trainees to learn the things through participatory group activities and hands on field exercise without much theories delivered through classroom based lectures. The new training approach was applied to a series of ToTs on artisanal fish processing, fisheries co-management and quality control of fish. This book describes the basic elements of this

new training and its mode of delivery while it was applied in the artisanal fish processing.

In fact, *Fish Processing* is a new subject not only to the target fishing communities, but also to the GO/NGO extension workers of the country who have long been acquainted and dealt with the aquaculture and fisheries management related issues. To bring this new subject to a training module, careful selection of topics and use of easy and learner-friendly phrases were felt important. For this purpose, a simplified manual with easy explanation of the practices, both in English and Bangla, has been prepared. *Complex* theories are mostly avoided in all cases.

Fisheries sector in Bangladesh has been entrapped with huge post-harvest loss every year due to ignorance and negligence of the stakeholders and policy makers in different stages from the primary producers, fish labourers, traders, artisanal small- and large scale processors, transporters, retailers, consumers, law enforcing agencies and the Government. The level of ignorance and negligence is too high but the Government has paid little attention to this sector restricted to export oriented products only, that covers only 2.5% of the total marine catch. On contrary, quality aspects of the rest 97.5% of the catch, those are consumed domestically, remain undiscussed within the government agenda. Therefore, beside the extreme vulnerability in the lives and livelihood of the poor coastal fishers, the health and nutrition of great number of people who can only be able to take fish and fish products as a source of protein are now at serious stack. In order to recognize the immediate need and demand of the poor fishing communities, artisanal fish processors, fish traders and huge number of fish eating people of the country, quality aspects of traditional small-scale fish processing have mainly been highlighted in these training modules. High cost involved export-oriented fish processing is not discussed here. Traditional process lines, associated constraints and scopes for development with suggested improved practices have been emphasized. Side by side, the issues related to quality assurance, food safety and public health that can be ensured through the improvement of traditional practices, are also discussed.

ECFC Project was implemented in 118 coastal fishing villages of Cox's Bazar District. The entire communities of the fishing villages were organized into village level organizations (VOs), separately for man and women. In each village, there was at least one man and one woman VOs and the total number of VOs was 248. All developmental activities were centered through these VOs. In order to prioritize the activities for the development of artisanal fish processing sector in the coastal areas, a year-long baseline survey was conducted from December 2001 to November 2002 throughout the coastal belt. The survey identified 5 major fish processing activities being practiced as the main livelihood of most of the coastal people. The study went into further depth of all traditional processes and recommended the need for immediate improvement of identified practices through which big changes in the socio-economic status of the coastal fishers and artisanal fish processors could be possible. Five major thrust areas identified were: i. wet fish transportation and trade; ii. sun drying of fish; iii. smoking of shrimp; iv. salting of river shad and v. *Nga-pi* (a kind of fermented paste) processing from small shrimp. Traditional processing sites and primary producers were identified and extensive programmes were undertaken to develop the traditional methods by the Fish Processing Expert of the Project.

The composite porgrammes taken for the development of artisanal fish processing sector were divided into four major steps: 1. Technical capacity building and skill development of GO/NGO and project extension workers including all Upazila and field level staffs; 2. Capacity building and skill development of all primary target beneficiaries and artisanal fish processors; 3. Development of infrastructure and facilities; and 4. Development and introduction of commercially viable, socially acceptable, low-cost, easily available, user-friendly and environment-friendly technology.

Five ToTs and 3 refresher courses were offered to the GO/NGO extension workers for the development of their capacity and technical skill on fish processing. For the capacity building of the target fishing communities and artisanal fish processors, an intensive programme was undertaken. This covered organizational development, field based meeting, awareness campaign (more than two hundred awareness campaigns on improved fish handling and processing of fish), activity based participatory planning (in all 248 VOs), community level training (about 300 beneficiary level training, 20 training for AIG Activists and focal points, 40 demonstration training with the successful processors) and several experience sharing workshops. Beside these, series of PRAs were conducted in the coastal villages to identify and implement suitable fish processing based livelihood. Traditional sun drying of fish was improved through active participation of small-scale fish processors and fishermen and through developing and promoting a sustainable, low-cost, user-friendly and locally available material-based technology. A low-cost solar dryer, a ring tunnel and a box tunnel were designed and developed from local, cheaper and easily available materials to produce insecticide free, organic and high quality dried fish. A low-cost but effective ice-box was designed, developed, introduced and popularized for the transportation, distribution, storage and sale of wet fish. Beside these, simple, appropriate and acceptable technology packages were developed and introduced for the processes for smoking of shrimp, salted-drying of fish, salting of *Hilsa* and preparation of *Nga-pi* by maintaining improved sanitation all along the process lines, improving handling of raw materials and modernizing packaging systems.

The contents of this book therefore include, along with the elements of new training method, the harvests of all successful implementation of the above programmes. Traditional fish processing, their advantages and disadvantages, along with suggestions for improvement, presented in the information sheet of this book were compiled based on the base line survey, PRA exercise, village based participatory planning and hundreds of community based training. New technologies under the heading of *"improvement of traditional practices"* were developed at field level with the active participation of the fishers and fish processors and taken for this book only after successful field tests done and profitable operations seen at the field for consecutive years. So, it is not embroidering if said that the acceptance level of these new

technologies, those have been suggested for sustainable development of traditional fish processing by the coastal processors, is very high. Besides, a simplicity and uniqueness is maintained in arranging the topics and using the language and phrases in this book, which have been developed through 5 ToTs and more than three hundred community trainings. In order to produce a group of good quality trainers with adequate practical field based and up-to-date advanced knowledge, the whole training programme is planned to be based on both field level practical and classroom based group exercise. A simple technique of auto-directed self-facilitating learning has been introduced where the role of the trainer is confined merely to a facilitator in practical, not as a lecturer. Group activities/exercises and their contents have been improved to such refined format through repeated revisions, corrections and fine-tuning after a series of ToTs and refresher courses. Therefore, it is expected that these group activities/exercises can be used effectively in any training course on fish processing.

The pictures used in this book were finally drawn by a professional artist after series of drawing, redrawing, revisions and fine-tuning at community level. During field level community training, the core trainer (Fish Processing Expert) selected the theme and drew some pictures on the flip chart to explain both conventional and improved processing to the fishermen and processors. The pictures were corrected, revised and redrawn with the help of the community people until those got a shape to be easily understandable by them. A professional artist then drew those pictures as the 2nd draft. The 2nd draft pictures were used and revised in more than two hundred field level community training to make them as effective as that the message expressed could be easily understood by the participants without the help of legend or text. As per field suggestions, 2nd draft arts were redrawn by the same artist as 3rd draft and sent again to the ToT and community training for final selection. They were developed further according to the comments and suggestions of the ToT participants and drawn finally for use in this book.

2

Self-facilitated Participatory Training

Nature of the training course

The training of trainers applied in fish processing is a new simple technique of presenting and organizing a training program, which is fully participatory and interacting in its approach and self-facilitating in its delivery. Field-based practical demonstration and group exercise dominate throughout the course. The role of trainer is, therefore, secondary here. The trainer, in practical, plays a true facilitator's role, as generally seen in any participatory rapid appraisal exercise. Trainer may explain the thing and make the trainees clear on it, if anything seems to be difficult to understand during the group exercise, group review and group presentation. The training is, therefore, completely different from that of classroom-based lecture-dependent subjective type training. In this method, ToT trainees can understand and *realize* most of the

things by "*learning by doing*" in the field based practical sessions. The rest can be understood during group exercise, group review and presentations. For such ToT to be organized, a fishing village is necessary for field level practical where traditional fish processing is practiced as the means of livelihood. Along with the practical learning for the trainees, side by side, a method and/or result demonstration training on improved fish processing is conducted for the fishermen/fish processors. Therefore, in field-based practical session two training courses are carried out by the same core trainer for two different stakeholders at a time: one is ToT for extension workers and the other is demonstration training for the primary beneficiaries. Through this interacting process, trainees of the ToT can come in functional contact to the primary producers directly and learn their field problems. It thus becomes easier for the ToT trainees to come to a realistic resolution of those field problems. Moreover, in addition to developing technical skill through demonstrations, the fishermen and processors can also develop their confidence through direct interactions with the extension workers and Government officials. The trainers can validate new technologies or approaches at the field. The whole process is so organized that the trainees at different levels (both extension workers and primary producers) can come across both the traditional and improved processing methods. Along side, they can understand the field problems at the beginning of the training. Field-based practical are therefore kept always at the pre-lunch session while the group exercises and group presentations are kept at post-lunch session (Table 3.1). Through such direct interactions among the extension workers, primary produces and trainers, the training has become very fruitful, as viewed by the participants (trainee's perceptions on this new approach have been presented in Chapter 17). Participants can review the previous day activities through a participatory review session on the next morning before going to the field practical. This review session is also auto-directed and very much interacting. Core trainer plays the same facilitator's role as before. To get adequately prepared for the next morning review session, trainees are divided into several groups at the end of the day. The groups may be formed according to the

number of chapters or topics discussed. Discussed topics/chapters are distributed to the groups as *'home task'* for detail learning. Trainees have the option to prepare themselves with the help of the training manual supplied beforehand. In the next morning review session, the members of the other groups will ask question to the group assigned on particular issue/chapter. The assigned group leader/members will answer the questions. Similarly, one by one, all groups have to answer the questions on their assigned issues/ chapters. Questions are made on the basis of the field problems and applicability of improved practice. The participants can be encouraged to find out solutions of field problems considering the socio-economic status and educational level of the primary producers, their affordability, market potential and environment issues. Through this review process, as it is self-directed and fully participatory, assimilation of things discussed in the previous day becomes easier. Core trainer may clarify/explain if anything is dropped or misunderstood. Keeping the discussion on a right track is another major responsibility of the core trainer.

This new training approach practiced in different ToT on fish processing conducted by the author was found to be very effective. In most cases trainees evaluated the new techniques as effective as 85-90% (Table 17.1 and 17.2).

Conduct of training

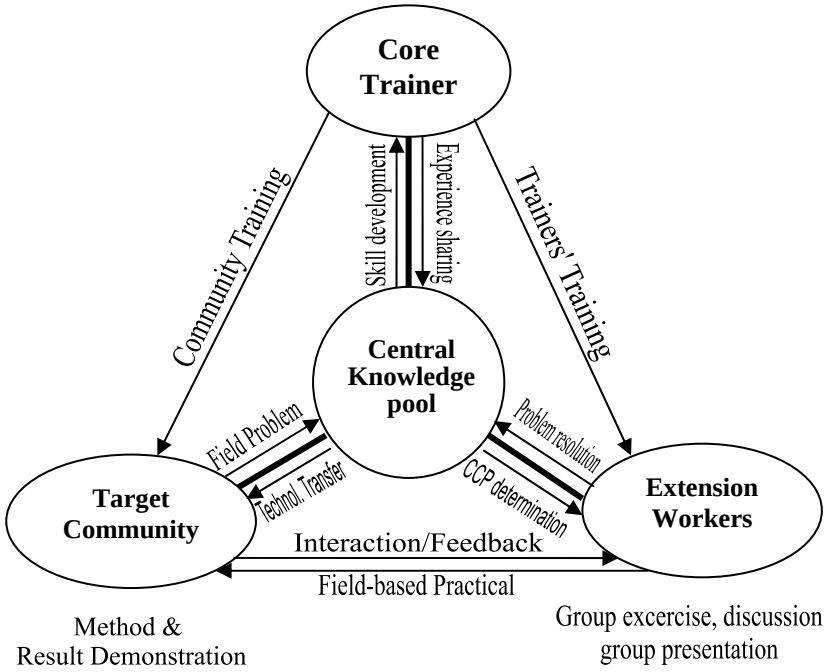
Training is a synthesis of techniques of art and science of delivering an apparently difficult and new subject through an easy, attractive and trainers-friendly way on one hand, and assimilating and realizing things through participatory interacting learning on the other.

In this participatory training method, two parallel training sessions are conducted at a time: one is ToT for the extension workers and the other is method and/or result demonstration training for the primary producers/beneficiaries. Field level demonstration training is used directly as field-based practical for the ToT. For

demonstration training, 8-10 primary producers/beneficiaries are selected considering gender equity and other issues (man:woman:: 50:50 can be a good choice). The people who are active, enthusiastic, innovative, well known to traditional knowledge and conventional fish processing and above all, interested to improve their traditional practice after the demonstration of improved technologies and methods would be good for effective participation.

The ToT for the extension officers/workers is, therefore, not at all a classroom based lecture-oriented training. Each morning, after a general briefing on a definite topic for about 30-60 minutes, the trainees will immediately go to the field where demonstration training goes on for the primary producers/beneficiaries (Table 3.1: Training schedule). Practical demonstration on traditional processes and problems, application of improved practice, analysis of the field problems and benefits and related interactions between the trainees of ToT and the primary producers will continue throughout the pre-lunch session in each day. In the post-lunch session, the ToT trainees are kept involved in resolving field problems on particular subject through group exercise, group presentation, cross interactions, group review and discussions. The problems are identified based on the constraints of traditional practices, critical control points within the process where improvement is needed, constraints related to the development and adoption of technologies at field level considering socio-economic, market and environment issues. A well-written training manual is essential for conducting group exercise. Training manual needs to be written very carefully since it will be used as a tool for auto-directed self-facilitated interacting learning. The subject matter is presented mainly in two forms in the manual - *Facilitation sheet* and *Information sheet*. The *Facilitation sheet* is primarily an exercise sheet where problems to be resolved during the group exercise are discussed, while technical information related to the resolution of those problems and development of traditional practices are given in the *Information sheet*. Information sheet should be very simple, easy understandable and devoid of exaggeration.

Fig. 2.1. A model of self-facilitated participatory interacting training. Here trainers' training and community training run in parallel and due to a three-way interaction, a central knowledge pool is developed- where everybody can contribute and equally draw benefit.



Instead of adding complex theories in the *Information sheet*, emphasis should be given to highlight detailed practice, field problems and their solution options. Useful improved technologies applicable to the field and their implementation steps should be explained in detail in the training manual. Trainees will draw full assistance from the manual during the group exercise. Trainees can be divided into two groups where they can perform the whole exercise on 50:50 share basis or they can be divided into several groups while one group may perform one or more exercise separately. Leader of each group will present the group work. The

members of the other groups will ask questions to the presenter and give feed back, whilst the presenting group leader or his group members will answer the questions. All participants should participate in the discussion, while the core trainer/facilitator will guide them to maintain the track. If any difficult or complex issue arises, the core trainer will make it clear. Participants can use the training manual during the question-answer session.

A lot of new information may come out through this open discussion, which may help for further development of the training manual. Before closing of a day exercise, the core trainer will summarize the whole day's activity and remind their responsibility so that every participant can equally participate in the review session of the next morning.

Home task is given to each group on specific topic to discuss and elaborate it at night. A participatory review session is held on the next morning, where members of the assigned group or group leader will answer the questions put by the members of counter groups. Questioning group can use the training manual to prepare their questions but the answering group cannot. In rotation, all of the groups will answer the questions on specific tasks or put questions to the answering groups. Review session will follow the field-based practical of the day. With such similar routine structure the whole training can be continued for 3 to 7 days, depending on the volume of the content and the nature of the course (5 to 7 days for a full ToT and 3 days for a refresher course). To make the course attractive, lively and participatory and to avoid monotony, unique amusement or other techniques can be applied during or in between the sessions and in the pre- and post evaluations.

During the group exercise, the facilitator can encourage the groups to perform better over opponent groups. Both the individual and group performance can be recorded and due incentives can be given instantly and also at the closing ceremony of the training.

Through this participatory interacting training, a central knowledge pool is developed (Fig. 2.1), from where the primary

producers/beneficiaries can get appropriate/improved technologies by sharing their experience and exposing field-based problems. On the other hand, through identifying the risks and critical control points (CCP) of conventional methods, extension officials/workers can provide required inputs to the knowledge pool for the improvement of traditional knowledge. The core trainer as well can develop his technical skill with the expense of experience and can make the training method and manual more effective and useful.

This new training technique can be applied for the training of extension personnel and primary beneficiaries of any disciplines of agricultural extension. For this, an adequately designed and appropriately written training manual with adequate *facilitation sheet* and *information sheet* is required. Other essential requirements are primary stakeholder/beneficiary group in the proximity for practical demonstration and finally, one or two dedicated core trainers who will devote themselves to develop a useful training manual and facilitate the entire course.

3

Application of ToT in Fish Processing

Scope of *Fish Processing* within the community

Fish processing is the area of *Fisheries Science* which covers post-harvest handling and processing of fish in the form of all sorts of pre-treatment, processing, reprocessing, packaging and quality control. In a restricted sense, fish processing covers the services and trade in landing operations, handling and transportation of raw materials and storage, distribution and exhibition of final products. In a wider sense, marketing and promotion of consumption is also under the purview of fish processing. Therefore, due to highly perishable nature of fish and fish products, fish processing starts from the harvesting of fish and ends at the final consumption of the products. To ensure the quality of fish and products for human health and nutrition, the importance of fish processing is enormous. Access to fish as food, *i.e.,* food security is human right but the fish food safety is the key to a healthy and prosperous nation that the fish processing is dealing with.

Although fishing is under the purview of fish processing in broader meaning, due to time constraints in training, discussions are restricted here on post-harvest handling and processing of fisheries organisms only. Similar training can be conducted on fish harvesting, quality control or other sub-disciplines. Due to marginal and vulnerable economic conditions of the artisanal fishing communities,

here the target is to address their traditional processing and allied problems. For this reason, technologies, which are appropriate for capital intensive medium and large-scale processing of fish, have not been included. Rather, discussions are mainly confined with simple improvements of the traditional small-scale processing.

Rationale of the training course on fish processing

Fishing and related activities are the prime livelihood of the primary stakeholders in the coastal villages. Related activities include fish processing, fish trade, fish vending, ice making, labour in processing, transportation and trade, etc. Fish processing is a major thrust area of livelihood, as it is directly related to the quality of fish and fish products where nutrition and public health are of great importance and so forth the sale value and income of the fishing activities. Good quality of the products and high profit – both can be achieved through the adoption of community based improved practices in process and trade. With these aims, this training course is designed to create a group of skilled extension workers and primary producers in the field.

Objectives of the training

The Department of Fisheries (DoF) is responsible for the implementation of the programmes related to the development of fish processing in the field. Upazila level extension workers of the DoF are the key personnel who are directly dealing with the target communities for the implementation of such programmes. Besides, many service providers are given contracts by the donor agencies or GoB to provide support on developing sustainable livelihood through social mobilization, alternative income generation, school-based primary education, primary health-care & water and sanitation, legal aid support, disaster preparedness and management, conservation and management of coastal and marine fisheries resources, etc. The ultimate objective of this ToT is to develop a collaborative bridge between the research personnel, extension workers, service providers and the primary stakeholders of artisanal fish processing for better

utilization of fisheries resources where both the Upazila and field level extension workers, service providers and community people will interact and contribute. The immediate objectives of the training are:

i. to give an overview, to the participants, of traditional fish handling and processing practiced in coastal villages;
ii. to provide information on reasons of post-harvest loss and CCP in various processing methods and stages stressing the need on minimizing such losses;
iii. to provide knowledge on sanitation and public health in post-harvest handling and processing of fish;
iv. to provide practical orientation on various processes and quality control of fish;
v. to acquaint with improved handling and processing techniques for producing high quality fish and fish products;
vi. to increase confidence of the primary producers through interactions with extension workers and GoB personnel;
vii. to demonstrate the benefits of the improved procedures to both primary producers and extension personnel;
viii. to contribute to formulating a strategy for the development of a sustainable fish processing system through assessment of field situation.

Outputs of the training

At the end of the training, the GO/NGO extension workers will be able to:

i. apprehend different traditional practices of fish processing in coastal villages;
ii. figure out CCPs where post-harvest losses occur;
iii. get an insight into the improved handling and processing of fish that can be disseminated to the primary and secondary target people;
iv. identify various management and technological measures for the reduction of post-harvest loss at different CCPs and for the sustainable development of traditional fish processing system as perceived by the poor target community.

The primary producers will be able to-

i. understand the benefit of improved handling and processing;
ii. build up confidence for producing and marketing quality products;

Overall, the training on fish processing will enable the extension workers and primary producers to understand and assess the status and needs of coastal fishermen, traders and processors, thus to contribute through active collaboration towards improvement of the overall fish processing sector and allied personnel of the country.

Training tools

Different learner-friendly aids can be used for the training**.** Emphases should be given to use audio-visuals, models, VIPP and flash cards. Participatory interactive learning can be ensured through increased number of practical, field demonstration, group exercise, group discussion and presentation, role-playing and other informal activities. Teaching aids may include LCD projector, power point presentation, OHP, transparency sheet, whiteboard, whiteboard marker, training manual, hand-out sheet, adhesive tape, marker, jumbo clip, flip chart, VIPP cards, flash cards, fool's-cap paper, pen, pencil, etc.

Simple fish processing infrastructures are always needed to be developed at field level for the improvement of traditional fish processing. After the training, the facilities and materials provided for the training like fish, ice, ice box, containers, elevated racks for drying, solar fish dryer, fly protected fish drying device like ring tunnel, box tunnel, smoking oven (kiln), processed products, etc. can be given to the trained beneficiaries to initiate a community-based micro-enterprise on fish processing.

Number of participants

For an effective self-facilitated ToT, number of participants (extension workers) should be within the range between 15-18. For community based demonstration, 7-10 fishermen/processors can be included. The total participants must not exceed 25.

Number of sessions

The ToT course designed here on fish processing is completed with a total of 19 sessions in 6 days (Table 3.1). Out of which, 6 sessions are for field based practical, 11 sessions for group exercise and 2 sessions for training management.

Table 3.1: Training schedule

Day	Time	Topic
Day 1	09:00-9:30	Self-introduction and ice breaking
	09:30-10:00	Introducing the training: design, modalities and time table, objectives and expected outputs
	10:00-10:30	Pre-training evaluation
	Field-based Practical: Method and Result Demonstration	
	10:30-11:30	Spoilage of fish and delaying spoilage
	11:30-13:00	Handling and preparation of fresh fish
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-15:00	Spoilage of fish and delaying spoilage : Activity 1-4
	15:00-16:30	Handling and preparation of fresh fish : Activity 1-5
	16:30-17:30	Participatory summing up of whole day discussion
Day 2	**Group Exercise**	
	09:00-10:00	Participatory review of previous day discussion through question-answer
	Field-based Practical: Method and Result Demonstration	
	10:00-11:30	Icing of fish, part-I
	11:30-13:00	Drying of fish, Part-I: Solar fish drying, Part-I
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-15:30	Icing of fish: Activity 1-7
	15:30-16:30	Drying of fish: Activity 1-10
	16:30-17:30	Participatory summing up of whole day discussion

	Group Exercise	
	09:00-10:00	Participatory review of previous day discussion through question-answer
	Field-based Practical: Method and Result Demonstration	
	10:00-13:00	Icing of fish, Part-II; Drying of fish, Part-II; Smoking of fish and shrimp, Part-I; Preparation of *Shidhal and Nga-pi*, Part-I
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-15:30	Smoking of fish and shrimp: Activity 1-6
	15:30-17:00	Salting of fish: Activity 1-6
	17:00-17:30	Participatory summing up of whole day discussion
Day 4	**Group Exercise**	
	09:00-10:00	Participatory review of previous day discussion through question-answer
	Field-based Practical: Method and Result Demonstration	
	10:00-11:00	Salting of fish, Part-I
	11:00-13:00	Drying of fish, Part – III; Smoking of fish and shrimp, Part-II; Preparation of *Shidhal* and *Nga-pi*, Part-II
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-16:00	Preparation of *Shidhal* and *Nga-pi*: Activity 1-10
	16:00-17:00	Participatory summing up of whole day discussion
Day 5	**Group Exercise**	
	09:00-10:00	Participatory review of previous day discussion through question-answer
	Field-based Practical: Method and Result Demonstration	
	10:00-13:00	Packaging and QC of fish & fish products: visit fish market, processing center, shopping mall
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-15:30	Packaging of fish: Activity 1-3
	15:30-16:30	Quality control of fish: Activity 1-2
	16:30-17:30	Participatory summing up of whole day discussion
	Group Exercise	
	09:00-10:00	Participatory review of previous day discussion through question-answer

Day 6	**Field-based Practical: Method and Result Demonstration**	
	10:00-13:00	Salting of fish, Part-II; Drying of fish, Part-IV: Smoking of fish and shrimp Part- III; Preparation of *Shidhal and Nga-pi*, Part -III
	13:00-14:00	Lunch and prayer break
	Group Exercise	
	14:00-16:00	Participatory review of whole training through question and answer
	Observations and Evaluation	
	16:00-16:30	Observations of the trainer/facilitator: individual/ group performance
	16:30-17:00	Post evaluation of the trainees
	17:00-17:15	Evaluation of the training
	17:15-18:00	Closing session, certificate distribution

Evaluation

Performance of the trainees will be evaluated through two evaluations: pre-evaluation and post-evaluation. Besides, there is also a provision of evaluating the effectiveness of the training course itself.

Evaluation of trainees

Pre-evaluation through *multiple choice questions* (MCQ) is an effective method for introducing the course content to the participants. It also helps to evaluate the level of perception of the participants, which in turn, assist the facilitator to review and reorganize the content and revise the mode of delivery. Post-evaluation helps to determine the efficacy of the contents and methods by analyzing the extent of interest and attentiveness of the participants.

For the pre- and post-evaluation of the ToT, a questionnaire with 25 MCQ have been set (*Annexure-II*). The MCQ covers all the topics or chapters proposed for the course. The questionnaire is designed in such a way that the participants can get a general understanding on the entire course before it is delivered. Most of the questions have three or more accurate answers in the question-

answer sheet. This can lead the participants, if understood fully, to put a tick mark (√) on "*all of the above*" in the answer sheet, thus can provide a self-directing approach in learning. A "*I don't know*" is also used in the answer options. Putting a tick (√) on it will add no mark, but contrarily, the examinee will lose nothing. Because, provisions are there that both no-answering and wrong-answering will be marked negatively, i.e. if someone does not answer a question or answers it wrongly, equivalent values (marks) for the question will be deducted from his total marks obtained. A "*I don't know*" is used to encourage the participants to attempt all questions. By this way, the level of knowledge of the trainees on the subject can be evaluated before the training is started, which can guide the trainer to adopt adequate measures so that the trainee can fully understand the subject matters during the training course. In addition, the marks obtained by this unique method may create a lively atmosphere among the participants. Because, due to such deduction, the total marks obtained by a trainee may drop to a minus figure, sometimes far below from zero.

Evaluation of training course

For the evaluation of both the ToT and the performance of the core trainer, a format is developed (*Annexure- III*). At the end of the training, the trainees are encouraged to rate the efficacy of ToT from four different considerations and allowed them to suggest both strong and weak sides of the course, which may guide the trainer to bring an adequacy in the design for conducting further ToT or refresher courses. Privacy is maintained on the part of the trainees as they are not asked to write their names on the sheet. They may put their designations but they must write educational qualifications. Qualification is required to consider the level of the trainees who are going to evaluate the training course. Through this evaluation sheet, a trainee can freely and un-biasedly put his comments or suggestions for the development the course.

Facilitation sheet-1

4

Introducing Training Course

Commercial fishing is a community-based approach. Fishing by the artisanal crafts in the sea is a collective venture of a group of fishermen ranging from 5 to 25. Modern fishing as well has become easy and successful due to such collective efforts. Likewise, the profit of fishing activity can be increased manifolds by reducing the post-harvest loss through community-based utilization of fish. Two important aspects of community-based utilization of fish are -

i. Fishing communities have to adopt appropriate technologies themselves to earn more profit by stopping or reducing post-harvest loss from the initial stage of harvest;

ii. Collective venture will ease adoption and implementation of improved post-harvest technologies.

The first one is more important since the responsibility for keeping the freshness of fish and maintaining good quality of the products entirely lies with the fishermen who catch the fish and handle it first. Beside earning profit or higher income, assurance of consumer's health also depends on proper handling and preservation of fish, to which the fishermen should also pay due attention. In this training, appropriate techniques for handling, preservation and processing of fish are discussed emphasizing on two above issues.

Activity 1 : Self-introduction and ice breaking

This step is a pre-requisite on the part of the trainees to get ready for the training. For this purpose, any method of ice-breaking can be used, depending on the level of participants. One of the very common methods is given here.

After registration, participants will be grouped in pairs. Each participant will try to know about his partner and draw a smiling face of the partner on a plain paper. Now, each pair will stand up and one partner will introduce the other partner showing his/her face and mentioning his/her good sides, interests and hobbies. Core trainer/facilitator will also take part in self-introduction process. Through this practice, friendliness, love and respect to each other will be increased that would lead to draw more mutual cooperation and benefit throughout the training.

Activity 2 : Explaining the training course, objectives and approaches

The trainer/facilitator will briefly discuss about the design of the course and its goal and objectives (Chapter-3). He/she will explain the programme of the training (Table 3.1). Presentation/ delivery and evaluation techniques will also be discussed so that the participants are well acquainted with the course and can fully participate in all the sessions and contribute to the course. Facilitator should not be haste but take extra time in explaining the programme and delivery method so that the trainees can go into the depth of the course.

Activity 3: Encouraging participation and group-work with all along positive approach

Participants will be divided into two to four groups of about equal size. Each group will be asked to select a name and a team leader for the group. The group members will also select a logo and a slogan highlighting the goals and objectives of the team. After selection, the facilitator will ask each team leader to clarify their selection criteria. He will also ask the participants to express their feeling about their team and team leader. How do they select the

name, agree for the logo and develop the slogan may also be asked. Through this discussion, important issues to come out are - team member's faith in team leader, team leader's consideration for team members, whether the elections are participatory, etc.

This session is very important for the participants to increase confidence through establishing a friendly and working atmosphere. Facilitator will carefully guide them to understand the benefit of participation. With the practice of democracy and participation at every step, the session will help in creating a creative working environment and improve the skill of the participants.

Activity 4: Pre-evaluation

As stated before, pre-evaluation of the participants will be done with a set of 25 MCQs, attached in *Annexure-II.*

The facilitator will distribute the questionnaire and collect it after 30 minutes. The participants shall put their name, position and address on the questionnaire.

Activities at the end of the training

Activity 1: Post-evaluation of trainees

At the end of the training, evaluation of the trainees will be made again with the same questionnaire as those used in the pre-evaluation (*Annexure–II*). Results of the evaluations will be presented through power point at the closing ceremony using a score sheet attached in *Annexure-IV.*

Activity 2: Evaluation of training

At the end of the course, the trainees will evaluate the training by a evaluation format given in *Annexure-III*. The trainees will be asked to rate the efficacy of the ToT from different considerations and to mention both strong and weak sides of the course. They will also be requested to put suggestions for the improvement of the course.

Their rating on training course and suggestions will be summarized on power point and presented at the closing ceremony.

Information sheet-1

5

Structure of Fish Muscles and Composition of Fish

Introduction

Knowledge on basic structure of fish and shrimp muscles and their biochemical compositions has become a primary requirement for adopting adequate handling and processing measures to reduce or stop post-harvest spoilage and minimize post-harvest loss. The structure of fish muscle is unique. It is composed of two bundle fibres, which are divided into upper mass and lower mass and again into hundreds of longitudinal tinny fibre blocks separated by connective tissue sheets. Placement of dark muscles in pelagic and meso-pelagic fishes along the lateral line adds extra dimension to its structure. These unique musculatures with diversified biochemical compositions have put different ratings to the fish or muscles in entertaining spoilage. Since the deterioration in fish quality is due to the post-mortem changes taking place in various body compositions like proteins and lipids, knowledge on biochemical composition will help the processors to identify optimum processing and storage conditions, so that the quality of fish and products is maintained at premium level. On the other hand, since fish is a health food due to rich in n-3 polyunsaturated fatty acids (PUFA), a proper understanding about its biochemical constituents has also become a primary requirement for the students, researchers, nutritionists, dieticians and the conscious consumers.

Basic structure of fish muscle

The structure of fish muscle is very simple. Basically there are two bundles of muscles on each side of the vertebral column and each of the bundles is further separated into an upper mass above the horizontal axial septum and a ventral mass below this septum.

Fish muscle tissue contains less connective tissue than mammalian muscle. It is composed of striated muscle. A muscle cell consists of sarcoplasma containing nuclei, glycogen grains, mitochondria, etc. and a number of (up to 1000) myofibrils.

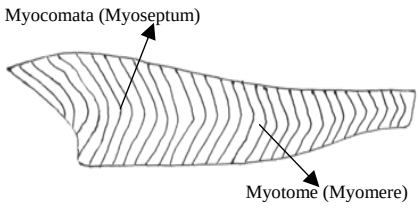


Fig. 5.1. Fish fillet

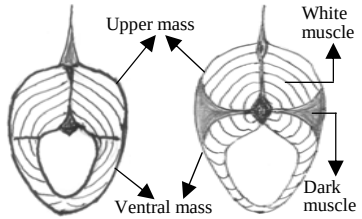


Fig. 5.2. Fish skeletal musculature

The muscle cells run in a longitudinal direction separated perpendicularly by sheets of connective tissues (myocomata) are called myotomes or myomere. The connective tissue, which is attached to the skeleton and to the skin, consists of sheets of collagen, is called myocomata and the sections of blocks of muscles are known as myotomes. The muscle blocks and associated connective tissue sheets are visible to the naked eyes. If the muscle is examined microscopically, it is seen to consist of muscle fibres of between 150 and 300 micro meter (μm) in diameter, surrounded by connective tissue which is continuous with the main connective tissue sheets. Further magnification shows that these muscle fibres consist of smaller fibres or myofibrils, 10-20 μm in diameter. Each myofibril is divided lengthwise into a large number of identical units called sarcomeres. These contain molecules of the main contractile proteins, actin (thin filament) and myosin (thick filament), the minor associated proteins troponin and tropomyosin, enzymes such as myosin-ATPase and many other components. The length of the

cells and the thickness of myocomata or myoseptum increase with age of fish.

These proteins or filaments are arranged in a characteristic alternating way making the muscle striated upon microscopic examination (Fig. 5.3). Contraction is the basic function of living contractile muscles, which is the result of series of metabolic reactions take place in living tissues. The mechanism needs to clarify to understand the post-mortem spoilage of fish.

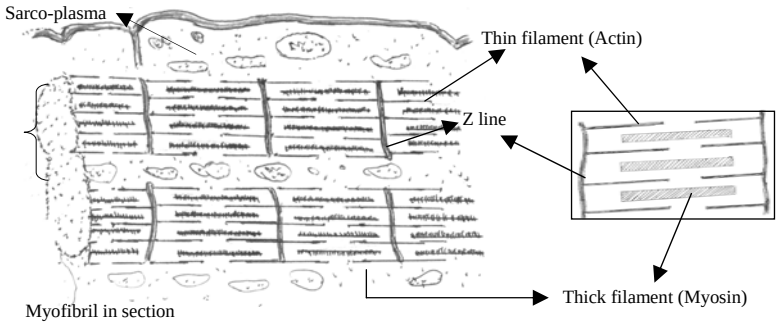


Fig. 5.3. Section of fish muscle cell (inset : actin and myosin in between Z-lines

Contraction of fish muscles

Muscle contraction in fish starts when a nervous impulse sets off a release of Ca^{++} from the sarcoplasmic reticulum to the myofibrils. When the Ca^{++} concentration increases at the active enzyme site on the myosin filament, the enzyme ATP-ase is activated. This ATP-ase splits the ATP found between the actin and myosin filaments, causing a release of energy. Most of this energy is used as contractile energy making the actin filament slide in between the myosin filaments in a telescopic fashion, thereby contracting the muscle fibre. When the reaction is reversed, i.e., when the Ca^{++} is pumped back, the contractile ATP-ase activity stops and the filaments are allowed to slip passively past each other, the muscle is relaxed. ATP is one of the most important component for muscle contraction, functioning both as a fuel for contraction and as a plasticizer in the

presence of Mg^{++} when the muscle is in relaxed state. When myofribillar ATP is absent, the actin and myosin filaments stay interlocked as actomyosin. This happens in the rigid muscle during post-mortem rigor mortis.

Types of muscles in fish

There are two types of muscles in fish: white muscle and dark or red muscle.

White muscle: Most of the fish muscle tissue is white but depending on the species many fish have a certain amount of dark muscle. All most all of the freshwater fishes have white muscle all along. These are slow moving, sluggish or bottom feeding types. In case of marine fish, generally, demersal fishes, which feed on mid-water or bottom and move gently or periodically, have higher content of white muscles, with very little dark muscle. White muscles have lower level of lipids, haemoglobin, glycogen and vitamins compared to dark muscles. In function, white muscle is sprinting muscle used for sudden, quick movements needed for escaping from a predator or for catching prey.

Dark muscle: In addition to white muscles, many pelagic or meso-pelagic fast swimming species have also certain amount of dark tissue of a brown or reddish colour. This darkness originates from the chemical combination of haemoglobin with myofibrillar proteins, called myoglobin. The dark muscle is located just under the skin along the side of the body or lateral line and in case of certain active species, also in a band near the spine.

The proportion of dark to white muscles varies with the activity of the fish. In pelagic fish like herring and mackerel which swims more or less continuously, up to 48 percent of the body weight may consist of dark muscle. Dark muscle is characterized with higher levels of lipids, haemoglobin, glycogen and most vitamins. Dark muscle usually contains more trimethylamine oxide and amino acids. From technological point of view, the high lipid content of dark

muscle is important because of problems with rancidity. Dark muscle also inhibits gel forming ability of muscle tissue which is an important characteristic of fish for heat treated textured foods. The dark muscle primarily functions as a cruising muscle, i.e., for slow continuous movement.

The reddish meat colour found in salmon and sea trout does not, however, originate from myoglobin but due to the red carotinoid, called asthaxanthin. Fish can not synthesize asthaxanthin and the red colour of this species depends on the intake of red pigments in the diets. The function of this pigment in fish has not been clearly understood.

Structure of shrimp muscle

Being a crustacean, shrimp differs in muscle structure substantially from true fish. The outer most layer, commonly called the shell, is an exoskeleton which supports and protects the softer parts of the body. The shell consists of modified protein and a polysaccharide called chitin.

If chitin is heated in sodium hydroxide solution it can be converted into a more useful chemical called chitosan. Some acetyl groups are removed from the molecular chain, leaving behind NH_2 groups.

The body within the shell consists of a head, thorax and abdomen. The abdomen and thorax is most prized for food.

The muscle is bounded externally by a pigmented layer which may conveniently be called as skin but which is not the exact counterpart of the skin of true fish. It is a heavily pigmented layer which is easily discoloured during post mortem. Crustacean muscle fibres are larger and frequently branched compared to true fish. These structural differences impart a more chewy texture in shrimp than in normal fish flesh. Considering these typical characteristics of shellfish muscle, various popular analog or fabricated shellfish are produced from fish mince.

The digestive system and reproductive organs are found in thorax but in practice, the reproductive organs and posterior part of the gut (sand vein) may be taken with the edible portion or tail. Body meat incorporating the digestive gland or liver is usually darker (often brown) in colour and contains more fat than relatively pale leg and claw meat.

Biochemical composition of fish

Fish is a highly perishable item and the perishness is due to changes taking place in the various constituents of fish. Knowledge on biochemical composition of fish will help the processors to define the optimum processing and storage conditions for premium quality products.

Edible portion of fish has four major constituents, *viz.*, water, protein, lipid and ash (minerals). The percentage composition of these constituents is called proximate composition. These four components account for about 96-98% of the total tissue constituents in fish. The range values for these constituents in the whole fish are given in Table 5.1.

Table: 5.1. Proximate composition of fish.

Constituent	Value (in percent)
Water	65-90
Protein	10-22
Lipid (fat or oil)	0.5-20
Ash (minerals)	0.5-5

Carbohydrates, vitamins, nucleotides and other non-protein nitrogenous compounds are also present in small quantities. These compounds, though present in small amount, play very vital roles in the quality and stability of the products.

Water: Water is the most vital of all and essential for any living system. Body fluid acts as medium of transport for nutrients, metabolites, etc. and regulates normal functions of any biological molecules. Proteins can maintain their native forms and normal

functions only in presence of water. The amount of water in the fish varies widely, as shown in the upper table, but in majority of cases the variation is between 70-80%. Bombay duck (*Harpodon nehereus*), a very common species of the Bay of Bengal and popularly used as dry fish in Bangladesh, has extremely high amount of water, as high as 90%.

Water in the fish tissue is present in two forms: bound water and free water. Beside the well defined biological roles, these two forms significantly contribute to the quality and stability of chilled, frozen, cooked or other uncooked fish products. There has been an inverse relationship between the water and lipid content: the sum of percentage of the two is approximately 80%, however, the summation of lipid and moisture is not always constant and frequently ranges from 78 to 85%.

Protein: Proteins are complex nitrogenous substances formed by sub unit amino acids through peptide linkage. Proteins occupy a central position in the architecture and functioning of living matter. All chemical and physical activities in the living cell are catalyzed by the enzymes which are also proteins.

Protein is the second major component in fish muscle tissue, amount generally ranges from 16 to 18%. Fish is considered to have low protein content if it is below 15%. Extent of variations in protein level is comparatively low. Feeding habits, spawning cycle, etc. affect the amount of protein in fish tissue. Red muscles usually have lower levels of protein compared to white muscles. Bombay duck contains extremely low amount of protein, as low as 8 to 10%.

Composition of fish proteins

Nair (2002) describes the functional classification and composition of fish proteins and amino acids. Proteins are highly complex molecules made up of repeating units of amino acids, with molecular weights ranging from approximately 5000 to many millions. Fish proteins are classified into 3 groups based on their solubility in salt solution. The proteins soluble in salt solutions of

low ionic strength (<0.15) are called sarcoplasmic proteins. This fraction includes myogen, globulin, different enzymes of muscle metabolism, etc. and accounts for 30-35% of the total proteins in fish. In mammal, this fraction is present comparatively in higher amount, as 35-40%. Sarcoplasmic protein content is generally higher in pelagic fish and lower in demersal fish. The electrophoretic pattern of sarcoplasmic fraction is species specific and can be used for species identification.

Protein fractions soluble in the solutions of high ionic strength (>0.5) are known as myofibrillar proteins. Actin, myosin, actomyosin, tropomyosin, troponin, etc. which are called contractile proteins are included in this fraction and they form about 60-65% of the fish muscle proteins. Mammalian muscle contains comparatively lesser amount of myofibrillar proteins (40-45%). The myofibrillar proteins play important role in determining the functional properties. The gelling properties of fish meat and the rheological characteristics of the gel entirely depend on the properties of myofibrillar fraction of the muscle. These properties of fish muscle regulate the quality of various heat processed texture-dependent kamaboko or fabricated/ analog fish products.

Stroma or connective tissue proteins account for about 3-5% of the total proteins in teleosts and around 10% in elasmobraches. Connectin, nebulin, etc. are such type of protein. Collagen present in skin and air bladder is another form of protein, similar to the connective tissue protein. These are insoluble in neutral salt solutions or in dilute acids or alkalis. The characteristic texture of fish muscle is due to the low content of stroma protein in it. Mammalian muscle contains very high amount of stroma protein.

Denaturation of protein

Amino acids are combined to form peptides and long peptide chains are folded in a regular manner to form globular proteins. The biological and functional properties of native proteins solely depend on this form. Changes in the environmental conditions like pH, ionic

strength, temperature, etc. affect the native form and the proteins become unfolded due to break down of weak bonds and denatured. The original properties of the molecules are lost as a result of denaturation. In fish after death, a number of chemical changes take place resulting in conditions favourable for protein denaturation. During processing and storage, protein denaturation takes place to varying degrees, depending on the severity of the method employed. Denaturation of protein is accepted at certain degree during processing for achieving desired quality, taste and texture of the products. Extensive denaturation of proteins, however, will affect the organoleptic properties of processed products.

Amino acids in fish protein

All proteins in the fish muscle tissue are made from 20 common amino acids in various proportions. All the common amino acids are present in fish proteins, but their proportions vary from species to species. Fish protein contains all essential amino acids in good proportions which enhances its nutritive value. Fish proteins are rich in lysine and low in tryptophan if compared to mammalian proteins.

Lipids in fish

Lipids are defined as the fraction of any biological material extractable by solvents of low polarity. Any material extracted with fat solvents like ethyl alcohol, ether, chloroform, hexane, petroleum ether, etc. are classified as a lipid. The compounds included in this group are fatty acids, glycerides, phosphoglycerides, sphingolipids, aliphatic alcohols and waxes, steroids and combination of the above type of compounds with proteins, peptides, carbohydrates, etc. In case of fish tissues, the major components of lipids are triacylglycerol and phosphoglycerides, both containing long chain fatty acids. Triglycerols are the major constituents in depot fat from muscle tissue where lipid content is more than 2%. Unusual high levels of squalene and wax esters are also found in some organs of some fish species.

Lipid content varies widely in fish muscle, from 0.5 % to 20%. Fish with fat content as low as 0.5% and as high as 16-18% are of common occurrence (Nair, 2002). Fat content varies between the species and also within the species. Within an individual fish, different types of tissues may have different fat content. In many species, there is a build up of lipid during the feeding season and decrease during spawning. Cod, haddock, hake, etc. have only about 2% lipid in the muscle. In such case depot fat is stored in the liver. In fatty fish like sardine, mackerel, herring, etc., the main site of storage of lipids is the muscle. The lipid content of such fish shows wide variation with season and sexual maturity. The lipid content of river shad, *Tenualosa ilisha* varies between 2% to 18%. The lipid content of the muscle of oil sardine, *Sardinella longiceps* is about 3-4% in June-July, which increases to about 18% by November-December.

The distribution of lipids within the body of a fish is not always uniform. Different tissues vary in their lipid content and composition. Dark muscles are rich in lipids. In cod, the dark muscle is three times richer in total lipids than the white muscle.

Fatty acid composition of fish lipids

The major chemical entity of most lipid molecules is fatty acid. The nature of the fatty acids present in fish lipids is very complex (Nair, 2002). Fatty acids with carbon chain varying from 10 to 22 and unsaturation varying from 1-6 double bonds are of common occurrence. The position of double bonds in the molecule, cis-trans isomerisms etc. add to such complexity. Yet, fish lipids have certain good characteristics in general. A great majority of the fatty acids, whether saturated or unsaturated, have an even number of carbon atoms in the molecules. Odd number acids are present, but quantitatively they are very insignificant. In the PUFAs (more than one double bond), the double bonds are separated by a methyl group and have cis-configuration. High degree of unsaturation, with 5 or 6 double bonds per molecule is very common and abundant in fish,

which is seldom observed in the lipids of other animals or plants. These features make the fatty acids of fish unique.

As in the case of lipid content, the fatty acid composition of fish lipids also shows wide variations. Proportion of individual fatty acids may vary from species to species and within the species depending on feed intake, spawning migration, etc. Commercially produced fish oils made from same species of fish often vary quite widely in fatty acid composition of the same species from year to year. The fatty acid profile of depot lipid is different from that of other tissue lipids. Depot lipids are generally richer in saturated acids when compared with lipids from the muscle tissue.

The number of fatty acids present in the fish lipid is very high. Myristic, palmitic and stearic acids are the important saturated acids, palmitoleic and oleic acids are the monounsaturated fatty acids, while arachidonic, eicosa-pentaenoic and docosa-hexaenoic acids are the major PUFAs.

Two types of changes generally take place in lipid during processing and preservation of fish: hydrolysis and oxidation. Lipid hydrolysis due to the action of lipase results in release of free fatty acids that can cause protein denaturation by alteration of native structure. These changes, however, are reduced at low temperature (–18 to –20^{o}C).

Oxidative rancidity

Oxidative rancidity is a serious problem for the keeping quality of fish products. Due to high degree of unsaturation, the fatty acids in fish are very sensitive to atmospheric oxygen or other oxidizing agents those initiate oxidation at elevated temperature. Copper, iron, etc. accelerate oxidation process. Once initiated, the oxidation will propagate itself through free radical mechanism. The products of oxidation impart odd flavour to the fish products, called oxidative rancidity and finally, products may become toxic in advanced stage.

Oxidation in fish lipids is a chain reaction that progresses through the propagation of free redicals. The process is characterized by an induction period during which the oxidation is slow, followed

by an accelerating rate of oxygen absorption with concurrent development of hydroperoxides, which are the primary products of oxidation. The hydroperoxides undergo decomposition to various products like aldehydes, ketones, alcohols, carboxylic acids, etc., some of which are volatile and some are non-volatile. The number and nature of these decomposition products depend on the position of double bonds being oxidized and the conditions under which hydroperoxides are decomposed. The rancid flavour is the net result of these changes. Further oxidation of highly unsaturated fatty acids will lead to formation of polymerized products and under these conditions fish or oil will become totally unacceptable.

Presence of air, elevated temperature, catalysts, etc. are the main agents which promote oxidation. Avoiding these conditions can minimize the risk of oxidation in fish lipid. Another effective method of preventing oxidative rancidity is the use of antioxidants. Antioxidants prevent or retard the propagation of free radical chain reaction and thus minimize the damage caused by the oxidation. Several naturally occurring and synthetic antioxodants like tocopherol, butylated hydroxyanisol (BHA), butylated hydroxyto-luene (BHT), propyl gallate, etc. are used in 0.1 to 0.2% during the processing of fish oils.

Minerals and vitamins

A large number of minerals are present in fish. Most of these minerals present in sea water are also present in fish tissue. There are, however, considerable variations in the content of individual elements. Important minerals present in fish are sodium, potassium, calcium, phosphorous, magnesium, etc. Elements of special nutritional significance present in fish are iodine and fluride.

Both water soluble and fat soluble vitamins are present in fish. Fish flesh in general is richer in fat soluble vitamins (Vitamin A, D and E) than meat. Water soluble vitamins, especially B-vitamins are almost same in fish and meat. In some species, vitamins get accumulated in the depot fat. Liver oils of some species of shark and cod are typical examples. Shark liver oil is an excellent source of vitamin A and cod liver oil is rich in vitamin D.

Information sheet -2

6

Post-mortem Changes and Assessment of Quality

After the death of a fish, considerable changes take place in the body. The changes, however, vary on the basis of size and types of fish, physical condition, season and death condition. Generally following changes are occurred in the carcass of fish.

Following the death of fish, the brain control as well as blood circulation ceases. This results in an inability to resynthesize ATP and to transport various materials essential in living cells. The death-stiffening of the muscle tissue, referred to as rigor mortis, occurs sooner or later and glycolysis forms some organic acids to decrease in pH values.

After finishing the rigor mortis, the muscle tissue loses the stiffness, followed by autolysis forming amino acids and other low molecular weight compounds. Then, microorganisms grow by utilizing these compounds which exist before and after the autolysis, and subsequently, attack high molecular weight compounds. During the spoilage by microorganisms, some specific putrefactive substances such as trimethylamine and histamine are formed depending on fish species. An outline on the postmortem changes in fish and shell fish is given in Fig. 6.1.

When glycogen is degraded to lactic acid, the pH of the muscle tissue begins to fall from initial physiological values of 7.2 to 7.4 to the ultimate postmortem pH of 6.0 or less (5.6 for tuna, bonito and mackerel). In most cases, however, the pH of the fish muscle hardly

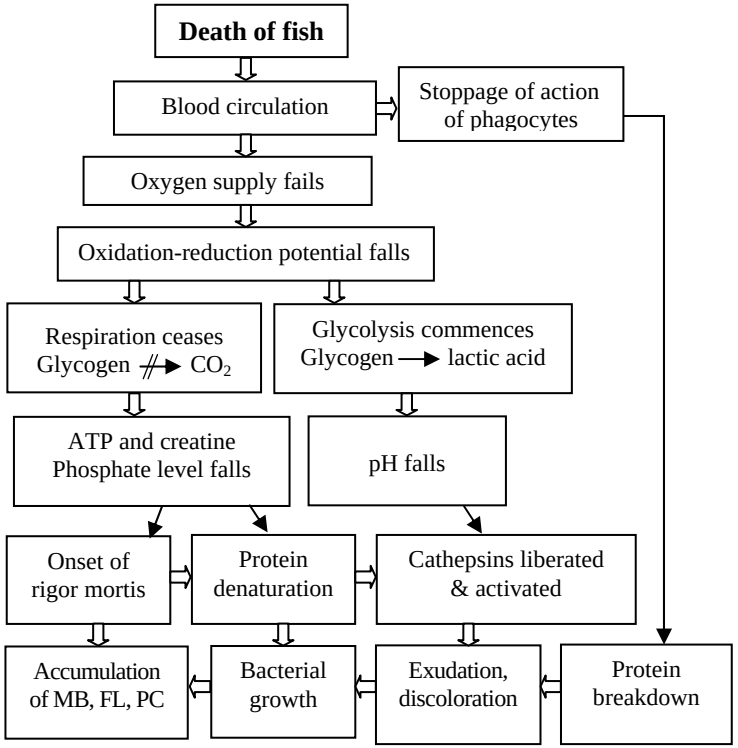


Fig. 6.1. Post-mortem changes in fish and shrimp (Sakaguchi, 1994)

goes down so much as reported for warm blooded animals, giving a value of 6.2- 6.6 or even higher as in the case of lake perch. Rate of pH decrease considerably depends on initial glycogen content of meat. Higher the glycogen content, lower is the pH values (Table 6.1).

The major source of ATP supply to the muscle fibres is lost after death of fish, since glycogen can no longer be oxidized completely to CO_2 and H_2O. Anaerobic glycolysis produces 3 moles (or 2 moles) of ATP for each hexose unit broken down:

$$(C_6H_{10}O_5)n + 3ADP + 3H_3PO_4 + H_2O \longrightarrow 2CH_3CH(OH)COOH + 3ATP + (C_6H_{10}O_5)_{n-1}$$

or, $$C_6H_{12}O_6 + 2ADP \longrightarrow 2CH_3CH(OH)COOH + 2ATP$$

For some time after death, ATP is maintained at a definite level in the muscle by active creatine kinase in addition to the above ATP producing reaction:

$$\text{Creatine Phosphate} + \text{ADP} \xleftrightarrow{\textit{Creatine kinase}} \text{Creatine} + \text{ATP}$$

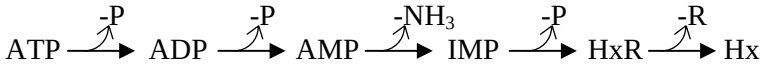
Table: 6.1. pH values and glycogen content of animal tissue (Sakaguchi, 1994).

Species	Glycogen content (G/100 g wet wt.)	Ultimate pH
Beef	1.0	5.6
Skip-jack (bonito), tuna	1.2-1.4	5.6 – 5.7
White fleshed fish	0.61 – 0.85	6.2-6.9

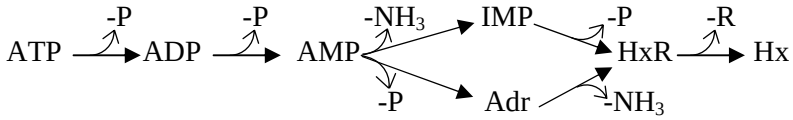
Mechanism of ATP degradation

The pathways of ATP breakdown in both vertebrates and invertebrates are shown below. Various steps involved are carried out by different enzymes present in the fish tissues as well as in bacteria. Hypoxanthin is formed by the action of tissue enzymes and later by bacterial enzymes. The values of hypoxanthin progressively increase from near zero in fresh fish to levels as high as 8 micro moles/g when the fish is considered spoiled. Hence the values of hypoxanthin can be considered as the measure of both autolytic deterioration and bacterial spoilage. The values of hypoxanthin and freshness of fish correlate well with flavour changes in the period of storage. It is, therefore, considered as a useful index of freshness provided the limits of acceptability are known for a particular species of fish. However, sometimes in certain species very low hypoxanthin values are observed despite the progress and onset of spoilage. This is because in those species hypoxanthin is immediately broken down into uric acid due to high degree of xanthin oxidase activity. In certain other species, the breakdown of IMP to hypoxanthin is slow due to reduced activity of some enzymes.

Vertebrates



Invertebrates



Post-mortem bacteriological changes

Fish generally harbours a large population of bacteria on skin, surface, gills and in the intestine, particularly in case of cultured fish. Usually the bacterial load is in the range of 10^3 to 10^5/cm^2 in the case of skin surface, 10^4 to 10^6/g tissue in the case of gills and 10^5 to 10^8/g of the gut contents. When the fish is dead, these bacteria enter the body, proliferate and cause deterioration of muscles. The multiplication of bacteria in fish is controlled by either icing or freezing methods. During freezing cold sensitive bacteria die out and the surviving cold tolerant bacteria take longer time to multiply. Therefore, the rate of bacterial spoilage is slowed down. Usually, a self life extension of 8-15 days is obtained if icing is done properly.

Freezing of fish causes death of bacteria to the extent of 60 to 90% depending on the initial bacterial count. The survivors are mainly gram positive bacteria which can not grow and cause spoilage of frozen fish. However, upon thawing at ambient temperature, these bacteria can multiply and cause spoilage of thawed fish.

In post-rigor stage, bacterial spoilage becomes very fast. The rise of muscle pH from acidic to alkaline range for accumulation of volatile bases like ammonia and trimethylamine produced by spoilt fish enhances bacterial growth. Trimethylamine is produced by the reduction of trimethylamine oxide by bacterial enzyme as well as by tissue enzymes.

Rigor Mortis in Fish

The catabolic process taking place in a freshly dead animal body lead to stiffening of the muscles is known as rigor mortis. There are 3 steps of rigor mortis progress in fish.

Immediately after death, the fish muscles are totally relaxed. The fish is soft and pliable and the texture is firm and elastic to the touch. At this time, the flesh is said to be pre-rigor condition. It is possible to make the muscle contract by stimulation in this stage, for example by means of an electric shock.

Eventually, the muscles begin to stiffen and harden and the whole body becomes inflexible, the fish is said to be in-rigor stage. The muscle will no longer contract when stimulated and it never regains this property.

After several hours or days, the muscles gradually begin to soften and become limp again. The fish has already passed through the rigor and is said to be in post-rigor stage.

Changes in fish during rigor mortis

Physical changes

When rigor sets in, the muscle becomes hard and stiff and the whole body becomes inflexible. If the fish is filleted pre-rigor, the muscle can contract freely and the fillet will shorten and have a wrinkled surface. Dark muscle may shrink up to 50-52%, while the white muscle up to 15-18% of the original length. After rigor, the muscle tissue returns to a relaxed state. With some experience, it is possible to distinguish between the pre-rigor and post-rigor fish since pre-rigor fish is fully flexible and do not show pressure marks after gentle squeezing.

Chemical changes

The course of main biological process leading to rigor mortis is the same in muscles of great variety of species of fish and homeothermic animals. During the transition from living state to full

rigor, fish muscle undergoes a series of biochemical changes. The most important reaction is the turn over of ATP, which proceeds for some hours in the dying muscle at about the same rate as in the resting living muscle. Living muscle cells obtain their biochemical energy (ATP) from respiring mitochondria. This aerobic respiration ceases when blood circulation stops after death. Under this circumstances, the enzymatic machinery of the cell which is geared to maintain a constant level of ATP initially use creatine phosphate (CP), a reservoir of phosphate bound energy normally present in the muscle to generate ATP from ADP. ATP level starts to fall when 70% or more of the CP has been degraded.

The major anaerobic sources of biochemical energy supply are via the break down of glycogen which through glycolysis does not only generate ATP but also produces lactate. As a result, the protons that are generated during the glycolysis and hydrolysis of ATP to ADP cause a significant decrease of cellular pH from pH 7.2 to pH 5.5. The glycolysis continues until all glycogen is consumed or glycolytic enzymatic system inactivated at pH 5.4. The change in acidity depends also on the liberation of inorganic phosphate and ammonia due to enzymatic degradation of ATP and on the inherent buffering capacity of the muscles.

Biochemical causes of rigor-mortis

Rigor mortis is caused by the bonding of myosin heads to the active centers of thin filaments, the actin. This leads to the formation of a rather rigid structure of inter-connected myofilaments, the actomyosin. As the individual muscle fibres contain different quantities of ATP, they do not enter rigor at the same time post mortem. Thus, stiffness in muscle sets in gradually. During the later stages of post-mortem changes, the decomposition of nitrogenous compounds leads to an increase in pH in the flesh. The rate of pH changes depends on temperature.

In live or newly died fish, muscular contraction starts when a nervous impulse sets off a release of Ca^{++} from the sarcoplasmic reticulum to the myofibrils. When the Ca^{++} concentration increases

at the active enzyme site on the myosin filament, the enzyme ATP-ase is activated. This ATP-ase splits the ATP found between the actin and myosin filaments, causing a release of energy. This energy is used as contractile energy making the actin filament slide in between the myosin filaments in a telescopic fashion, thereby contracting the muscle fibre in living tissue. When the reaction is reversed, i.e., when the Ca^{++} is pumped back, the contractile ATP-ase activity stops and the filaments are allowed to slip passively past each other, the muscle is relaxed. ATP is one of the most important component for muscle contraction, functioning both as a fuel for contraction and as a plasticizer in the presence of Mg^{++} when the muscle is in relaxed state. During rigor mortis progress, as mentioned elsewhere, myofribillar ATP is absent, whereby the actin and myosin filaments stay interlocked as actomyosin. This is why the muscle becomes rigid and stiff during postmortem rigor mortis.

Factors influencing the rigor mortis progress

It is possible to distinguish between pre-rigor and post-rigor fish since pre-rigor fish are fully flexible and do not show pressure marks after gentle squeezing. The time involved in each stage of the development, duration and subsequent resolution of rigor mortis depends on many factors such as species, size, catching method, handling of fish, temperature and the physical condition of the fish.

Exhausted fish and fish kept at high temperatures will enter and pass through rigor quickly. Small and active, struggling fish does the same while large and flat fish takes a longer time. If rigor develops at high temperatures, the rigor tension may become very strong and can cause “gaping”, i.e. weakening of connective tissues and rupture of fillets. The following factors are responsible for rigor mortis progress in fish.

1. Species: Some species take longer time than other to go into rigor, because of their differences in chemical composition. Fish with high lipid content goes to rigor earlier than low fat species. Generally, dark muscle goes quiet earlier than white muscle. Northern whiting goes into rigor very quickly and becomes

completely stiff one hour after death, whereas red fish stored under the same condition may take as long as 24 hours to develop full rigor.

2. State of activeness: Fish that are very active in their normal habitat may become excited and die in a frenzied state when caught shows a shorter period of rigor mortis. Exhausted fish have little or no glycogen reserve and therefore, very little or no delay period.

3. Condition and seasonality: Rigor mortis starts immediately or shortly after death if the fish is starved and the glycogen reserves are depleted, or if the fish is stressed. The poorer the physical condition of the fish (less nourished) before capture, shorter is the time it takes to go into the rigor, because of very little reserve of energy in the muscle to keep it pliable. Spent fish is an example.

4. Degree of exhaustion: Fish struggled in the net for long time before hauled and gutted on board vessel will have much less reserve of energy than those entered the net just before hauling and thus will go into rigor more quickly.

5. Size: Small fish usually go into rigor faster than large fish of the same species.

6. Handling: Manipulation of pre-rigor fish does not appear to affect the time of rigor, but manipulation or flexing of the fish while in rigor can shorten the time they remain stiff.

7. Temperature: This is the most important factor governing the time a fish takes to go into and pass through rigor because the temperature at which the fish is kept can be controlled. The warmer the fish, the sooner it will go into rigor and pass through rigor. Although it is generally accepted that the onset and duration of rigor mortis is more at high temperature, it has been observed in certain tropical fish that the biochemical change and thus rigor mortis may actually be stimulated at $0^{o}C$ compared with $22^{o}C$.

Impact of rigor-mortis on keeping quality of fish

Rigor can affect the quality of frozen whole fish in three main ways: by causing i. gapping in fillets taken from frozen whole fish; ii. toughness and drip loss in frozen whole fish or fillets and iii. shrinkage of frozen fillets. These undesirable effects can be reduced or prevented by i. keeping the fish cool, particularly before going into rigor; ii. handling it carefully when in rigor and iii. freezing fillets from pre-rigor fish as soon as they are cut. Only careful treatment of the fish before and during rigor will result in a higher quality frozen product. For appropriate handling, careful labeling scheme for frozen fish is necessary that enables processors to identify the fish frozen pre-rigor, in-rigor or post-rigor. Reliable and the safest way to avoid negative impacts of rigor is to keep fish chilled at every stage before freezing. If the fish pass through rigor at chilling temperature, the effects of rigor on the quality will be not so serious.

Gapping

A fillet is said to be “gapped” when the individual flakes of muscles come apart, giving the fillet a broken and ragged appearance. This happens when the material that binds the flakes together, known as connective tissue, breaks down. There are several causes of gapping, important one is rigor process. As muscle goes into rigor, it attempts to contract but skeleton and connective tissues prevent contraction and tension increases within the muscle. As long as the connective tissues can withstand this increase in tension, the flesh will not gap. But when the tension is greater than the inherent strength of the connective tissue, some gaping will occur.

The temperature of the whole fish as it goes into rigor has marked effect on gaping. The higher the temperature when it goes into rigor, the greater is the rigor tension, the weaker the connective tissue and higher is the gap between the flesh. If the temperature of the whole fish is lowered so much that the fish start to freeze while it goes into rigor, the connective tissues is again weakened due to ice formation and gapping occurs.

Rough handling of fish in rigor can cause gapping. Any attempt to bend or straighten a rigid/bent fish will break the muscle or connective tissues. Pressure from freezer–plates can damage the fish.

Full stomach of fish has impact on gapping. Gapping by freezing fish in rigor is more in well-nourished fish than spent fish. Gapping is also more in well-fed fish kept at high temperature and then frozen after they have started to go into rigor.

Prolonged frozen storage may also lead to gapping.

Toughness and drip-loss

The higher the temperature of fish at rigor, greater will be the drip-loss on thawing and tougher and more stringy will be the muscle when it is cooked and eaten. This will be aggravated when fish are well fed and not exhausted. Whole fish frozen pre-rigor tends to have higher drip-loss than the similar fish frozen in rigor or post-rigor.

Impact of rigor in frozen fillet

When rigor sets in, fish flesh becomes hard and stiff and the whole body becomes inflexible. If the fish is filleted pre-rigor, the muscle can contract freely and the fillets will shorten and have a wrinkled surface. Dark muscle may shrink up to 52%, while the white muscle up to 15% of the original length. After rigor is passed, the muscle tissue returns to a relaxed state.

If the fish are filleted pre-rigor, the fillets may shrink; if these fillets are frozen, they will often have a poor texture and enhanced drip-loss. The shape of the fillet becomes distorted and the surface takes on a corrugated appearance. This distortion will remain throughout subsequent freezing and frozen storage. The extent of shrinkage depends on the condition of fish and the temperature at which it is kept.

It is very important that fillets be frozen immediately after they have been cut from pre-rigor fish. If delay between filleting and

freezing is unavoidable, the fillets must be kept chilled to reduce the shrinkage, but even at 0^oC some of the fillets will shrink after certain time. Immediate freezing is the only safe way to avoid shrinkage. Pre-rigor fillets should not be chilled by freshwater ice, because shrinkage enhanced by contact with freshwater. The cut surface of a pre-rigor fillet is different from that taken from a post-rigor fish. It is dull, rough and corrugated with a texture that feels like creperubber caused by exposure of the cut ends of individual muscle fibres.

When filleting is delayed until after the whole fish has gone into rigor at a low temperature, most of the problems of shrinkage are avoided and the quality of fillet becomes good. But there are some disadvantages too. Mechanical filleting is difficult when the fish are in rigor and hand filleting may give slightly lower yield from fish.

Rough handling of fish in rigor will also cause gaping. In principal, it is safer to fillet the fish post-rigor and freeze these fillets but often this is not possible, as it requires a large chilling chamber for the whole fish.

Frozen fillets taken from post-rigor whole fish are normally of uniformly good quality, provided that the whole fish is properly handled and kept adequately chilled.

Thaw rigor

When fish muscle is frozen pre-rigor and kept for a short time in cold storage, it is still be able to contract and go into rigor after thawing. This is called thaw rigor. If this thawing is done at high temperature, the muscle then can suffer from the defects associated with high temperature rigor. Thaw rigor is not a problem in case of whole frozen fish because contraction is negligible due to skeleton restrains the stresses. Thaw rigor is really a problem in case of fillets those are frozen and frozen stored pre-rigor. The effects are most serious when the pre-rigor muscles is cooked from the frozen state. For example, when consumer packs of fillets or fish fingers are

prepared from pre-rigor fish. When a fish finger is given a preliminary cook, the flesh can contract and cause it to distort, resulting in difficulty in packing. The texture will be tough and stringy and drip-loss will be high. On final cooking, the free water will boil off and causes the batter to spatter. Thaw rigor is, however, not the only source of free water in frozen fillets and fish fingers. The effects of thaw rigor are more noticeable when single fillets or small portions are thawed, rather than blocks of fillets.

Thaw rigor, although uncommon in commercial practice, but if met with, the bad impact can be avoided very simply. The simplest way is to extend the frozen storage time of the stock of pre-rigor fish. If the fish flesh is kept at least 8 weeks at -20^oF or -28^oC, the flesh has time to pass through rigor in the frozen state. This has no bad impact on the quality of either whole fish or fillets, since both are held rigidity enough while frozen to prevent the muscle from contracting. If the fish has to be taken out of frozen storage in less than 8 weeks, they should be thawed slowly at room temperature. In this way rigor is completed while the fish are in semi frozen state, thus preventing severe contraction of the muscle.

Methods of Quality Assessment of Fish

a. Biochemical methods

A variety of chemical compounds or groups of compounds accumulate post-mortem fish muscles. These chemicals are either intermediate or end products of biochemical changes occurring in the muscles of fish after death.

Proximate composition: Because of influence of chemical composition on keeping quality, proximate chemical composition like moisture, lipid, protein and ash contents of fish samples from the time or day of harvest to different storage periods or conditions are often investigated. Proximate composition may vary with species, sex, season, place of harvest, feeding condition, etc. So, conclusive results are very difficult to obtain.

Hypoxanthin value: As a consequence of post-mortem changes, breakdown of ATP to ADP, AMP, IMP and finally to hypoxanthin takes place. Hypoxanthin content of muscle increases on storage of fish. Estimation of hypoxanthin is an objective test of freshness of fish. However, the estimation of hypoxanthin is too cumbersome and it is seldom employed in practice. Fish with a hypoxanthin value of 7-8 micro moles/g is considered spoiled (Gopakumar, 2002a).

Histamine content: Histamine develops in freshly caught fish after 40-50 hours of death, if the fish is not properly iced. To avoid histamine formation in tuna, skipjack and mackerel, care is taken to ice or freeze fish as quickly as possible. Histamin is a major problem in warm water pelagic species that causes a form of food poisoning known as scombroid poisoning, as the name derived from the family name of tuna and mackerel, scombroidae. The term is also applied to other family members too. The symptoms of scombroid poisoning are facial flushing, rashes, headache and gastro-intestinal disorders.

Histamin is produced from histidine which is one of the constituents of muscle protein of all fishes. Generally, pelagic fishes contain sizable amount of histidine in free state as well as bound state within protein. Upon death, histidine in fish muscle is converted to histamine by bacterial enzymes. Histamin content over 20mg/100g in canned fish is prohibited by the US-FDA standard.

pH: Change in pH of the fish muscle is an usual good index for freshness assessment.

Trimethylamine: Marine fish contains sizable amount of trimethylamine oxide (TMAO) which is reduced to trimethylamine (TMA) during the spoilage of fish. TMA determination is a useful index to measure the quality of stored fish. Fish with a level of 1.5 mg TMA nitrogen/100 g fish is considered acceptable, while 10-15 mg/100 g limit is set for moderately spoilt fish and beyond this range is set for highly spoilt fish (Gopakumar, 2002a).

Total volatile base nitrogen (TVBN): A number of volatile bases like ammonia are released in fish during decomposition by bacteria.

A limit of 35-40 mg TVBN per 100 g of muscle is considered acceptable for good quality fish, while a value of 50-70 mg/100g of muscle can be taken as upper limit beyond which fish is considered inedible. For salted and dried fish the range is 100-200 mg/100 g beyond which the products are marked unacceptable.

Peroxide value: Oxidative rancidity developed in fish tissue is determined by the estimation of peroxide value. Good quality fish should have a peroxide value quite less than 10. Peroxide value above 20 for any fish is considered rancid.

Thiobarbituric acid value (TBA): It is also determined as an index of oxidative rancidity in fish. For a good quality moderate lipid fish, TBA value of less than 2 is usually accepted.

K value: High level of adenosine related compounds or inosine mono phosphate in fish muscle imparts sweet, meaty flavour and is regarded as a reliable index of freshness. Post-mortem accumulation of inosine or hypoxanthin generally reflects poor quality. The conversion of ATP to IMP is very fast and is usually complete within a day. Subsequent accumulation of inosine or hypoxanthin is related to both autolytic and microbial action. Based on hypoxanthin values and their correlation with freshness of fish, Saito et al (1959) first proposed the K value as an index of the freshness of fish. K value is calculated from the values of hypoxanthin, inosine and total nucleotide levels in fish at the point of measurement as shown in the equation (i). However in practical situation adenosine compounds are deleted because of their conversion into IMP, HxR and Hx, shown in equation (ii). In freshly caught fish K value would be as low as zero, in moderate quality fish the value could be 10 to 20, but in spoilt fish it can go upto 90 (Gopakumar, 2002a). K vales are found to have excellent agreement with sensory data of fish. K values also rise with the ice storage period of fish.

$$\textbf{K Value} = \frac{HxR + Hx}{ATP+ADP+AMP+IMP+HxR+Hx} \times 100\ (\%)\ \text{(Theoretical)}\ldots\ldots\ldots\ldots\text{(i)}$$

$$\textbf{K Value} = \frac{HxR + Hx}{IMP+HxR+Hx} \times 100\ (\%) \quad \text{(Practical)}\ldots\ldots\ldots\text{(ii)}$$

b. Biological method

Total plate count (TPC): Total number of microbial flora is changed with the time in fish or fish products. The numbers per gram of fish or fish products or per square centimeter of the surface area indicate the quality of fish from the microbiological view point. Total plate count or viable bacterial count is determined by the culture of bacteria present in fish sample using a suitable bacteriological media that could recover maximum number of bacteria in fish tissue. A known weight of fish sample is minced aseptically and serial decimal dilutions are pour-plated with the media. For marine fish agar agar and for processed fish products tryptone glucose beef extract agar media are commonly used. Inoculated plates are incubated at 37^{o}C for 24 hours and the bacterial colonies are counted. From the colony counts, TPC is calculated by multiplying with appropriate dilution factor. TPC does not strictly indicate the edibility of the fish. Fish with low TPC may bear pathogen that would have more dangerous if consumed. Therefore, qualitative analysis is done to determine the presence of any pathogenic or health hazard bacteria. Different types of selective or ordinary media are used for the identification of pathogenic organisms in fish. For example, SS-agar or XLD agar medium are used to detect coliform bacteria like *Salmonella, Shigella, E. coli*, etc.

c. Organoleptic method

Sensory methods are used to assess the degree of freshness based on organoleptic characteristics such as general body appearance, consistency of flesh, odour, colour, eye and gill condition, etc. These characteristics are judged by panel members, i.e, subjective judgments are made by individuals. Various numerical scoring or

ranking systems have been developed to evaluate the judgments or results. Sensory methods have advantages that it can be adapted by the human being easily and the quality can be assessed by odour or visual inspection for quality defects. Human senses indeed are more efficient in some complex tasks than the instruments. The method is described more in chapter 16.

There is, however, no single satisfactory test developed for the quality assessment of fish. A combination of chemical, biological and organoleptic tests would be the best procedure to assess such freshness.

Facilitation sheet -2

7a

Spoilage of Fish and Delaying Spoilage

The participants can be divided into several groups and one group can perform one or more of the following activities/exercises. They may be divided into 2 groups to perform all the exercises on fifty:fifty share basis. After group exercise the group leader will present the results. Members of the other groups will ask question to the group leader who is presenting the results. The group leader or his team will answer. The trainer will facilitate the group exercise and question-answer session.

Activity 1: Why does a fish spoil?

The facilitator will ask the participants to write down the reasons for spoilage of fish on the VIPP cards. The facilitator will then analyze the existing concept and discuss each point. He will make an easy explanation if the concept is true, or explain the right cause, if it is wrong.

Activity 2: Acceleration and delay of spoilage

The participants will be divided into 2 groups. The following chart will be fixed on the board or drawn on a flip chart. Group A will be asked to write the answers of how does fish spoilage accelerate, while Group B will be asked to write how can fish spoilage be delayed or stopped. The group leaders will justify their concepts before the participants. One group will ask questions to other group. The facilitator will explain the things in detail.

	Group A How does fish spoilage accelerate?		**Group B How can spoilage be delayed or stopped?**
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	

Activity 3: How can you protect fish from physical injury and contamination?

Group members will discuss the matter and write the answers on the following chart. The group leaders will justify the respective team's findings. One group will ask question to the other group. The facilitator will explain in detail.

	Group A Protection of fish from physical injury or damage		**Group B Protection of fish from contamination**
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	

Activity 4: What do you mean by post-harvest loss of fish? How can you reduce such post-harvest loss?

Participants are divided into small groups of 4 to 5 persons representing different stakeholders. The group members will discuss

the issues related to reduction of post-harvest loss and come up with measures that could be adopted at each stake holder's level. They may suggest how best the quality of fresh fish be assured. Each group will summarize their recommendations on the following table and the group leaders will present in the plenary to stimulate discussions. The facilitator will clarify the extent of damage.

a. Qualitative loss

Stakeholder groups	**Desired measures/actions to minimize qualitative loss**
Fishermen	
Boat/Trawler owner	
Wholesaler	
Retailer/Vendor	
Consumer	
Extension worker	
Government	

b. Quantitative loss

Stakeholder groups	**Desired measures/actions to minimize quantitative loss**
Fishermen	
Boat/Trawler owner	
Wholesaler	
Retailer/Vendor	
Consumer	
Extension worker	
Government	

Information sheet -3

7b

Spoilage of Fish and Delaying Spoilage

Introduction

Of all the food items we eat and see around us, fish spoils most quickly. The chemical composition of fish, qualities of inherent proteins and lipids and most of all, the nature of habitat where it lives, all contribute considerably to make it susceptible to spoilage soon after death. Since it is a food item and it undergoes post-mortem spoilage very quickly, the fishermen, traders and processors should carefully consider all sorts of possible measures to delay or stop such spoilage. A review of knowledge on fish spoilage will help to identify affordable quick measures that can delay the spoilage and improve the quality and shelf life of fish. Knowledge on general principles of fish processing/preservation is also important, on the basis of which such fish spoilage is stopped or delayed.

Why does a fish spoil?

Fish lives in water. There are millions of very small organisms, called bacteria, in the water that can come in direct contact with fish. Water passes through the mouth and gills during respiration. Marine fish drinks water, so these bacteria may enter the stomach. Thus the whole body of fish (skin, eyes, mouth, gills, stomach) is exposed to bacteria. Most of these bacteria are harmless: some of these are of use to fish, some breakdown vegetation in the soil to release nutrient to the water, but some cause disease in fish and some also spoil fish (Clucas and Ward, 1996). The spoilage bacteria, however, can not spoil the muscle when the fish is alive. After death, spoilage bacteria enter the muscle from the skins and gills, disintegrate the muscle cells and take necessary energy to grow. As soon as fish dies, the supply of energy ceases. The fish muscles gradually harden and the entire body becomes stiff within a few hours of death. This hardening remains for a couple of hours depending on the species, temperature and other conditions at death.

After stiffing, the muscles become soft again, from when spoilage starts (Love, 1992). Chemicals, namely enzymes that are present in the muscle, viscera, digestive tract and that produced by bacteria breakdown the muscles into smaller components. The production of acids in the muscle increases, whereby spoilage bacteria from surface, gill and gut attack and feed on such smaller components and spread out. Increased bacterial activity results in a heavy slime on the skin and gills and an unpleasant sour odour with

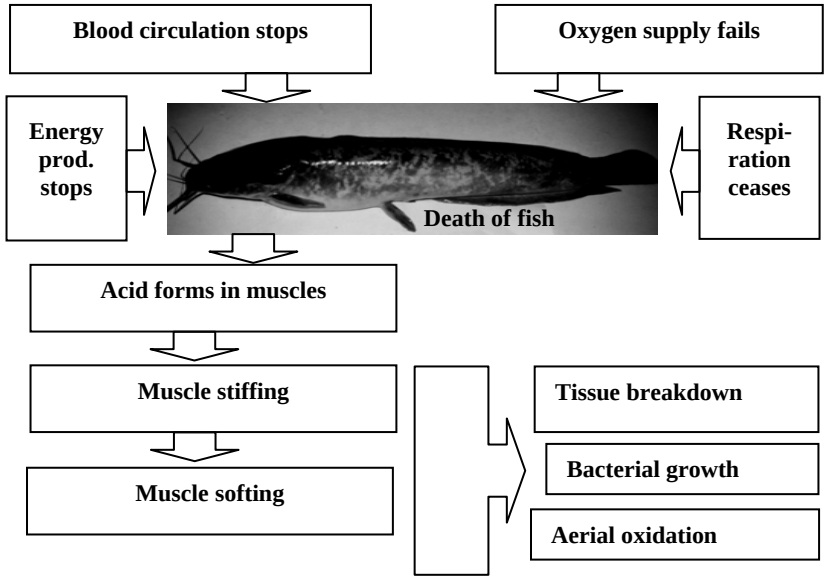
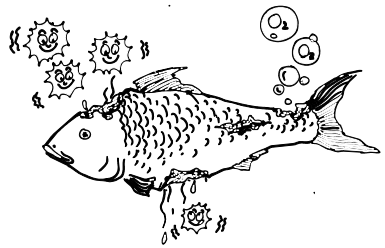


Fig. 7.1. Factors and causes of fish spoilage

soften muscle tissue. During this time fish lipids are broken down by the action of oxygen of the air that may result off flavour and colour changes. By this way spoilage accelerates in fish with the lapse of time at room temperature.



Fish spoils for three reasons:

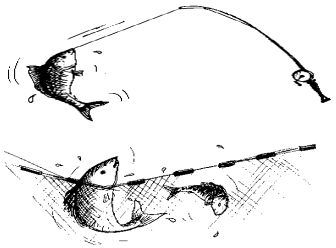
- **Action of enzymes**
- **Action of bacteria**
- **Oxidation of lipid**

Bacterial action is the most important cause of fish spoilage

If disease producing bacteria contaminate the fresh fish, it can cause serious illness or even death of the consumers. If the fish are kept clean and properly iced, bacterial contamination can be kept to a minimum and growth of any bacteria can be reduced**.**

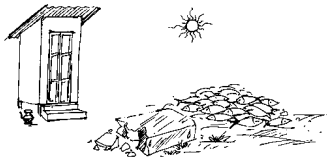
Bacteria and enzymes can not spoil fish if they do not get adequate environment. Both bacteria and enzyme need certain congenial conditions under which they are most active. Both of them like warm temperatures: not too cold and not too hot. Bacteria like to have water present for it to survive. They also need to have a substrate (food) on which to be active- in this case the flesh of fish.

How does spoilage accelerate?



Spoilage of fish is accelerated by

- **struggle/excitation during fishing**
- **rough handling: injury or damage of muscle**
- **improper sanitation**

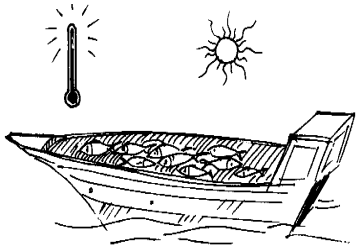


- **contamination**
- **delay of icing**
- **exposed to sun at any stage**

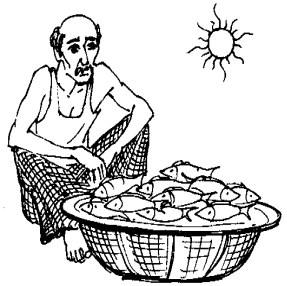
Delay of icing is the most important critical factor that accelerates the spoilage

How can we delay or stop fish spoilage?

Fish spoilage can be delayed or stopped by



- protecting fish from physical injury or muscle destruction
- applying proper sanitation and avoiding contamination
- lowering temperature immediately: keeping cool during transportation and storage

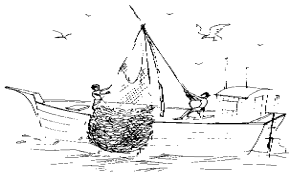


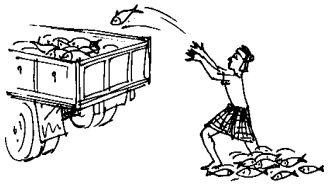
- destroying enzyme and killing bacteria by high temperature: canning, heat processing (fish ball, fish sausage, fish stick, burger, etc.)
- reducing water content in fish body: drying, salting, smoking

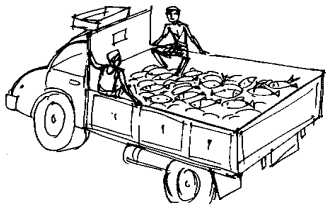
Lowering of temperature immediately after catch uniquely delays or stops the spoilage of fish

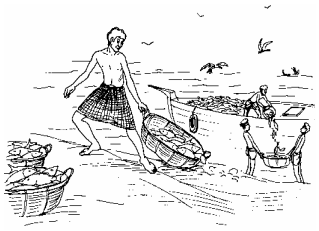
Any delay of cooling down the temperature will mean that fish can continue spoiling. The rate of bacterial reproduction and growth, digestion of the flesh by gut enzymes and the oxidation of fish body lipid depend on temperature. Therefore, lowering of temperature will slow down the spoilage caused by any of the three means discussed above. Moreover, lowering of temperature extends the lag phase of microbial growth that delays the development of rapid growth and reproduction of bacteria.

How can we protect fish from physical injury?









To protect fish from physical injury or muscle damage -

- **be careful on handling fish during harvest, keeping in fish hold, taking out of fish hold, unloading and transportation;**
- **do not throw fish;**
- **do not stand on fish;**
- **do not mishandle fish in any way that might bruise flesh, split skin or burst gut;**
- **do not pack too tight / too large volume;**
- **do not stack ice/fish mixture too great a depth;**
- **do not overfill boxes;**
- **remove damaged fish;**
- **use finely-crushed ice, no rough-edged large ice pieces**

Packing too tight and too large volume can cause damage even if immediate proper icing is done

How can we maintain proper sanitation?

For maintaining proper sanitation in post-harvest handling, preservation and transportation –

- acquire good knowledge on sanitation and contamination;
- wash everything with clean/ chlorinated water;
- use clean place and container to keep fish
- prepare ice from clean water;
- avoid contamination from guts and rotten fish;
- keep small fish apart from large fish;
- keep separate catch caught different times separately;
- keep fish of soft bellies separately;
- remove guts and wash out traces of guts in body cavity;
- wash fish hold, deck and ice chamber of boat thoroughly;
- do not put fish on the ground.

How can we lower the temperature of fish immediately?

Temperature of fish can be lowered by -

- **Icing of fish with ice crystals;**
- **Chilling of fish with other means (dry-ice, liquid nitrogen, etc.);**
- **Dipping fish in cool brine/ RSW/CSW;**
- **Freezing of fish**

Icing with ice crystals is the easiest and low cost method to lower the temperature of fish

From the above discussions, it is clear that the fish processing or preservation is to be done on the basis of certain principles in order to stop or delay the spoilage immediately in the muscle tissue. Four principles are generally involved in the preservation/processing of fish and shell fish by various methods.

General principles of fish preservation/processing

1. Prevention or delay of microbial decomposition

a. By keeping out micro-organisms (asepsis)

b. By removal of micro-organisms, eg. through filtration

c. By hindering the growth and activity of micro-organisms
   - low temperature (chilling, super-chilling, freezing
   - irradiation (gamma rays)
   - modified atmosphere (nitrogen, carbon dioxide, carbon monoxide, oxygen, etc)
   - drying and dehydration, cold smoking, other curing methods
   - other treatments like hypobaric storage, ozone, blanching, chemicals, etc.

d. By killing the micro-organisms
   - heat treatment
   - canning, hot smoking
   - irradiation
   - heat processing of fish paste: boiling, broiling, grilling, microwave and retort heating, etc.
     - surimi based products, kamabokos
     - fish ball and fish sausage
     - analog and fabricated products: artificial crab leg, beef jerky, etc.
     - battered and breaded products

2. Prevention or delay of self decomposition of fish

a. Removal of digestive segments of fish by dressing

b. Destruction or inactivation of fish enzyme:
   - blanching
   - heat treatment: modori, inhibition of serine and cystein protease

c. Prevention or delay of purely chemical reactions:
   - prevention of oxidation by antioxidants, smoking, anaerobic conditions

3. Prevention or delay of rancidity

a. By lowering temperature

b. By reducing or hindering contact of air through packaging or brining, glazing.

c. By removing or reducing lipid content

d. By using chemicals, antioxidants

4. Prevention of damage due to insects, animals, rodents or other biological means.

a. By cleaning and keeping clean of factory premises

b. By fixing fly/mosquito proof nets.

c. By protecting drainage mouth, holes, ventilators, out lets of the building by wire-mesh covers, nets, etc.

Facilitation sheet-3

8a

Post-harvest Handling of Fresh Fish

The participants can be divided into several groups where each group can perform one or more of the following activity/exercise. They may be divided into 2 groups and may perform all the exercises on fifty:fifty share basis. After group exercise, the group leader will present the results. Members of the remaining groups will ask question to the presenter or his group. The group leader or his team will answer. The trainer will facilitate the group exercise and question-answer session.

Activity:1 Benefits of good handling of fish on board vessel

The facilitator will divide the participants into two groups. Group A will write the benefits of good handling for the fishermen while Group B will write the benefits for the processors in the given chart. The group leaders will present their observations and allow other groups to ask question. Side by side, the facilitator will explain the benefits of good handling of fish.

Group A Benefit for fishermen		Group B Benefit for processors	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 2 : Quality of fish caught by different gears and their proper handling

The trainer will divide the participants into 2 groups. Group A will write about the quality of fish changed due to different gears and Group B will point out adequate handling of fish for each of the gears, following the chart below. The group leaders will present the findings. Other group members will ask questions for clarity. The trainer will explain the thing in detail.

Group A Quality of fish due to different gears		Group B Desired handling for each gear	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 3 Handling of fish on the deck and in the fish hold

One of the trainees will draw a motorized fishing boat in the white board and show different sections, others will help him. The trainer/facilitator will ask the first group to discuss about appropriate handling of fish on the deck on board vessel and the second group to jot down the nature of handling required in the fish hold. The group leaders will write the summary of their discussions in the given chart and present those before the participants. The facilitator will allow question-answer session and side by side, explain the issues in detail.

Group A Handling of fish on the deck		Group B Handling of fish in the fish hold	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 4 : Maintaining good sanitation & hygienic condition in the fishing boat

Any one of Group A will draw a fishing boat on the white board and show different sections, chambers and appliances used. Other members of the group will help him in drawing and demonstration. Now the members of Group B will be asked to mention (as per the following format) what measures should they take after each haul and/or each day's operation. The facilitator will explain the conditions of good sanitation and hygiene in the fishing boat. The two groups will take part in the discussion and answer the questions of opponent group members.

Component	Sanitation measures to be taken
Gear	
Deck, platform, wooden board	
Fish hold, pen walls, shelf-brackets, shaft alley plates & shaft alley	
Gutting utensils, wash box, pound box & pestle, sorting rackers, knives	
Ice	
Keeping container, box, drum	
Rotten or distorted belly fish	

Activity 5 : Handling during unloading and transportation

Group A will identify good handling during unloading, while Group B will identify the same during transportation. The group leaders will write down the observations on the flip charts and present those before the participants. The facilitator will elaborate the points.

Group A Handling of fish during unloading		Group B Handling of fish during transport	
1		1	
2		2	
3		3	
4		4	
5		5	

Information sheet-4

8b

Post-harvest Handling of Fresh Fish

Group exercise : 5
Field demonstration: 1

Introduction

Fish is one of the most perishable food items in nature. Fish spoilage is a one-way process: fish loses its freshness and quality after death and eventually becomes unfit for consumption. Proper handling of fish is necessary to control and slow down spoilage so that it reaches the consumer fresh. Due to delicate nature and rapid deterioration of fish muscles, that occurs if treated badly, it is extremely important to handle the fish very carefully during all stages of transportation, retail distribution, processing, preservation and marketing.

Why good handling is necessary?

Good handling of fish brings about tremendous benefits to fishermen, processors and retailers because consumers are always demanding and willing to pay for premium quality fish.

Benefits to fishermen
- Increased landed weights
- Premium price
- Reasonable pay back period
- Increased efficiency

Benefits to processors
- Faster offloading
- Long shelf life
- Higher output
- Increased yield

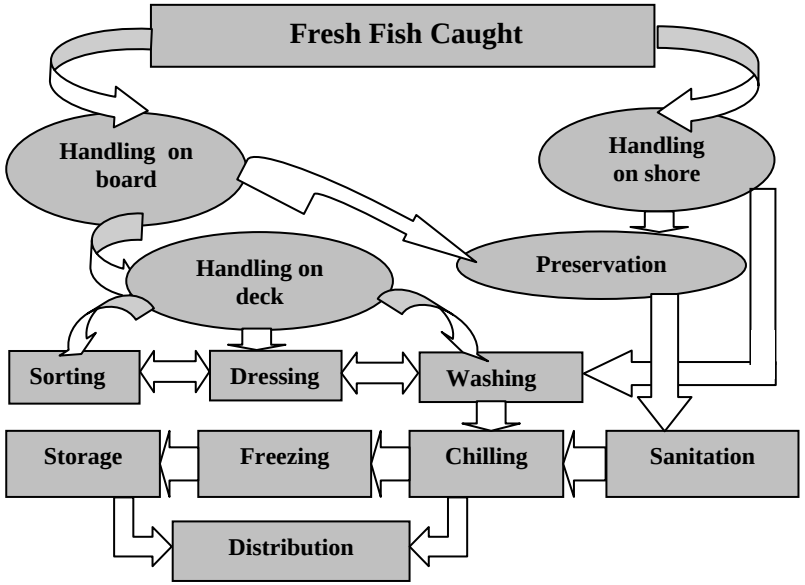


Fig. 8.1. Post-harvest handling of fresh fish

Condition of fish in different gears

- Fish in "*Current jal*", "*Vasha jal*" (drift gill net) and other gill nets spoil rapidly as they struggle much during fishing;
- Fish in hand line, hook & line and long line are excited as they struggle to escape. They also spoil very rapidly;
- Fish in the cod-end of estuarine set bag net (ESBN) and marine set bag net (MSBN) remain in serious stress as they have to stay their until hauling, for about 6 hours until the direction of water current is changed. These fish spoil within a few hours of hauling.

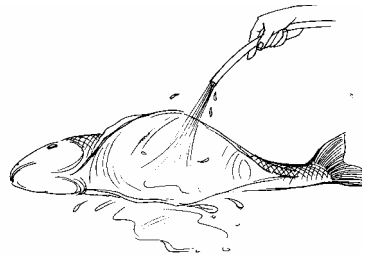
Handling during hauling

- Use appropriate gear for the fish;
- If possible haul more frequently, not after longer time. Since hauling of MSBN and ESBN is not possible until the direction

of water flow is changed (effect of high and low tide: 2 high tides and 2 low tides in 24 hrs.), these fish need special care and handling soon after hauling;

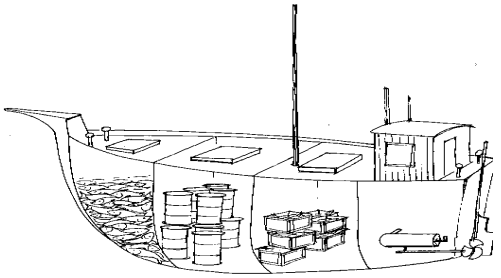
- In such case, in order to separate old fish from newly entered one, catch of the cod end can be divided by taking out fish differently as top layer, middle layer and bottom layer;
- Take less weight per tow. In case of the operation of pocket mounted beach seine, *kum jal*, etc. or trawl net, be careful of not to over fill the pocket;
- Remove fish from the pocket as quickly as possible;
- Stow fish more quickly and efficiently;
- If sufficient ice is not available, make the fishing trip short;
- If longer trip is unavoidable, separate older fish from newer fish;

Handling on the deck



- Fish is food, so handle it as food;
- Use equipment and tools made of easily cleanable materials: eg. metal or plastic;
- Do not use container made of bamboo or wood. These can harbour bacteria;
- Sort and grade fish as quickly as possible – on the basis of species, size and physical conditions;
- Remove damaged, sickly and spoiled fish promptly;
- Do not keep fish under the sun. Always keep fish in the shade or under a shed.

- Dress fish as required (scaling, fining, etc.);
- Bleed as required for big fish: keep water flow over the fish to accelerate bleeding;
- Remove gill and gut of big fish;
- Wash and clean deck, fish hold, container, bucket, cutting utensils, ice crusher, ice chamber, etc. with (50-100 ppm) chlorinated water;

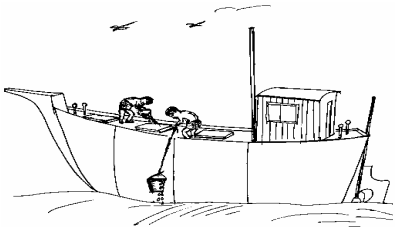


- Wash fish thoroughly with chlorinated sea water (5-10 ppm).Use hose pipe for effective washing;
- Ice the fish quickly to reduce the temperature (1 to 2^{o}C). Avoid bulk icing in fish hold, rather use plastic box, drum or small container in fish hold for icing. Ice old and new fish, spoiled or distorted one and fresh fish and different species of fish in separate containers;
- Always use extra ice to maintain the temperature at 1 to 2^{o}C;
- Use a fish : ice ratio of 1 : 2 in summer or 1 : 1 in December, January and February;
- Monitor temperature change always with a thermometer. Check temperature every night before going to bed and take corrective action to maintain temperature around 1 to 2^{o}C.

On board fishing vessel sanitation

- Wooden surface absorbs water and becomes full of bacteria. Fresh fish are contaminated when contact is made with these surfaces. Cover the surfaces of the fish hold or deck with aluminium sheet. Use corrugated aluminium pen boards, plastic or steel drum, etc. These are light, durable, occupy small area and can be cleaned easily.

- Inspect the fish hold/ice chamber for cleanliness and remove leftover dirty ice before taking on next trip's ice.
- Make certain that all equipment used to handle fish (gutting knives, sorting checkers, washing boxes, tanks) are rinsed and properly cleaned before use.
- While fishing, make certain that the deck is thoroughly washed between tows. Wash all gutting utensils regularly.
- Change the sea water in the washing box continuously to provide expected rinsing action on the fish.

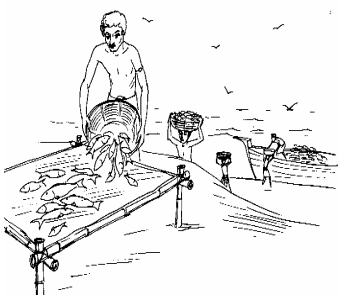


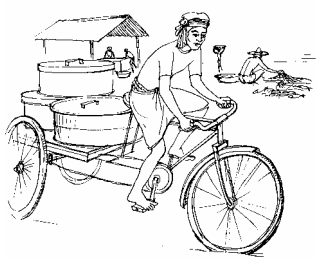
- Completely stop using container made of bamboo, since it harbours dirt, spoiled fish and bacteria which can contaminate fish during successive operations.
- Use a flushing rinse spray if a bleeding tank is used.
- Upon unloading clean and sanitize the following:
  i. pen walls and overhead;
  ii. stanchions and shelf-brackets;
  iii. shaft alley plates, top and bottom and shaft alley;
  iv. all strainers in bilge – check that they are free and clear;
  v. inside and outside surface of hatch;
  vi. all pen boards and strong-backs;
  vii. wash boxes, tanks and any other equipment used to handle fish.

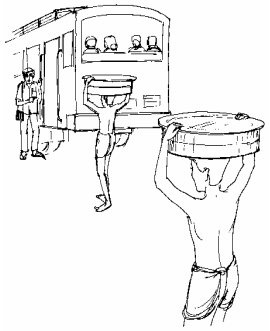
- When using chlorinated water as a sanitizer, keep the effective strength to around 50-60 ppm. The strength can effectively kill bacteria without corroding the materials used in containers.

Handling during landing and transportation

- Handle fish very carefully while unloading so that no injury occurs;







- Do not stand on fish in the fish hold while unloading;
- Do not throw fish from the fishing boat to the basket;
- Keep fish in clean elevated place and container after unloading;
- Ice fish immediately if further icing is required;

Handling of low priced underutilized fish

- Most of these fishes are caught as by-catch in shrimp trawling. As these are mostly underutilized, due to implementation of HACCP, processors of shrimp or other high value items do not appreciate the contamination of target catch by such species. Trawler owners/shrimp processors can be motivated to carry these items to the port

separately. Proper handling will stop contamination of shrimp or larger fish by these species. Capacity of ice storage in all types of fishing vessels can be increased to carry such species;

- Market price of these underutilized species is very low. Generally, these are sold as lot through auction and middlemen get maximum profit. The fishermen are deprived in most of the cases. Marketing can be improved by reducing the activity of middlemen during auction and sale;
- Fishing crews engaged in fishing do not get time to sort and handle these species. To handle these underutilized species they have to stop or delay next fishing. Boat owners can be encouraged to increase labour on board vessel to sort and handle these species.

Some keys to good handling of fish are -

- Avoid conditions which might accelerate normal spoilage;
- Introduce procedures, whenever possible, which slow down normal spoilage;
- Avoid or minimize contamination of fish by spoilage agents;
- Keep the fish ice cool;
- Keep the fish uninjured and muscle undamaged;
- Keep the fish clean and uncontaminated;
- Move fish through each stage without delay and control the time taken in each stage.

Facilitation sheet-4

9a

Chilling and Icing of Fish

Activity 1: Why do we chill or ice fish?

A belief persists among the coastal people of Bangladesh that iced fish does not taste good. This prejudice might have developed due to the availability of freshest catch in the coastal area all the time. To satisfy the need of such consumers, the fishermen either do not use ice or use only a negligible quantity, hiding the ice blocks or pieces during fish sale. Sometimes the fishermen are seen to sprinkle iced-water over the fish to try to keep the fish ice-cool and simultaneously, to let the consumers know that only water is sprinkled to keep the fish wet. By this time the fish may undergo deterioration, posing threat to the public health. It is, therefore, very important to understand the importance of icing of fish. The situation have, however, been improved in Cox's Bazar district due to continuous motivational campaign, community based training and demonstration and various logistic supports in wet fish trade provided by a UNDP funded FAO implemented project (BGD/ 97/017). In order to realize the benefit of icing, the facilitator will encourage the ToT participants to initiate a motivational discussion on the importance of icing and note the bullet points. The facilitator will then sum up the discussion.

Activity 2: Nature of ice and ice piece for appropriate icing

The participants will be divided into two groups. Group A will discuss about the quality of water to be used to make ice and Group B will review the nature of ice piece required to be appropriate for icing of fish. The results will be written in the following chart. Group Leader will present group's finding, while the other group members will ask questions. The facilitator will sum up the discussion.

Group A **Quality of water to be used in ice**		**Group B** **Nature of ice piece for adequate icing**	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 3: How do we ice fish? What are the constraints of traditional icing?

Icing in artisanal fishing is generally done in three stages: i) on board vessel immediately after catch; ii) after unloading before transportation; and iii) during selling of wet fish. The participants will be divided into three groups: Group A will be asked to write about existing icing process on board fishing vessel, Group B to write on icing after landing and Group C to write about icing procedure during distribution and sale of wet fish. The group leaders will present the existing processes, while the counter group members will find out its constraints. The facilitator will underline missing points and explain the appropriate process of icing.

Group A **Icing on board vessel**		**Group B** **Icing after landing**		**Group C** **Icing during sale**	
1		1		1	
2		2		2	
3		3		3	
4		4		4	
5		5		5	

Activity 4: Characteristics of ideal fish hold and ice box

Participants are divided into two groups. Group A will draw a fishing boat and write the characteristics of an ideal fish hold. Group B will draw an ideal ice box and write its characteristics. Group leaders will present their own findings. One group will ask question to the other group. Finally, the facilitator will explain the appropriate ones.

	Group A Characteristics of an ideal fish hold		Group B Characteristics of an ideal ice box
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 5 : Proper icing in fish hold

Traditionally fish are iced and stock-piled in the fish hold. Fish can also be kept in box or drum and shelf in the fish hold. Group A will discuss the constraints of stock-piling of iced fish in the fish hold, while Group B will discuss the advantages of using box or drum in the fish hold. The group leaders will present their findings. One group will ask questions to the other group. Facilitator will sum up the discussions.

	Group A Constraints of stock-piling of iced fish in fish hold		Group B Advantages of using box or drum in fish hold
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 6 : Appropriate icing in the ice box

The participants are divided into 2 groups. Group A will draw an ice box and point out appropriate icing method in ice box, while group B will justify each points. They can also use the pictures of ice box previously drawn. The facilitator will join in the discussion.

Activity 7: Appropriate icing- views of different stakeholders

The participants are grouped to represent different stakeholder groups like, boat owners, fishermen, fish processors and wet fish traders. Each group will be asked to discuss and contribute about their responsibility on proper icing and suggest measures that may contribute to improving the existing icing practices on board fishing vessel, during transportation and selling of fish. They may also suggest how, when and by whom such measures be implemented. The groups will write their suggestions/ recommendations as per the following chart. Respective group leaders will present their findings for open discussion. The facilitator will sum up the discussions.

Stake holder	Period	Measures for proper icing	Respon-sibility
Boat Owner	On-board vessel		
	During transportation		
	During sale		
Fishermen	On-board vessel		
	During transportation		
	During sale		
Fish Processor	After landing		
	During transportation		
	During sale		
Wet Fish Trader	After landing		
	During transportation		
	During sale		

Information sheet-5

9b

Chilling and Icing of Fish

Group exercise: 7
Field-based practical: 2

Chilling of fish

Chilling is a process by which temperature of the fish is lowered to a point near freezing but not below it by means of heat withdrawal. The freezing point for different fish species varies between –0.6 and –2.2^{o}C and depends on the concentration of the cell fluids. It is usually taken as equal to –1^{o}C. Fish and fishery products processed in this way are called as chilled products.

Supper chilling

Supper chilling is a word used for fishing industry to describe the condition of the fish stored at temperature just below freezing point where the fish flesh begins to freeze. Super chilled fish are held at even one degree lower than –2.2^{o}C. The optimal temperature for supper chilling is about –2.2^{o}C, but varies from –2.0 to –5.0^{o}C, at which point half of the water is frozen in fish. From the quality control stand point, super chilled fish have a shelf life extending from 2 to 3 weeks beyond that of normal ice-stored fish.

Different chilling methods

1. Chilling of fish with ice;
2. Cold air blown over fish;
3. Fish immersed in chilled water-
   a. Refrigerated sea water (RSW)
   b. Chilled sea water (CSW)
4. Chilling of fish by dry ice (solid carbon dioxide), liquid nitrogen, cold ammonia or other refrigerants, etc.

Icing of fish

Icing is one kind of chilling method. High heat absorption capacity of ice makes it an ideal medium for chilling of fish. Icing of fish is very easy that does not involve sophistication or high level of skill. Ice is available almost everywhere in the country and the fish can be kept for couple of weeks (20-30 days) in acceptable quality if proper icing is done. However, due to lack of knowledge icing is not properly practiced in traditional fish handling and preservation. The use of ice can substantially reduce post-harvest losses and improve the quality of fish.

Advantages of icing

Ice protects the fish from spoilage by reducing the temperature.

Besides, icing has the following advantages (Clucas and Ward, 1996):

- **ice melt-water helps to wash away surface bacteria and contaminants;**
- **ice melt-water keeps the surface of fish wet that prevents dehydration and preserves the glossy appearance;**
- **ice melt-water in contact with the fish is a good conductor of heat that facilitates cooling;**
- **ice made from potable water is non-toxic and safe;**
- **ice can be transported from place to place and is, in effect, a method of portable refrigeration;**
- **as ice melts at 0^{o}C it will not freeze the fish but automatically controls the temperature at the ideal chill level;**
- **ice is relatively cheap compared with other means of preservation;**
- **fish can be iced for some times in any container even if ice-box is not available;**
- **fish can be iced anywhere. Fishermen, transporters, large traders, small-scale traders, consumers-everybody can ice fish.**

Types of ice

Following types of ice are generally used in icing of fish:

1. Block ice: Block ice is the most common type of ice used to ice fish outside the processing plant in Bangladesh. Traditional ice plant makes the ice in cans which are submersed in tanks containing circulating sodium or calcium chloride brine. The dimension of the can and the temperature of the brine are usually selected to give a freezing period of between 8 and 24 hours. The block weight can vary from 12 to 150 kg depending on the requirement. A common size produced in Bangladesh is 2.5 x 1.5 x 1 feet weighing 70-80 kg. Due to inadequate freezing, the ice blocks often remain hollow inside.

2. Flake ice: This type of ice plant make a very thin ice, 2 to 3 mm thick on the surface of a cylinder or drum and the ice is harvested as dry sub-cooled flakes usually 100 to 1000 mm^2 in area. Normal freezing temperature in a flake ice machine is –20 to –25^oC. Low temperature is necessary to produce a sub-cooled ice quickly. This type of flake ice is mainly produced and utilized in the fish/shrimp processing plants.

3. Tube ice: 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. As ice drops from the tube a cutter chops the ice into suitable lengths, normally 50 mm. The usual operating temperature of this type of plant is –8 to –10^oC.

4. Plate ice: Plate ice is formed on one face of a vertical plate and released by running water on the other face to defrost it. Optimum ice thickness is 10 to 15 mm and particle size is variable.

   Besides, there are many other types of ice used in fish preservation, like shell-ice, chip-ice, soft-ice.

Factors regulating the amount of ice required in ice box

When ice is placed in close contact with the fish to be chilled, heat is transferred from warm fish to the ice, thus lowering the temperature of the fish and melting the ice.

How much ice is required to chill a fish in fish hold or ice box can be calculated (Clucas and Ward, 1996). We know that one kcal is the amount of heat required to raise the temperature of 1 kg water by 1^oC. More heat is required to warm water than almost any other substance. This capacity of substances to hold heat, when compared to water, is known as specific heat (SH). The SH of water is 1, for other substances it is less than 1. For eg. ice- about 0.5; wet fish- about 0.9, frozen fish- about 0.4, air- about 0.15, most metals- about 0.1.

The SH can be used to calculate how much heat has to be removed to cool a substance, e.g.

Heat to be removed = Weight of substance x temperature change x SH

If we want to cool 10 kg fish from 25^oC to 0^oC, we would need to remove-

10 x (25-0) ^oC x 0.9 = 10 x 25 x 0.9 = 225 kcal

Thus the weight of ice required = 225/80 = 2.81 kg

The present simple calculation shows that unless at least 2.81 kg ice is melted, it is impossible to chill 10 kg fish from 25^oC to 0^oC.

But this theoretical calculation cannot take into consideration of some other important factors. Because, in practice, when fish is iced, say in box, some ice will be used in cooling the box and more will be melted on the journey by heat coming in through the lid and wall of the box.

Therefore, in quantifying the amount of ice the following points should be considered:

- ♣ Insulation of ice box: Ice absorbs the heat from the fish body and thus melts. Ice is also melted by surrounding air unless fish and ice is protected with insulating materials. Therefore, quantity of ice varies depending on the condition of insulation of the box.
- ♣ Cooling the box itself: Ice is needed for cooling of the box or container/insulation of the box.
- ♣ Nature of packing in ice: All the ice are not in direct contact with all fish. If ice crystals are small and homogeneous, packing is good, cooling of fish is prompt and ice will last long.
- ♣ Time for keeping fish in chilled condition/length of journey.
- ♣ How quickly the fish are chilled.
- ♣ Thickness of the fish.
- ♣ Ambient temperature.

Therefore, depending on the situation, it is wise to use 10-20% more ice than the calculated value.

In tropical climate, outside heat consumes more ice than heat from fish. Therefore, insulation is particularly important in Bangladesh.

Nature of ice crystals for appropriate icing

Ice melts at 0^{o}C. It absorbs heat from the fish body when melted. Absorbed heat goes out with melting water. Ice crystals need to come in direct contact of fish to absorb heat. More the ice crystals come in direct contact of fish, more promptly they will absorb heat from fish body. If the size of ice crystal is big, only an edge or side of such crystal can come in direct contact of fish, most of the surfaces of ice can not touch fish body. If the ice crystals are small and thin, they can easily come in contact of fish skin and absorb heat very quickly. Finely crushed block ice or flake ice have large surface area to get more contacts with fish compared to large

pieces of block ice. It readily melts and cools the fish. Fine pieces of ice can easily fill the empty spaces between fish and ice and reduce the number of high temperature pockets. Therefore, heat removal from fish is rapid. Moreover, edges of large crystals are sharp that may damage the skin or scale and injure the fish. Due to high pressure of ice and fish from the top, fish in the bottom of the fish hold or ice box may have serious damage on the skin and may spoil very rapidly.

The size of ice crystal, whether it is big or small, has no relation to its melting in insulated container. That is, if insulation is adequate, melting of ice does not depend on the size of ice crystals. Ice will melt until the temperature of the fish body comes down to equal to that of ice. When an equilibrium state is reached, small ice crystals will quickly solidify again to form hard iced mass over the fish and act as an insulator itself allowing no heat transfer and no ice melting. Therefore, wastage of ice in insulated ice box is less in case of small crystal than bigger one.

Different types of ice are produced in the ice plant, like crushed ice, block ice, tube ice, flake ice, etc. Flake ice is used in fish processing plants to reduce the temperature of fish very rapidly. Block ice is commonly used in the traditional handling and preservation of fish.

Ice block should be crushed into fine pieces in a clean pounding box with clean hammer/pestle. Ice crystals should be as small and uniform as possible.

To lower the temperature of fish body quickly small ice crystals should be used.

Nature of water to be used in ice

- Clean and contamination free water should be used for the manufacture of ice;

- Municipal water should not be used directly in ice production. It can be used after necessary cleaning and chlorinating (5-10 ppm);
- Water from ponds, lakes, ditches, rivers, canals or sea-shore should not be used. These natural waters contain mud, dirt, debris, bacteria and other contaminants that, if used in ice, may serve as a basis of fresh contamination in fish and lead to quick spoilage;
- Sea water contains salt and transformed into ice at much lower temperature than the usual temperature required in ice formation (0^oC). Therefore, the quality of ice from sea water is not good. To form ice, seawater requires longer time and more electricity. However, seawater is sometimes used in ice production if freshwater is scare, as in case of big trawler or factory ship in the sea or in desert states.
- Quality of ice will be good if adequately treated tube well or deep tube well water is used;
- Large tanks/reservoirs where water is preserved in ice plant should be cleaned regularly;
- Antibiotics in water at prescribed dose may increase shelf life of iced fish but this should strictly follow local and international regulations.

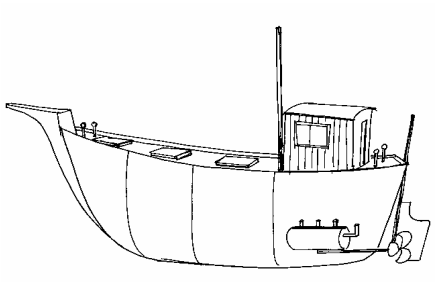
Appropriate method of icing

Generally, icing of fish is done in 3 stages:

i. on board fishing vessel after harvest
ii. after landing or before transportation
iii. during retail sale

i. Icing on board fishing vessel

Use of ice on board fishing vessels is a common practice in commercial fisheries where trips are of several days duration and fish



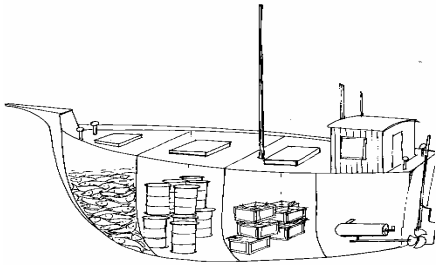
must be kept in good condition until landing. In our country, in small artisanal boats which are engaged in daily fishing, it is not practicable to construct fish hold, because the boats are too small to provide space. However, icing must be done in fish in all types of fishing boats including motorized or non-motorized daily fishing boats. To minimize space problem, small boats can use ice box on the deck. The size of ice box may be determined on the basis of the size of the catch. In such case where the fishermen is at sea for only a short time (2-3 hours) and can not carry ice, icing should be done as soon as the fish lands.

Mechanized fishing boats (18 – 75 HP) which store their catch on ice have three fish holds beneath the working deck. These fish rooms are used to carry and keep ice and fish.

The fish hold in the fishing boat must be -

- ♣ so designed that it is easy to clean and keep clean;
- ♣ hard and smooth surfaced, free from cracks and crevices which could harbour dirt and bacteria;
- ♣ strong and corrosion resistant;
- ♣ robust and able to withstand blows inflicted by ice axes, shovels and pound boards, etc;
- ♣ well insulated and watertight;
- ♣ light in colour and light in weight;
- ♣ must not contaminate fish;
- ♣ must not be corroded by fish oil, ammonia, brine, etc;
- ♣ must have adequate drainage to drain out ice melt-water.

Icing method on board vessel



Fish is ice-stored on board vessel by 3 methods:

Bulking: practiced in small engine boats;

Shelving: limited use in trawlers; and

Boxing: popular in trawlers and mechanized boats

Generally, fish are bulk-iced in the fish hold of the motorized artisanal fishing boats. The size of fish holds depends on the size of boat. Generally, it varies from 10 x 8 feet with a depth of 4-5 feet in 18 HP engine boats to 12.5 x 10 feet with a depth of 6-7 feet in 65

Table 9.1. Advantages of keeping fish separate in the fish hold

Sl.	Disadvantages of bulk-icing	Advantages of icing fish in box/drum
1	Due to pressure of fish and ice from the top, fish at the bottom are rapidly deteriorated	No such high pressure exerted on to the bottom fish as the depth of box is small
2	Due to bulk content adequate handling is not possible	Fish can be adequately handled, iced or transferred separately
3	Excess labour is required for moving and handling fish	Minimum labour is required for handling boxes
4	Fish of different species, sizes and qualities are mixed together that may pose certain species vulnerable to spoilage	Fish of different species, sizes and qualities can be kept in ice separately
5	Icing is not proper	Adequate and appropriate icing can be done
6	Skill of fishermen is not improved	Fishermen can improve skills in fish handling

HP engine boats. Fish are stock-piled with ice in such a big room. Sometimes, this big room is divided into sections using pound boards supported by stanchions. Because of the pressure of huge quantity of fish and ice from the top, the fish at the bottom of the fish hold are deteriorated rapidly, although they are kept in sufficient ice. Besides, it is extremely difficult to handle and take care of such huge quantity of fish. Most of the times, different species and qualities of fish are stock-piled together. This also deteriorates the quality of fish. To overcome these problems, small boxes made of plastic, aluminum or steel and/or empty plastic drums as shown in the picture can be used to keep iced fish in the fish hold.

Adequate fish hold temperature

Ice has the capacity to insulate as well as chill fish. However, fish can only be properly chilled if the ice can melt and cold melt-water can trickle around the fish to absorb the heat of the fish. If the fish hold is so cold that the ice cannot melt, pockets of heat around the fish will form and cause rapid spoilage.

The ideal fish hold temperature is 0^{o} to 1^{o}C, enough above freezing to allow some melting but cold enough to maintain quality. Fish must be protected from the heat coming into the fish room from outside as well. Poor insulation in the fish hold can be compensated by using extra ice against the walls as added insulation.

Fish is properly iced in fish hold when

- ♣ finely crushed, clean ice is used to speed up cooling while minimizing bruising of fish;
- ♣ all areas in the fish room where heat penetrates are given extra-heavy layers of ice;
- ♣ fish are stowed evenly to avoid clumping while allowing even distribution of fish and ice;
- ♣ not too much fish is stowed vertically in the fish room, room-section, pen, drum or box so that the pressure of fish from above cannot damage the fish kept at the bottom;

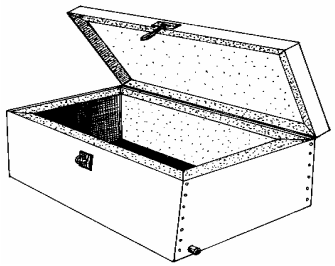
- there is a substantial amount of ice evenly mixed with fish at discharge and the fish at discharge is at 0^{o} to $1^{o}C$;
- all fish stowed in pen/drum/box is top-iced with at least 6 inches of ice layer throughout the trip;
- the ratio of fish to ice is 1:1 in the winter and 1:2 in the summer.

Icing fish during landing and transportation

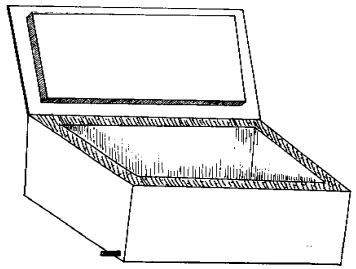
Fish still needs to be chilled after landing, whether it is destined for different processing in chilled room or for marketing as wet fish. Icing can quickly reduce the temperature within several hours whereas fish kept in a chilled room may take several days.

In Bangladesh, urban areas take daily deliveries of fresh fish from fish landing centers, those are generally many hundreds of kilometers away. Fish are generally packed with ice in bamboo baskets or gunny sacs wrapped by polythene sheets or mats made of plant leaves, locally called *Hogla*, with negligible insulation; they are loaded into open trucks or freight wagons on passenger trains and may spend up to 1-2 days in transit. Sides and bottom of the fish hold on the truck are covered with plain polythene sheet. A layer of *Hogla* is sometimes used at the bottom. Fish are bulk-packed with alternate ice layers in the truck and transported with top surface covered by polythene sheet and course tent. Under these circumstances, melting of ice is very high and re-icing during transport is necessary. But re-icing during transportation is not done.

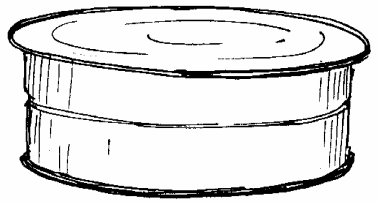
Appropriate ice box for transporation



- Insulated ice box of 45 cm deep is an ideal container. For fatty *Hilsa*, it should be less than 20 cm deep.



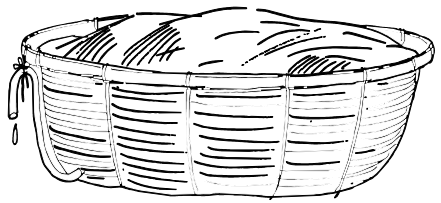
- It is not bad to use plastic box to transport iced fish. Plastic box can be insulated by covering it with a lid and placing styrofoam in between two layers of walls, bottom and top.



- Aluminium container with a lid can also be used to carry iced fish locally.
- Out-let at the bottom of the ice-box to drain out melted water is a must.

Low-cost ice box

Several methods have been developed (Nowsad, 2005b) to transport and preserve fish effectively in rural areas of Bangladesh.

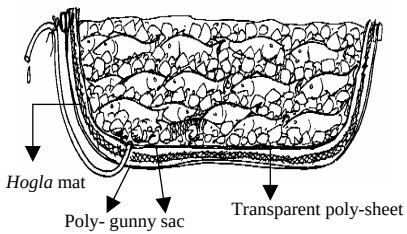


Some of the methods have been successfully used by the field level fishermen, fish traders, small-scale fish processors and transporters in the coastal region and freshwater landing centers. Construction of such a low-

cost but effective ice-box that is being used by small-scale fish traders of the country is given below:

1. Bamboo basket presently used in wet fish transportation throughout the country is transformed into insulated ice box very simply. In such modified baskets fish can not come in contact of the wall of basket, since it is wrapped all along with polythene gunny sacs and plain polythene sheet. Thus there is no chance of contamination of fish from the split bamboo that generally harbours bacteria and contaminants. It is easy to clean and keep clean too.

2. To make a low-cost ice box, take a fine woven split bamboo basket of 25-30 kg capacity. Wrap inside of the basket with one layer polythene gunny sac in such a way that the extended portion of the sac remains beyond the upper edge of the basket. Place an adequate size of mat of plant leaves, *Hogla* in side the basket (on the 1st layer of gunny sac) to cover the whole area inside. Put another layer of equal size polythene gunny sac on *Hogla* layer and stitch these 3 layers of wrapping materials (1 layer *Hogla* in between 2 layers of gunny sac) with nylon twine to the basket so that all wrapping materials remain fixed with the basket.



Now, to ice fish in the basket, place a plain polythene sheet or a polythene sac in side the wrapped basket. This polythene sheet/sac can be washed and reused after each operation. Place ice and fish alternately in adequate fashion in the polythene sac of the basket so that an ideal icing condition is maintained. Use extra layer of ice on the top of fish. Insert a small plastic pipe through the bottom of the basket to pass out melted water. Keep the pipe finely tightened with the basket and wrapping materials in the bottom so that it is not misplaced during handling and transport and melted water can not leak out through the outside wall of the pipe. Finally, wrap the extended portions of all wrapping materials (polythene gunny sacs, *Hogla* and plain polythene sheet/sac) at the top of the basket. The basket is now ready to preserve and transport iced fish.

3. Transportation of iced fish in traditional baskets creates a problem with the melted water. In this modified basket, a 2 feet long plastic pipe (1 cm diameter) is inserted through a hole at the bottom of the basket to drain out water. The rear end of the pipe is tightened with the top edge of the basket. When the rear end of the pipe is down at regular intervals during the initial stages of icing, melted water will pass out easily. Adequately iced fish in such modified ice box can be kept in good quality for 24 hours without adding new ice. Fish can be kept well for 6-7 days if small amount of crushed ice is added every after 24 hours at the top of fish. *Hogla* leaves can serve as good insulating material. Total cost incurred for such a modified basket is Tk. 60-70. Such an ice box can carry 20-25 kg of iced fish and can be used for more than a year.

Plastic container modified into ice-box

Besides, although little bit expensive for the poor fishermen, another effective icing device introduced in coastal region (Nowsad, 2005b) can be used throughout the country. For commercial transportation of fish this ice box has been proved to be very fruitful.

A similar type of plastic containers, which are now being used in shrimp processing plants for various purposes, can be used in outside transportation and preservation of iced fish after necessary modification. The side walls of the container should be double layer all along - including bottom, and the top, keeping 2.5-3.0 cm space between the two layers. Insulating materials like styrofoam sheet is placed in between the two layers. A screw-tap is installed at the base of one side-wall to drain out melted water. Efficacy of these modified plastic containers as ice-box has been tested and found very good result. This type of plastic ice-box can be manufactured by any ordinary plastic factory. Commercial fish traders can use this type of light and durable ice box extensively to transport wet fish through trucks, ships and other vehicles.

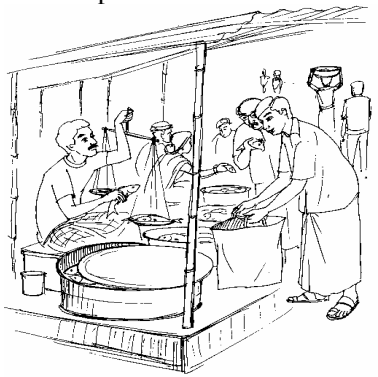
Such ice boxes have recently been introduced by the author in some fishery projects of Daudkandi Floodplain area, while using these boxes the fishers have been able to improve the quality of transported fish and increase profit.

Method of icing fish in ice box

- ♣ Use ice block prepared from clean and contamination-free water;
- ♣ Use clean pound-box and pestle to crush block ice, crush ice into small pieces;
- ♣ If necessary, gut larger fish and wash all fish with sufficient clean water;
- ♣ Put a layer of ice at the bottom of the box before filling, put ice layers on either sides and a layer on the top of the fish;
- ♣ Stow fish at even and alternate fish and ice layers;
- ♣ Keep sufficient ice around the fish;
- ♣ Follow a fish to ice ratio of 1:2 in hotter months and 1:1 in December-February;
- ♣ Change ice during transportation, as and when necessary, but at least once in every 24 hours.

Icing fish in fish market

- ♣ Keep fish in ice in covered ice box all day long, even during sale.



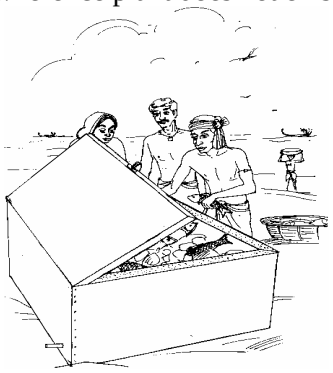
- ♣ Keep excess or left over fish in community ice box (extra-large ice-box for preservation of fish and ice block) for next day sale.
- ♣ Deposit extra ice in community ice box.
- ♣ If necessary, operate community ice box through community-based approach.

Protection against quick melting of ice

1. Ice will melt slowly if the ice box is kept in the shade or under a shed, not directly under the sun;
2. Keeping the door of fish hold or ice box closed will reduce the rate of ice melting;
3. Adequate insulation of ice box will reduce the rate of ice melting. Insulation can be done by placing different insulating materials in between the two layered side walls, for example-styrofoam, polyestyrine, cork, glass fibre, plastic, polythene, saw dust, tea, etc. Most of these are very expensive. Ice box can be insulated by cheaper materials too. These include old clothes, used nets, dried plant leaves, etc. A kind of plant leaves, *Hogla* can be used as an effective insulator.
4. Small and thin pieces of ice absorb heat from fish more quickly than the large ice crystals and maintain an equilibrium temperature state inside the box. Within 30 to 60 minutes of icing, melting of ice stops in the ice box. Ice crystals solidify again around the fish making a large solid mass of ice. Under adequate insulation, small ice crystals can rapidly and effectively lower the temperature. Therefore, rate of ice melting is also reduced by this method.

Preservation of ice and fish in community ice box

Excess or unsold fish of the day can be preserved in community ice box kept in fish market. Ice block can also be preserved in community ice box in remote areas along the coastal belt or islands, where ice plant does not exist.



Community ice box is a large ice box, preferably 4 x 8 x 3.5 feet deep in size, primarily designed (Nowsad, 2005b) to preserve fish for next day's sale. This is so named by the fishers community of Cox's Bazar because of its operation through community based approach. Small enterprise groups (5-6 members) of the ECFC project in the coastal fishing

villages have jointly constructed these large ice box and kept in common places, preferably in the fish markets. The boxes have been jointly used by the business group members on space sharing basis.

Individually, one fisherman can not afford the cost of this large ice box, but collectively, they can draw substantial benefit from it. The space inside is partitioned into several portions and allocated for different members. Ice blocks can also be preserved in such ice box for couple of days or weeks. To avoid solidification, small pieces of wood or bamboo may be placed in between the blocks while keeping ice blocks for several days. In coastal areas or islands, ice blocks can be transported from the ice plant by the empty fish hold of the fishing boats. Insulated rickshaw van, power trailer, etc. can be used in other areas.

Ice storage life of adequately iced fish

During ice storage, generally-

- Non-fatty fish can be kept longer than fatty fish;
- White fleshed fish can be kept longer than dark fleshed fish;
- Freshwater fish can be kept longer than marine fish;
- Tropical fish can be kept longer than temperate fish;
- Tilapia can be kept for 28 days, but Indian major carp, rohu for 35 days;
- Maitta/Surma (mackerel) can be kept within the range of 9 and 15 days;
- *Hilsha* (river shad) can be kept for a range between 15 and 17 days.

Fish kept at 0^oC in crushed ice remain fit for human consumption for about 18 days;

Fish kept at 5^oC remain fit for about 6 days;

Fish kept at 10^oC remain fit for only 2 days.

Every 5^oC reduction of body temperature towards 0^oC can increase the keeping quality of fish by 3 folds.

Factors influencing the quality of fish during chilling/icing

Following important factors should be considered to maintain the quality of fish during icing/chilling.

iv. Care in handling: Transfer of fish in and out of board and during transportation might cause physical damage which can provide access through cuts and wounds for spoilage bacteria. Careful handling during chilling/icing results in considerable improvement of the quality of fish;

v. Delay in icing: Delay in icing even in winter causes considerable adverse effect on the keeping quality of fish when the fish lie on deck after catch. Fish packed into ice boxes straight from the net and then left undisturbed are noticeably superior to fish taken from bulk lots and packed inshore boxes at landing.

vi. Evisceration and removal of gills: According to the practice and also supported by official regulations in many countries, it is advisable to remove gills and guts from the larger species of fish in cold condition. There are two reasons for gutting: first, the large number of bacteria in the intestine spoil the fish; second, the continuous action of the digestive juice of the fish cause greater incidence of autolytic spoilage.

vii. Cleanliness: Cleanliness is important for high keeping quality of fish in two ways:

a. Natural source of bacteria can largely be removed by washing out of the gut cavity and off the slime from the body surface.

b. Fish is handled in a hygienic manner during icing so that the chances of contamination are kept to a minimum.

Changes in fish during the chilling/icing process

i. Protein and weight loss: The fish chilled with ice shows gradual weight loss in the lower layers. Losses which occur in iced fish fillets and steaks are largely or entirely due to formation of free liquid drip. Melting water carries with it a considerable percentage of soluble proteins, salts, other flavouring and nutritive substances of the fish.

ii. Discolouration: Excessive pressure of ice on fish during chilling results bruising and damage and consequent discolouration of flesh during icing. If the fish is not gutted soon after being caught, the powerful digestive enzymes attack the viscera and belly walls called *belly burn* or disruption in course of few days at ice temperature which also cause discolouration. It is well known that pelagic fishes with full of stomach may develop torn bellies long before the sign of spoilage set in.

iii. Rancidity: In case of fatty fishes in low temperature at even 0 to -2^{o}C, rancidity may develop and the rancid flavour becomes a limiting factor of keeping quality during long time storage in ice.

iv. Shrinkage: Shrinkage is a common phenomenon in fish packed with ice, particularly in the upper layers. The shrinkage in the lean fish is higher than that of fatty fishes. Subcutaneous layer of fat serves to reduce the evaporation of tissue moisture.

v. Weight gain by fish in RSW: Fish in RSW gain weight and salt uptake is probably the most important factor that limits the application of RSW system. Fish intended for normal

processing and marketing can acquire salt which would make them unacceptable for this purpose. Salt uptake in industrial fish is also critical since it is concentrated during processing and the upper limit is usually equivalent to a concentration of about 0.5% in the raw fish.

Information sheet-6

10

Freezing of Fish

Introduction

Fish freezing is a process of preservation in which the temperature of fish and fishery products is lowered at –40ºC or below with most of the water inside of fish tissue turning into ice. Icing and chilling can keep the fish for a few weeks only. Fish is required to be kept for longer periods, for example to even out supplies during gluts, to enable fish to be distributed and sold in distant markets, and to stock pile products for lean seasons. If fish are properly frozen and stored at correct temperature, it is possible to provide a product which closely resembles fresh fish; in many cases consumers are unable to distinguish between a piece of fresh fish and a piece of frozen fish.

Mechanism of freezing of fish muscle tissue

Clucas and Ward (1996) have described the freezing mechanism in fish muscle tissue in detail. Freezing may be defined as the processing of fish by lowering the temperature of fish body so that all most all of the water inside becomes frozen. Fresh fish contains approximately 80% water. At normal atmospheric pressure, pure water will change from liquid to solid (ice) at 0^{o}C, i.e., it will freeze. However, the water in fish flesh contains dissolved salts and chemicals which have the effects of lowering the temperature at which the tissue water begins to freeze. The exact temperature of freezing varies between species but is usually between –1 and –2°C. As the temperature drops below this critical temperature, water tends to be frozen out of solution. The temperature at which the remaining water freezes is lowered further as the solution becomes more concentrated. At –5° C, when it would appear that all the water is frozen, over 20% of the water in the muscle may still be *unfrozen*; at –30°C, about 10% of the water remains unfrozen but at –40°C almost all of the bound water is frozen.

In order to change the physical state of a substance from a liquid to a solid, which is what happens when fish are frozen, energy or latent heat has to be removed from the substance. To lower the temperature of 1 g of water by 1°C at temperatures above 0°C, 4.2 J of heat must be removed; this is known as the specific heat. However, to change liquid water at 0°C to solid ice at 0°C, 334.7 J must be removed from each gram of water; this is known as the latent heat.

The specific heat of liquid water is therefore 4.2 and the latent heat of fusion for water is about 80 times as much, i.e., 334.7 J. The specific heat of solid water (ice) at temperatures below 0°C is 2.1 *J/g*. For most practical purposes, it is assumed that fish (which contain 70-80% water) have the same specific and latent heat values as water.

If heat is removed from fish at a constant rate, there will be a period while the fish is freezing when the temperature will not drop. This period occurs while latent heat is being removed and the liquid water changing to solid; it lasts until approximately 75% of the water has been frozen, after which the temperature will begin to fall again.

The temperature profile of freezing fish has three stages:

i. During stage I: the temperature falls fairly rapidly, at a more or less constant rate, to just below 0°C while the specific heat is being removed.

ii. During stage II: the temperature remains fairly constant at about –1°C to –5°C while the latent heat is being removed and the liquid water is changing to ice; this is known as the thermal arrest period (TAP).

iii. During stage III: the temperature drops rapidly again while the specific heat of ice is being removed and most of the remaining water freezes.

Using simple mathematics, the theoretical amount of energy required to freeze fish can be calculated. This is demonstrated in the following example.

Example: 1 kg of fish at 25°C needs to be frozen to –30°C (from Clucas and Ward, 1996).

Step I

During this stage 4.2 J of energy needs to be extracted from each g of fish for each 1°C drop in temperature. The temperature of 1000 g of fish will be lowered from + 25°C to –1°C, i.e., by 26°C. The energy required to be removed will be

1000 x 26 x 4.2 (specific heat of water) = 109200 J or 109.2 kJ.

Step II

During this stage, 334.7 J of energy for each g of material frozen needs to be extracted. In this example, 1000 g of fish are to be frozen. The energy required will therefore be

1000 x 334.7 (latent heat) = 334700 J or 334.7 kJ.

Step III

During the last stage, 2.1 J of energy for each g of material, for each 1°C drop in temperature needs to be extracted. In the example the temperature of 1000 g fish will be lowered from –1°C to –30°C, i.e., by 29°C. The energy required will be equal to

1000 x 29 x 2.1 (specific heat of ice) = 60900 Jor 60.9 kJ.

To summarize:

Step I	1000	x	26	x	4.2	= 109.2 kJ
Step II	1000	x	334.7			= 334.7 kJ
Stpe III	1000	x	29	x	2.1	= 60.9 kJ
					Total	= 504.8 kJ

Therefore, to freeze 1 kg of fish from 25°C to –30°C requires the removal of 504.8 kJ of heat.

Thermal arrest period (TAP)

From the example above, it is thus apparent that more than 65% of the energy extracted in freezing occurs during stage II, is called the TAP when little or no drop in temperature is taking place. This period is critical if good quality frozen products are to be produced. Ideally, the fish should pass through the TAP in as short a time as possible for the following reasons:

(a) slow freezing produces large ice crystals in the cells of the fish which, as they can be larger than the cells themselves, can break the cell walls;

(b) as water begins to freeze in the flesh, it tends to freeze out as pure water; the remaining liquid water therefore contains a higher concentration of salts and enzymes, and these can accelerate autolysis;

(c) at around 0°C, certain types of bacteria are still active, so bacterial spoilage will slowly continue;

(d) as it takes long time to freeze body fluid, drip-loss and as a result, thaw drip is pronounced in case of slow freezing that removes valuable nutrients.

The end result and most apparent effect of slow freezing is the textural change caused by the break-up of the cells of the fish. In addition, water originally bound within the cells will be lost, and this will produce increased drip when the fish are thawed. Thaw drip can cause a considerable loss in weight and a poor dry texture when

eaten; it can also be increased by fluctuating cold store temperatures. Even if a product is frozen quickly so that only small ice crystals are formed at this stage, the water may partially defrost if the product is held at fluctuating cold store temperatures. The small crystals will become larger and larger and cause the same sort of effect on complete defrosting.

From a textural point of view, it is unlikely that a taste panel would detect any difference between fish passing through the TAP in 1 h and those frozen in 8 h; once the freezing times extend beyond 12 h, however, the difference may become apparent. Freezing times of 24 h or more will almost certainly result in inferior products, and very long freezing times can result in the products being unfit for consumption because of bacterial spoilage.

Types of freezing

1. Slow freezing: This is the process of gradual lowering of temperature of fish up to freezing. The temperature is usually –25^{o}C or lower, but may vary from –15^{o}C to –29^{o}C and freezing may take 3 to 72 hours.
2. Quick freezing: This is the process of sudden decrease in the temperature of fish up to freezing. The temperature is usually –40^{o}C and freezing time is 30 min to 1 hour. In practical, quick freezing of fish is generally practiced as lowering the temperature from –1°C to –5°C (TAP) in around 30 min, and further reducing the temperature at the end of the freezing period to the recommended storage temperature of – 40°C. This has two important parameters:
   * fast passage through the arrest period; and
   * reduction to low temperature.

Advantages of quick freezing

i. Smaller ice crystals are formed, hence less mechanical destruction of fish tissue cells;

ii. Shorter period of solidification and less time for diffusion of soluble materials and for separation of ice;

iii. More prompt prevention of microbial growth;

iv. More rapid slowing of enzyme action.

Some definitions of freezing

Freezing rate (^{o}C/h):

The freezing rate of a product is defined as the difference between the initial and final temperature divided by the time taken for the freezing. It is calculated by the speed of movement of the ice formed through the product. The speed is faster near the surface and slower at the core or centre.

Some freezing codes and recommendations define freezing in terms of thickness of fish frozen in unit time. The freezing rate, however, is always faster nearer the surface of the fish which is in contact with cooling medium, and slower in the centre. Freezing rates are therefore only average values. Following table shows some of the terms used in relation to freezing at different rates.

Table: 10.1. Terms used in relation to freezing rates

Term used	Rate of freezing (mm/h)
Slow freezing	2
Quick freezing	5-30
Rapid freezing	50-100
Ultra rapid freezing	100-1000

The term 'freezing rate' may be better applied to the time taken for the center of a product to reach a certain temperature; this is often the case in commercial operations.

Sharp freezing

The term is often used when referring to the freezing of fish, but it has no precise definition. In practice, sharp freezing is often slow.

Deep freezing

Deep freezing is defined as a process whereby the average temperature of a product is reduced to 0°F (–17.8 °C) and then kept at 0°F or lower. This definition does no take into account the rate of freezing, and a product that has been deep frozen may not necessarily have been quick frozen.

Sashimi freezing

One exception to the general requirements for quick freezing is the freezing of fish (usually tuna) for the Japanese *sashimi* (raw fish) market. The tuna used for *sashimi* can be very large (60-100 kg) and they have to be frozen gutted but in the round. The vessels which catch these fish operate blast freezers at –50°C to –60°C, but heat extraction from the center of very large fish is still slow; it often takes 24 h to freeze them completely. The requirement for air blast freezing of tuna is one special case in which the general rules for quick freezing are impractical.

Thermal centre

The thermal centre of a product is the point within the product which has the warmest temperature at the end of the freezing process.

Adiabatic condition

These are conditions at which no heat is either added or abstracted from the environment: they can be achieved by the use of an insulated container.

Blanching

It is the process of subjecting the products to heat treatment for a short interval of time prior to processing for freezing or canning (Gopakumar, 2002b). The heat treatment, time and temperature varies for different products. Blanching is done at temperatures between 85^{o}C and 100^{o}C. Blanching inactivates enzymes responsible for spoilage and time of blanching is related to heat sensitivity of the enzymes. For products like canned shrimp higher

time and temperature are recommended and for frozen shrimp short intervals of times are used.

A number of additives like citric acid, salt, sugar and polyphosphates are used in blanching water. Acidification of blanching water increases the thermal liability of enzymes and also helps to reduce the time of blanching. During blanching of shrimp for freezing 0.2% citric acid is sometimes added to water. Blanching also brings down the microbial load of the fish, particularly on the surface. Blanching has number of advantages and disadvantages. In freezing of shrimp, it improves the colour as well as consumer acceptability. It can, however, cause loss of some flavour, pigments, water soluble nutrients and proteins.

Glazing:

Glazing is the application of a layer of ice to the frozen fish as a surface coat. Dipping or spraying with cold water maintained at 0 to 3^{o}C immediately after freezing accomplishes it. Glazing is done to prevent freeze dehydration of the frozen products when kept in cold storage. During frozen storage water escapes from the surface of the frozen fish to atmosphere and the surface gets dehydrated and oxidized causing severe loss in quality. Glaze acts as a close-fitting wrapper. Good freezing techniques recommend hardening of glazed water by refreezing prior to storage. During extended cold storage glazing has to be done if there is loss of glaze.

Double freezing

Double freezing means freezing a product, thawing or partly thawing it, and then re-freezing it. This process is often used when making frozen fish products from raw material which has previously been bulk frozen. Cod frozen whole (gutted) at sea in vertical plate freezers is often used for the production of items such as fish fingers or sticks. The whole frozen fish are defrosted and filleted; the fillets are then refrozen into blocks for sawing into uniform pieces for fish stick manufacture.

The prawns are often frozen into 2 kg (or 5 Ibs) blocks in horizontal plate freezers in their country of origin. The frozen blocks are exported to other countries where they are defrosted; the prawns are then separated and refrozen as individual quick frozen products, consumer packs, ready meals, etc.

In both examples, it is vitally important that only first class raw materials are used for freezing, that the freezing and thawing processes are strictly controlled, and that hygiene and quality control procedures are adhered to, if the final product standards are to be maintained.

Table:10.2. Some important temperatures related to low temperature processing

Process	Temperature (^{o}C)
Chilling	0.6 to – 2.2
Icing	0 ±1.0
Super chilling	–2.0 to –5.0
Refrigeration	4.0 ± 1.0
Freezing	–8.0 to –40.0
Sharp freezing	–22.0 to –28.0 (slow freezing)
Air blast freezing	–40.0
Contact freezing & IQF (spiral air blast freezing)	–40.0 (quick freezing)
Immersion freezing (ordinary)	<–20.0
Immersion freezing (shashimi)	–50.0 to – 60.0
Frozen storage	–20.0 to –25.0

Frosting

During the freezing process, there is loss of water from the surface of the fish, mainly in the early stages of freezing. This moisture is deposited and frozen on to the freezing coils of the evaporator, called frosting. If this ice is allowed to build up it will restrict the air flow, so defrosting (melting of ice) of the evaporator will be necessary. If ice collects on the evaporator coils, the heat transfer will be slow and the air will be less effectively cooled. If the evaporator becomes fully iced up, there will be very little refrigeration effect. A well designed freezer should be able to operate

for 8 h before defrosting; a poor design may need defrosting every 2h.

Although the product must be left in the freezer long enough to ensure effective freezing, it is important that unpacked products are not left in the freezer too long. This would not only lead to increased dehydration and frosting on evaporator coil, but it is also wastage of energy and therefore money.

Freezing Methods and Equipment

There are several ways in which fish can be frozen, but all require specialized equipment to effect the necessary rapid drop in temperature and reduce the core temperature sufficiently to ensure that the product can be safely placed into cold storage. If unfrozen fish are simply put into a cold store running at –30°C, the temperature will be reduced sufficiently quickly and poor quality frozen fish will result; cold stores are designed to hold fish already frozen, at low temperatures. The types of freezer in common use can be divided into the following three categories:

a) Type I: Those in which a stream of cold air absorbs heat energy from the product as it passes over them, thereby reducing their temperature. These are generally known as air blast freezers.

b) Type II: Those in which heat is absorbed when the products are placed in contact with a refrigerated surface. These are generally known as contact freezers.

c) Type III. Those in which heat is rapidly absorbed from products surrounded by a cold liquid or a spray of liquid. These are generally known as immersion freezers.

Type I

Air blast freezers

Air blast freezers are generally small rooms or tunnels in which cold air is circulated by fans over an evaporator, cooled by ammonia,

brine or other refrigerants around the products to be frozen. The freezers are loaded at one time by rolling or pulling a rack of shelves of fish into the insulated rooms. Now a days, conveyer have been used to move fishery products through the rooms or tunnels. Most freezers of this type operate at air temperature of –40^{o}C. The velocity of air moving over the products generally varies between 5 m/s and 10 m/s to give most economic freezing.

The main advantage of air blast freezers is that they can be used to freeze different sizes and shapes of product without adaptation and are therefore versatile. They are economical in operation under full capacity utilization and lesser degree of handling of products is required during freezing. However, they tend to occupy more space than other freezers and consume more energy. Because of their versatility, they are often used inefficiently as well. The greater energy consumption can be attributed to their larger size, greater internal volume, heat transfer through the insulation, and air circulation system. As the products are often exposed, it may occur dehydration, freeze burn and desiccation of the products. Packaging of fish fillets often undergoes bulging. Sometimes discolouration of products occurs at low temperature and high velocity of air.

As the name suggests, air blast freezers operate by blasting refrigerated air over a product to remove heat. Air is usually blown by means of a fan through a cooling coil (evaporator) to produce cold air. This cold air then passes over the product which needs to be frozen, picks up heat from the product and the walls of the freezer and returns to the evaporator for reduction of temperature. The air circulation needs to be efficient, and there are several factors which may affect the freezing rate of fish:

a) *Air speed*: Although a faster freezing rate is achieved with a faster air speed, a lot of energy is expended through convection. A compromise between high costs and low freezing rates is therefore necessary. Air speeds are usually about 5 m/ s, but this can be increased to 10 or even 15 m/ s in continuous freezers where size is a limiting factor.

b) *Temperature:* If the temperature of the air as it passes over the product is too high, the freezing rates of the more remote products will be reduced. Normal air temperatures are between –30^{o}C and –40^{o}C with an acceptable average rise of between 1 and 3°C as the air passes over the product.

c) *Air flow*: Uniform air flow is essential for efficient operation. Fans should always be positioned so that they can blow air through the cooler. It is important to stack and layer the product correctly on the freezing trays or trolleys. Air will always take the easiest path. If a blast freezer is only partly filled, it is best to load it so that the air passes evenly over fill the product. Even spacing throughout the freezer will ensure even air flow and uniform freezing rates. If the freezer has a very small load, it might be advisable to block off some of the areas of air flow completely so that maximum use can be made of the air flow.

Air blast freezers can be divided into continuous and batch types, depending on their mode of operation.

Batch freezers

In these freezers, trolleys, shelves or plates are used for loading the products in batches. When fully loaded, they are placed in the freezer, the door is closed and freezing is started. When fully frozen, the first batch is removed for cold storage and another batch is loaded into the freezing compartment. Compared to continuous freezers, batch freezers have a very high refrigeration load at the beginning of the cycle because of their mode of operation.

Continuous air blast freezers

These can be divided into batch continuous freezers and continuous belt freezers.

Batch continuous freezers

These freezers are those in which fish packed on to trolleys or trucks move through the freezer on rails. The product moves through

the freezer in the opposite direction to the flow of air, i. e., the coldest air passes over the coldest product. Loaded trolleys are pushed into the freezer at one end, and when the product is fully frozen, they are removed from the other end to make room for a fresh batch at the entry point.

There are also batch continuous freezers in which the transport of fish through the chamber is mechanized. Multi-shelved racks are suspended from an overhead conveyor which moves the fish through an air blast freezing tunnel. The speed of transport through the tunnel can be varied to suit the type of product being frozen, i.e., small fish, fillets or prawns would go through the tunnel in about 1-2 h whereas large whole fish or pre-packed products would need much longer.

Continuous belt freezers

These are used for small individual items which can be frozen within 30 min; longer freezing times would require longer belts which would be cumbersome and costly. Double or treble belts may be installed if the product can be transferred easily between belts. Spiral belt freezers in which a long belt can be compacted into a relatively limited space are now available.

Belts are usually made from stainless steel or plastic interlocking mesh. Air flow may be either counter to the flow of the product, or across the belt. The points of entry and exit for the product must be protected against loss of refrigerated air and entry of warm air. This is usually achieved with plastic or rubber curtains. The belt speed can be altered to cater for the different freezing times of different products. Belt freezers need to be fully loaded and used continuously as much as possible in order to be economic.

Merits of air blast freezer

i. Main advantage of air blast freezer is its versatility;
ii. The freezer is very economical;
iii. Only little handling of fish is involved during freezing.

Demerits

i. May occur dehydration, desiccation, shrinkage and freeze-burn of the products;
ii. Discolouration of product may happen at low temperature or high velocity of air.

Type II

Contact freezers

Freezing by placing the products in direct contact or plate freezers are commonly used in the fishing industry for the production of blocks of fish or other seafood. The two main types of plate freezers are horizontal plate freezer and vertical plate freezer. In both types, the products are brought into close contact with aluminium alloy plates which contain circulating refrigerant. All plate freezers have hydraulic system which move the plates closer or further apart. This allows the products to be compacted so they freeze more quickly by closer contact, and are released more quickly after freezing.

Horizontal plate freezers

In this type of freezer, the product is packed into freezing trays before freezing. The trays may either be lined with polyethylene sheet prior to packing, or cardboard cartoons may be used. Depending on the product, the aluminium trays may be divided into compartments to give uniform block sizes. The trays, which may also have closely fitting lids, are then placed on the freezer shelves. The hydraulic system positions the plates in close contact with the top and bottom of the trays to ensure maximum heat exchange. Trays and cartons should be filled to the top to ensure good contact with both plates.

It is important that the plates are kept free of ice and frost in order to ensure good contact between the plate and the product. If

water is spilt on the plates, it will freeze in lumps, cause poor contact, and prolong freezing. With careful loading and unloading, it should be possible to avoid ice build-up so that defrosting between freezing batches is unnecessary. With care, defrosts should only be required once or twice a day. Defrosted plates must be free of ice and must be dried before re-use.

Similarly, compression is important to ensure good contact between the food and the plates. However, excessive pressure will damage the food. It is essential that the plates should be fully loaded; if this is not possible, spacing bars should be used. If a plate is only partially loaded when the product is compressed, the plates may bend, causing poor contact and damage to the plates. Spacing bars should be made as per the specifications of the manufacturer for the thickness of product being frozen. Generally, spacers are slightly thinner than the packs to be frozen so that the blocks are slightly compressed and good contact is ensured. All the blocks of product to be frozen must be of the same thickness; this ensures that contact with both sides of the block is correct, all the blocks freeze at the same rate, and the plates are not subject to stress and distortion.

Horizontal plate freezers are used mainly in shore-based fish freezing plants, although they are sometimes installed on board ships for freezing prawns at sea. If the plant is installed within a processing line, the loading and unloading of the freezer is often done from opposite sides to speed up the process, increase efficiency, and reduce the time the doors of the freezer cabinet are open and thus, frosting of the plates.

Vertical plate freezers

This type of freezer is particularly suitable for freezing fish at sea. It was originally designed for use on board trawlers for freezing cod as a whole gutted product. After freezing, the fish are kept in a cold store for later on-shore processing. The freezer consists of a

series of vertical, aluminium alloy, refrigerated plates with spaces known as stations between them. The refrigerant passing through the plates reduces their surface temperature to between –30°C and –40°C when in operation. Warm fish are dropped between the plates until each station is full. The plates are then closed together to form the fish into blocks; the refrigerant flowing through the plates then freezes the fish. Fish of similar sizes should be packed into each block; mixed sizes will lead to uneven freezing rates and may damage smaller fish. As these freezers are often used on fishing vessels the fish to be loaded may be very fresh. Consequently, they may not yet have passed through *rigor*, or they may be *in rigor* when they are put in the freezer. If they are already *in rigor*, no attempt should be made to straighten them to make them fit between the plates as this will tear and damage the muscle structure. Freezing *pre-rigor* can cause serious problems on thawing. If fish are frozen *pre-rigor* and stored for only a short time (less than eight weeks at –18 °C for cod), they will not have come out of *rigor* when they are thawed, and a large amount of water, known as thaw drip, will be lost from the fish at this stage. This can be overcome by thawing the fish slowly at ambient temperature so that *rigor* is resolved before thawing is complete. If fillets are cut from a fish still *in rigor*, the meat will contract as it is released from the bone; the fillets will then shrink and have a corrugated surface and a tougher texture when cooked and eaten.

Once frozen, the blocks are released from the stations by a partial defrost. They can either be removed from the side of the station by raising a plate at the bottom, or they may be dropped through the bottom directly into the fish room below. In contrast to the horizontal plate freezer, the plates must be above freezing point before loading, otherwise the fish will stick to them and prevent full loading. The blocks must be handled carefully on removal from the freezer so that they remain in one piece. It is not normal for water to be added to the block to assist in block formation, but if it is

necessary, plastic film or paper liner should be placed in the station to hold the water in the block.

Fish loaded into a freezer on board a boat will usually be at ambient temperature. If a horizontal plate freezer is used, the fish are often chilled before loading. This means that the initial refrigeration load on a vertical plate freezer is often higher than it would be on a horizontal plate freezer.

Advantages of contact freezers

i. Very rapid and effective cooling;

ii. Suitable for block and packaged fishery products;

iii. No chance of dehydration, shrinkage or freeze burn.

Demerits

i. Ice on plate and open space inside the block may loose contact and deform the products.

Type III

Immersion and spray freezers

Immersion and spray freezers operate by maintaining direct contact between a very cold liquid, or gas from that liquid and the fish.

The various liquids which have been used can be divided into:

(a) solutions of salts in water which are mechanically refrigerated to well below freezing point; and

(b) pressurized liquids which boil at very low temperatures.

The first type relies on the mechanical refrigeration of the liquid and the circulation of that liquid through a tank containing the products to be frozen. In the fishing industry, the commonest type of freezer in this category uses sodium chloride brine which can be made to any strength to achieve the desired freezing point. However, saturated brine, which contains 26% salt, freezes at –21°C and in

practice, the operating temperature cannot be reduced below about –18°C. This limits the use of this freezer as the temperature needs to be –30°C or below for most freezing processes. However, even with brine it is possible to achieve rapid freezing because of the intimate contact between the product and the freezing medium. The rate of freezing depends on the circulation of the refrigerated brine throughout the tank, and this can be a critical factor in the efficiency of a brine freezing system. Another disadvantage of using brine freezing is that the fish will absorb salt. The amount of salt taken up depends on several factors including the temperature of the brine, the length of time of immersion, the fat content of the fish and the surface area.

The brine freezing process is not widely used because of the technical limitations. Its most common application is for on-board freezing of tuna destined for canning. Newly caught fish are chilled in a tank containing sea water refrigerated to about 0°C. They are held in chill until the tank has been filled by the addition of subsequent catches, or for up to five days. Salt is then added to the tank to produce a freezing-brine and the temperature is reduced to freeze the fish. When they are frozen (which takes at least 24 h), the tank is pumped dry and used for storage until landing. The fish may thaw, or partially thaw on board the boat as it returns to base so that they are ready for immediate unloading. The sea water and brine is usually refrigerated by a series of pipe grids on the tank sides which may be supplemented by an external heat exchanger.

The second type of immersion freezer uses liquids with low boiling points such as liquid nitrogen, carbon dioxide or liquid air. The most common is liquid nitrogen. This is used for freezing individual fillets and for prawns which sell for a relatively high price when sold as individual quick frozen product. Liquid nitrogen boils at –196° C. If the warm fish are brought into direct contact with the liquid nitrogen, the outer layers would freeze very rapidly; this would cause thermal stress and the break-up of the material.

Therefore, the fish are normally sprayed first with nitrogen gas at about –50°C, and then gradually reduced to much colder temperatures by spraying with liquid nitrogen.

The freezer consists of a stainless steel conveyor belt, which moves against the flow of gas and liquid spray in a freezing tunnel. Nitrogen freezers are small and freeze very quickly. They can be operated without the need for an on-site mechanical refrigeration system. However, in spite of the apparent advantages, the freezers are used only for specialty products. This is because first, operating costs are higher than air blast freezers, secondly, they can only freeze small products, and thirdly, they rely entirely on a regular and reliable supply of liquid nitrogen which requires special storage. These disadvantages severely limit their use in developing countries.

The other types of low boiling point liquid freezers are not so common. At one time, refrigerant 12 (dichlorodifluoromethane) in a specially purified form was used for immersion/ spray freezing. However, the high costs and concerns over the effects of R12 on ozone depletion in the atmosphere have led to a rapid decline in its use. Liquefied carbon dioxide (CO_2) is used to a limited extent for freezing. The gas under pressure in cylinders is sprayed onto the product in much the same way as liquid nitrogen. The management of CO_2 freezing is more difficult than liquid nitrogen and its use is less widespread. Normally, liquid CO_2 is refrigerated before spraying.

Merits of immersion freezer

i. Ideally suitable for freezing unpackaged fish and shrimp on vessel;
ii. Transfer of heat from fish to a surrounding cold liquid is better than from a fish to cold air, as in blast freezer;
iii. No chance of freeze burn.

Disadvantages

i. There is no standard design and vary considerably with each application;

ii. Products are difficult to handle in side the tank;
iii. Immersion solution will penetrate into the fish and may adversely affect the quality if temperature of the medium and time of immersion are not precisely maintained.

Sharp freezing

The sharp freezer consists of an insulated room, usually maintained at –25°C, containing a number of shelves, made from pipe coils through which cold brine or ammonia or other refrigerants circulates. Fish frozen by this method are placed directly on the shelves or aluminium pans/plates covering the pipe coils. Sharp freezing is largely out-dated and its use is limited. It is a slow freezing method.

Some other freezers

Due to modernization of freezing equipment, depending upon the nature and shape of the products, various other freezers are used in seafood processing industry. Some of them are as follows:

Band freezer

Band freezers are designed to freeze small layer of pastes or fish fillets whose thickness is around 15 mm. The product is allowed to press between two plates and freeze very rapidly. The plate is usually placed in a polythene bag to avoid sticking to the metal plates.

Spiral freezer

Spiral freezer is basically an air blast freezer, usually a round chamber in which cold refrigerant blows over wire mesh belt that moves spirally and carries individual items to be frozen. The freezer is used to freeze blanched or cooked IQF shrimp or fish products. Freezing temperature is usually maintained within the range of –30°C to – 40°C, depending on the thickness of the items to be frozen. Spiral freezer is very effective for IQF products as it freezes very quickly, as quickly as between 15 to 60 minutes.

Rotary freezer

Rotary freezer is a high capacity freezer that can handle about 10 to 15 tons of fish a day. It is mostly used in commercial seafood processing, where products of thickness up to 8 cm and length/width 80 x 50 cm can be cooled down to – 11°F in two hours. The freezer applies pressure to the products being frozen and is fully automatic in operation.

Cryogenic freezer

Freezer that uses liquid nitrogen at –196°C (–32°F) is called cryogenic freezer. This is essentially a single belt freezer and the refrigerant is sprayed over the items on the belt. The nitrogen evaporates and is allowed to escape into atmosphere after the vapours are used to cool the fish/shrimp. Alternatively, the material can be dipped into liquid nitrogen, but this often results in development of cracks on the surface. For freezing 1 kg of fish 1.0 to 1.5 kg of liquid nitrogen is needed. So, only cheaply available nitrogen can make this process economically viable. Solid carbon dioxide, dichloromethane and R12, with boiling point –22°F can also be used to freeze fish in cryogenic freezer.

Freezing of shrimp

Shrimp freezing is the most vital of all freezing plants operating for processing of seafood. General freezing steps and methods are described below.

Pre-processing for freezing

1. Inspection for quality: The shrimps are inspected for freshness visually. There should not be any black spot formed. If any black spots are seen, it should be discarded.
2. Icing: The shrimps are iced immediately after capture and re-iced after coming to the factory. At no stage should the temperature of shrimp be above 5°C to maintain top quality of the final product.
3. Grading: grading is done as per the size of shrimp.

4. Weighing: The desired quality is weighed in bulk for processing.
5. Icing: The graded and weighed shrimp is iced again to maintain the temperature around 0°C.
6. Chill storage: The iced shrimp is kept in a chilled room maintained at an operational temperature of 4°C ± 2°C until further processing for freezing.

All these types of pre-processed shrimps are frozen either as block or individual quick frozen (IQF) product depending on foreign buyer's requirements.

Freezing method

Quality of frozen shrimp depends on the freshness of raw materials. Hence, it is imperative that the shrimp should be iced immediately after capture. The recommended storage temperature is 3°C till it is processed in the factory. The material should be stored in stainless steel or polypropylene/plastic containers in crushed ice-water maintained at 2 to 3°C.

For blanched products, the materials should be blanched in stainless steel container, heated electrically or by steam by holding the products in water with or without additives or exposing to steam. Blanching gives a good colour to the meat but care should be taken that the product is not cooked. Best result can be obtained by immediate cooling in chilled water subsequent to blanching. After blanching, the shrimps are graded into different sizes. They are washed in potable water containing 10 mg/kg available chlorine. The material is then processed further for freezing either as blocks or individuals.

For block freezing, the graded shrimps are weighed and packed in wax laminated cartons with a lining of water-proof material. They are then quick frozen in contact plate freezer at – 40°C. The time taken for the freezing operation varies from 1.5 to 3 h depending on

the cooling efficiency of the freezer and the thickness of the slab. The quicker the freezing, the better the quality. Thickness of the block should be around 5 cm. The anterior core of the block should attain a temperature of about – 15°C to – 20°C.

For individual quick freezing (IQF), the blanched or graded shrimps are individually loaded into the conveyer of the IQF machine and frozen rapidly in the freezing chamber. Either spiral, tunnel or belt freezer can be used for individual quick freezing of shrimp. A common equipment for value-added IQF products of shrimp is spiral freezer. The contact time may vary from 5 to 15 min depending on the thickness of the shrimp.

In order to prevent freeze drying of the body surface, glazing is done with cold water. The glaze water should contain 5 to 10 mg/kg available chlorine. In block freezing glaze water can be added prior to freezing to produce uniform glaze. Addition of citric acid, sugar and chloride are permissible in glaze water at the levels 0.2, 0.5 and 0.5% respectively.

The products are packed in master cartons and kept stored at – 20°C. The storage of frozen fish is ideal at –30°C to have minimum quality changes and many countries have adopted –30°C as recommended storage temperature for frozen shrimp.

Freezing of prawn in Bangladesh

The raw material prawn, either headless on head on, is received through the receiving window (temperature 4 to 5°C) of the processing factory. The prawns are washed with potable chilled water, graded, called the *factory grading* and then weighed. Factory grading is done on the basis of the size of prawn, ranging from U5 to U16. U5 means five individuals in one pound. Prawns are washed again with chilled water and re-iced with the flake ice or crushed block ice produced by the factory itself. Prawn mixed with ice is taken on the panning table for dressing and preparing for the product

as per the buyer's demand. Products of different categories, like tail on, tail off, peeled undeveined (PUD), peeled and deveined (P & D), shell on (S/O), etc. as shown in Table 10.3 are generally prepared. Prepared items are washed again followed by pressure washing through strong water jet by a motor. Items to be frozen through contact freezer are packed in small paper boxes according to export grade such as 2/4, 4/6, 6/8, 8/12, 12/15, 15/18, etc. Grade 2/4 means that there are two to four prawns in each pound in the packet. Generally, a two-pound pack is prepared. Prawn is also weighted in kg, if the buyer wants. The weight of the blocks are generally maintained at 2 Ibs, 4 Ibs, 1 kg, 1.8 kg or 2 kg, as dictated by the buyers. The packets are transferred to the contact plate freezer, but before that, very often, a 200 g water is added to each packet to fill the pack tightly. Water helps to freeze the prawn as a block but not to stick each other. Surrounding frozen water also protects the products from dehydration, desiccation, damage, abrasion, etc. Sutter packing is also done without water, but glazing is done after freezing. The packets are kept fixed to the plates of contact freezer. It generally takes 2 hours to freeze the whole block. The temperature at the core of the prawn must reach – 20° to – 25°C. The core temperature is checked with a special type of thermometer. After freezing, the prawns are glazed with little amount of water if water is not added during freezing. Frozen block is checked for filths, passed through a metal detector, packaged in polythene-polypropylene coated paper carton and finally in master carton (generally 6 blocks in case of shrimp). The product is kept in frozen storage until shipment.

For IQF cooked product, dressed and prepared prawns are cooked through steaming or boiling at 90°C for variable time period as per buyer's specification. Salt or other chemicals may be added if the buyers demand so. After definite cooking, the prawns are immediately dipped into chilled water (4°C) to stop the effect of cooking. Cooked items are transferred to the belt of the spiral freezer and frozen at – 40°C for 30 to 40 minutes. Frozen prawns

are glazed, packed, weighed, checked for filth and stored in the frozen storage after master packaging. The temperature of frozen storage is maintained at –22°C. Different prawn/shrimps like galda, bagda, chaga, tiger shrimp, brown shrimp (lailla or horina icha), etc. are processed as IQF products. The main IQF shrimp/prawn products manufactured in Bangladesh are beheaded IQF, raw IQF, blanched IQF, cooked IQF, black tiger tail-on, black tiger tail-off, gold easy (butter fly), peeled IQF, horina PUD, horina P & D, peeled and deveined, etc.

Semi IQF of white fish

The white fish are not processed as IQF products. Some semi-IQF products of whitefish like frozen hilsa, frozen ruhu, frozen catla, frozen carps, frozen baim, frozen aier, frozen chital, frozen boal, etc. are produced in the shrimp processing plants. After receiving in iced condition, the raw materials are dressed, gutted, washed with chilled chlorinated (10 to 20 ppm) water (4°C) and weighed. Ilish is, however, not gutted during processing for semi-IQF product. Adhered water of the washed fish are dried by fanning and then kept necked in air blast freezer at –40°C for 6 hours. The fishes are individually glazed and packed in 20 kg carton under the grade 3/5, 5/6, 6/8 according to buyers demand. A 3/5 grade means that there are three to five fish in a 20-kg package. Ilish and *Calbasu* are packed as 1000 g+, 1200 g+, etc. The carton is packed in durable poly bag and frozen stored at –25°C.

Quality requirements of frozen shrimp/prawn

Quality maintenance of frozen shrimp/prawn products, as per buyer's requirement, has become increasingly difficult day by day, due to new to newer regulations imposed by the buyer countries. A set of general physical, chemical, biological and organoleptic quality requirements of frozen shrimp/prawn (Gopakumar, 2002b) has been given in Table 10.4, 10.5 and 10.6.

Table: 10.3 Exportable shrimp/prawn products produced in processing plant

Products	**Characteristics**
Whole	Head and shell on
Headless	Head removed, shell on
Fantail round	Head and shell removed except having shell on the last segment and tail
Fantail deveined	Fantail round with dorsal digestive tract removed
Fantail butterfly	Fantail round split open
Peeled and deveined	Head, shell and dorsal tract removed
Cooked peeled	Peeled after cooking by boiling/steaming
Peeled, deveined cooked	Peeled and deveined material is cooked by boiling/steaming for 20-40 min
Whole cooked	Head and shell on shrimp cooked by boiling/steaming
Peeled undeveined	Head and shell removed
Headless blanched	Head removed, shell on and blanched completely
Peeled, deveined blanched	Head, shell and dorsal tract removed completely and blanched
Peeled, undeveined and blanched	Head and shell removed but not the dorsal tract and blanched
Extended shrimp	Head and shell removed and pressed to extend the length by 1 to 2 cm

Table: 10.4 Permissible limits of physical spoilage indices of processed shrimp/prawn

Characteristics of the products	Maximum permissible limit	
	Headed with shell on (%)	Other items (%)
Deterioration of spoiled pieces	5	5
Discolouration of shell and meat	10	10
Black spot on shell and meat	3	2
Broken, damaged and soft shelled pieces	5	10
Legs, loose shells, etc.	2	5
Dehydration	15	15

Table: 10.5 Chemical and biological quality requirements of processed shrimp/prawn for export

Quality attribute	Whole headless and IQF type	Peeled & deveined type including butterfly, fantail, round and IQF type	All cooked type including cooked-peeled deveined, coked & IQF	All blanched type including headless blanched, peeled-deveined blanched and peeled un – deveined blanched & IQF type
Total bacterial count/g in final product, Maximum	5×10^5	1×10^6	1×10^5	2×10^5
Escherichia coli, Maximum	20	20	Nil	Nil
Faecal Streptococci count/g, Maximum	100	100	Nil	Nil
Coagulase positive Staphylococci/g, Maximum				
Salmonella/Arizona	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)
Vibrio cholerae	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)
Listeria monocytogenes	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)	Nil (per 25 g)
Formaldehyde mg/kg, Maximum	10.0	10.0	10.0	10.0
Indole mg/kg, Maximum	2.5	2.5	2.5	2.5
Heavy metals mg/kg, Maximum:				
a. Mercury	0.5	0.5	0.5	0.5
b. Copper	20.0	20.0	20.0	20.0
c. Zinc	50.0	50.0	50.0	50.0
d. Arsenic	1.1	1.1	1.1	1.1
e. Lead	1.0	1.0	1.0	1.0
f. Tin	250.0	250.0	250.0	250.0

Table: 10.6 Organoleptic quality requirements of frozen shrimp/prawn

Characteristics	**Grade**	**Whole & headless**	**Peeled deveined and undeveined**	**Cooked frozen prawns**
Colour of shell	1	Natural color, characteristics of freshly dim or faded	-	-
	2	Slightly dim or faded		
Colour of flesh	1	Characteristics of freshly caught prawn	Characteristic white colour	Characteristic bright cook colour
	2	Slightly discoloured	Faded or slightly yellowish	Slightly faded colour
Black discoloration of shell and meat	1	Nil	Nil	-
	2	At the shell joints only	Nil	-
Texture of meat	1	Firm and consistent	Firm and consistent	Firm and consistent
	2	Not mashy but tending to become loose	Slightly mashy but not loose	Firm but breaking into pieces if pressed between the fingers
Odour on cooking	1	Characteristic flavor of freshly caught prawn	Absence of any off dour	Odour of freshly caught cooked prawns
	2	Absence of any off odour	Absence of any off odour	Absence of any off odour
Flavour on cooking	1	Characteristic flavour of freshly cooked prawn	Characteristic flavour of freshly cooked prawn	Characteristic flavour of freshly cooked prawn
	2	Not off flavour	Not off flavour	Not off flavour

Storage of frozen products

Once fish have been frozen they need to be kept under suitable storage conditions to maintain quality. The recommended storage

temperature for frozen products varies between the range from –20 to –25°C. At this temperature, protein changes and denaturation are minimized, and bacterial action is practically arrested. However, even at these low temperatures, other changes can occur which lead to loss of product quality. These include oxidation of fat, dehydration, colour changes and possible protein deterioration under fluctuating storage conditions. Correct design and use of cold stores can reduce these problems. The most important design factors are :

- ♣ low temperature
- ♣ uniform temperature (throughout the store)
- ♣ steady temperature (with minimal fluctuation)
- ♣ good air distribution (to maintain uniform conditions)
- ♣ minimum air circulation (to reduce dehydration losses)
- ♣ minimum air ingress (to minimize fluctuations).

Dehydration of the product is a major concern for the cold store operator. It occurs as a consequence of the different amounts of water which can be held as vapour in the air at different temperatures. Warm air at 100% relative humidity holds more g/litre of water than the same volume of air at a lower temperature. As air passes over the product in cold storage and circulates inside the cold store, it becomes warmer than it was when it left the evaporator. As it warms it becomes less saturated with water and is therefore able to pick up moisture from the surroundings. As a result, water is removed from the product in storage. This moisture is carried along by the air which is returning to the evaporator. The evaporator cools the air down, so that it becomes over-saturated (more than 100% relative humidity). The water then precipitates out of the air to form frost on the evaporator coils. Cold stores are therefore generally designed to minimize these problems.

The cold store can affect the storage life of products by the ability or inability to maintain a low, uniform and steady temperature with the minimum of air circulation. The use of good thermal insulation during construction, the installation of adequate vapour

barriers for the insulation, the construction of an air lock, air curtain or similar device to reduce air ingress, and the proper management and organization of the stored products, are all factors which will help to produce optimum and efficient use of the store.

Insulation of cold storage

Good thermal insulation is a prerequisite for cold store design; the type of insulation and its correct installation are vital to efficient operation. An insulating material is one which slows down the passage of heat energy from higher to lower temperatures. The choice of insulator depends not only on its low thermal conductivity, but also on its -

- ♣ resistance to passage of water and water vapour
- ♣ resistance to rot
- ♣ resistance to attack by vermin and insects
- ♣ structural strength
- ♣ toxicity
- ♣ flammability
- ♣ price.

Various 'traditional' materials have been used for insulating cold store walls including cork, wood shavings, sawdust and vermiculite. These have been replaced in recent years by foam and expanded plastic materials which have a number of advantages. The traditional, vegetable-based materials were not resistant to water, had a tendency to rot and settle after installation, were not as efficient as the newer materials, and in some cases such as cork, had become very expensive. The commonest modem insulating plastics are expanded polystyrene and polyurethane foam.

Changes in frozen fish during storage

Several changes are found in the fish body and muscle during the freezing and frozen storage of fish. These changes are, however, influenced by the temperature of the medium, packaging and glazing

of the products and relative humidity of the stores. The changes are as follows:

1. *Physical changes*
    i. Crystallization of water in tissue increases the volume about 8-10% of the raw fish;
    ii. Desiccation starts from the surface of the body;
    iii. Discolouration occurs due to break down of haemoglobin;
    iv. Toughness of muscle increases;
    v. Rigidity increases as it becomes hard;
    vi. Loses weight;
    vii. Freeze-burn occurs;
    viii. Trimming loss in association with the loss of nutrients occur;
    ix. Thaw-drip or water drip occurs when frozen fish are thawed slowly;
    x. Slow freezing produces big ice crystals that ruptures the cell wall and causes physical damage.

2. *Chemical changes*
    i. Chemical and enzymatic actions take place slowly;
    ii. Proteins irreversibly dehydrated;
    iii. Myoglobin oxidized;
    iv. Lipid oxidized and hydrolyzed.

Facilitation sheet-5

11a

Traditional Sun-drying of Fish

Activity: 1 Fish drying season in the coastal belt

The participants are divided into two groups. Group A will show the monthly fluctuation of the marine catch and Group B will show the intensity of fish drying in different months of the year in the following calendar. From the calendar a general pattern of glut and lean period for fish and monthly fish drying activities can be understood. Group leaders will present respective group findings. Facilitator will initiate a question-answer session pointing out the variation in the catch of fish in different parts of the country.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fishing												
Fish Drying												

To show the intensity one can use 5 circles for the highest and 1 circle for the lowest

Activity: 2 Various sun-dried products and species used in sun-drying

The participants are divided into 2 groups. Group A will point out various dried and dehydrated products, while Group B will mention the species used. Group leaders will arrange those in the following chart. One group will ask question to other group. Through the discussion a detailed list of dried products and species used will be prepared.

Group A **Different dried products**		**Group B** **Fish species used**	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 3 Factors influencing the process of sun-drying

Generally two major factors influence the drying process. Group A will discuss the environmental factors, while Group B will discuss the physiological factors. Both the groups will fill up the following chart. One group will ask the other group for further detail. Finally, the facilitator will explain the nature of influence.

Group A **Influencing environmental factors**		**Group B** **Influencing physiological factors**	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 4 Existing process of sun-drying and its constraints

Group A will explain the existing process, while Group B will find out the constraints of existing process. The group leaders will present their findings. After each presentation, opponent group members will ask questions. The facilitator will contribute to fill the gaps of discussion.

	Group A Existing process of sun-drying		Group B Constraints of existing process
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 5 Improvement of the existing process

Group A will propose an improved method of sun drying and point out its merits, while Group B will try to explain the construction and operation of an effective solar dryer. After each presentation by the group leaders, one group will ask question to the other group to know the merits and demerits of each improved method. The facilitator will fill up the gaps.

Activity: 6 Application of salt in fish during sun-drying

Group A will discuss about the nature of salt to be used in dried fish, while Group B will discuss about the benefit of salt application. Two groups will furnish the following chart and the leaders will present those before the participants. The trainer will explain the mechanism of salt action in drying process highlighting its benefits and limitations.

	Group A Nature of salt to be used		Group B Benefits of salt application
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 7 Infestation of dried fish by insects and control measures

Group A will fill up the following chart about the nature of infestation of fish by the maggots of blowflies, locally called *"lock"* during processing. The group will also address its possible control measures. Group B will write about the infestation of dried fish by beetles, locally called *"Kaissha poka"* and mites, called *"Gun poka"*. They will also write about the control measures in the following chart. One group will ask questions to the other group. The trainer will explain the details of insect infestations in dried fish and their control measures.

	Group A Blow fly infestation and remedies		Group B Beetle and mite infestations/remedies
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 8 Role of different stakeholders in the improvement of traditional process.

The participants are divided into 4 groups, *viz*., boat owners/ fishermen, small-scale processors, dry fish traders and extension workers. Each group will discuss about their responsibility to improve the existing sun-drying process. The group leaders will present group's findings. After a question-answer session, the facilitator will sum up the discussion and present an improved process for sun-drying of fish.

Stakeholder	Measures to be taken for improvement
Boat owners/ Fishermen	1
	2
	3
	4
	5
Small-scale processors	1
	2
	3
	4
	5
Dry fish traders	1.
	2.
	3.
	4.
	5.
Extension personnel	1.
	2.
	3.
	4.
	5.

Activity: 9 Quality of dried fish produced from fresh or spoiled raw material

The participants are divided into two groups. Group A will find out the characteristics of dried fish prepared from fresh fish, while Group B will find out those produced from spoiled fish. Now, the two groups will cross-discuss and reach to a common understanding towards setting the criteria of the quality of dried fish. The facilitator will explain more on the characteristics of quality products and finally sum up the discussion.

Group A Characteristics of dried fish produced from fresh fish		Group B Characteristics of dried fish produced from spoiled fish	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 10 Quality of dried fish produced from salted/salt-free and pesticide used/pesticide-free raw materials

The participants are divided into 2 groups. Group A will define the characteristics of salted and salt-free dried fish, while group B will explain the characteristics of pesticide used and pesticide-free products. Group leaders will present each group's findings. The facilitator will explain more about the physical qualities of salt and the nature of pesticides used in dried products.

Group A Characteristics of dried fish			Group B Characteristics of dried fish		
Sl	Salted	Un-salted	Sl	Pesticide used	Pesticide-free
1			1		
2			2		
3			3		
4			4		
5			5		

Information sheet 7

11b

Traditional Sun-drying of Fish

Group Exercise : 10
Field Demonstration: 4

Introduction

Traditional sun-drying of fish in Bangladesh has been reviewed by the author in detail (Nowsad, 2005a). Dried fish is an important source of protein in Bangladesh. It is relished by many people of coastal, central and North-eastern districts. However, the physical and organoleptic qualities of many traditional sun-dried products are un-satisfactory for human consumption (Nowsad, 2005a). One of the major problems associated with the sun-drying of fish is infestation of the products by the blow fly and beetle larvae. Other problems markedly evident with dried fish are the contamination during different stages of handling and processing and the indiscriminate use of various types of pesticides. Dried fish contaminated by both insects and insecticides comprises about 60% of the total dried products that is considered to be unfit for human consumption (Nowsad 2005a). Many consumers are now very much conscious about the quality of dried fish. In order to ensure micro-nutrient supply to the growing population and to enable the fishers and processors to produce high quality marketable products, the improvement of traditional fish drying is an urgent necessity.

Principle of sun drying

Traditional sun-drying is carried out in the open air, using the energy of the sun to evaporate the water and air currents to carry away the vapour (Fig. 11.1). Low humidity facilitates evaporation. However, during initial stage of drying, evaporated vapour makes the surrounding environment humid. Therefore, strong air flow is needed to carry away the vapour rapidly. Theoretically, moisture content of the final product should be reduced to less than 15-16% where most of the microbiological and enzymatic activities are slowed down or stopped. In practice, however, water content is not reduced to this theoretical 15-16%. In commercial processing water content is often higher when storage times are short, where salt is used in the processing and where consumers prefer an intermediate moisture product. Local consumers generally prefer unsalted products. To increase the storage life of such products insecticides are used. Moisture content of unsalted products ranges from 18-23%, while those of semi-salted or salted products ranges between 25– 30% (Nowsad, 2005a). Salt accelerates the drying process by rapid removal of water from the body. During drying, substantial shrinkage and other irreversible changes take place. Therefore, dried fish can not be reconstituted.

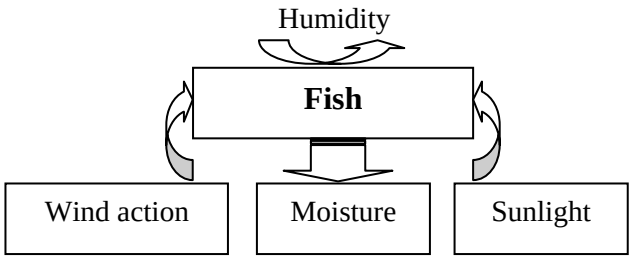
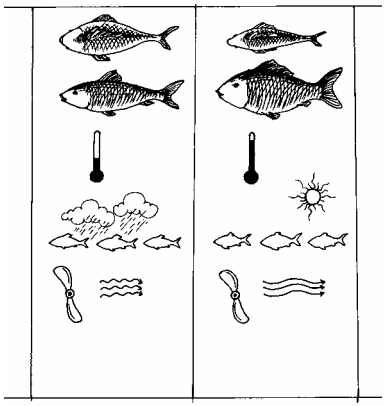


Fig. 11.1. Process of sun drying of fish

During sun drying evaporation of water from fish is accomplished in two distinct phases (Clucas and Ward, 1996). In the first phase, when the surface of fish is wet, the rate of evaporation depends on the conditions of the air surrounding the fish. These are:



Slow drying Fast drying

Fig. 11.2. Conditions of fish drying

relative humidity of air, air velocity, air temperature and surface area of fish. In the second phase, when all the surface moisture has been carried away, drying of fish depends on the rate at which moisture is brought to the surface of the fish. The rate of moisture flow to the surface depends on the constituent nature, thickness, temperature and water content of the fish.

Water activity

Water activity, a_w, is defined as the ratio of partial pressure of water vapour in equilibrium with a substance to the saturation partial pressure of pure water vapour at the same temperature, as expressed as

$$a_w = P_v/P_{sat}$$

The water activity of pure water is 1.0. When water molecules are bound physically or chemically within a material, the water activity of that material drops. The addition of table salt, for example, acts to bind water molecules. Some humectants such as sugar, glycerol, saltpeter, etc. that are commonly added to foods have the effect of lowering the water activity of the food. Drying of fish substantially reduce the water activity in the tissue. It is found that lowering of water activity below 0.9 is sufficient to prevent the growth of the dangerous toxin forming pathogenic bacteria (Doe, 2002). Below a water activity of 0.75 only the halophilic bacteria can survive, whereas at water activities below about 0.63 molds will fail to germinate and grow.

Importance of sun-drying in Bangladesh

- ***The method of sun-drying is simple and versatile***
- ***It does not require huge money or highly skilled man power***
- ***Almost all species of fish can be sun-dried***
- ***Huge sunshine and air flow are available throughout the year***
- ***It can be performed everywhere, from the deck of the fishing boat to the roof of the house***
- ***Nutritional quality remains intact - sometimes retains higher quality standards compared to fish (as per unit weight)***
- ***The product is easy-transportable, marketable and storable***
- ***It has good market in the country or abroad***
- ***Special flavour is highly relished by different ethnic people***

Season of fish drying

In the coastal belt, fish drying generally starts in October and ends in March. In some coastal villages, drying starts sporadically in early September and lasts till the end of May. The fish are dried depending on the raw material supply and market demand. In other parts of the country drying of fish is done in the winter months.

Table 11.1. Intensity[1] of fishing and related activities in coastal region throughout the year

Activity	Baishakh **Apr-May**	Jaistha **May-Jun**	Ashar **Jun-Jul**	Srabon **Jul-Aug**	Vadra **Aug.-Sep**	Asshin **Sep-Oct**	Kartik **Oct-Nov**	Agrahayan **Nov-Dec**	Poush **Dec-Jan**	Magh **Jan-Feb**	Falgun **Feb-Mar**	Chaitra **Mar-Apr**
Fishing	2	1	1	1	3	5	5	4	2	2	4	5
Fish trade	1	1	2	2	2	5	5	5	1	1	3	3
Net mending	1	1	5	5	2	2	2	1	0	0	2	2
Sun dying	1	1	0	0	2	5	5	5	4	3	3	2
Shrimp smoking	0	1	4	5	5	1	0	0	0	0	0	0
Rainfall	1	2	5	5	4	2	1	0	0	0	0	0

[1] *On a scale of 0-5 with 5 being the highest*

Peak drying is observed in October, November, December and January. The intensity of fishing, drying and related activities throughout the year is shown in Table 11.1, extracted from a seasonal calendar, conducted in coastal villages of Cox's Bazar during a PRA exercise (Nowsad, 2005a).

Fish used in traditional sun-drying

Any species of fish, either marine or freshwater, can be sun-dried. This is reflected in the homestead and small-scale sun-drying

Table: 11.2 Marine fish species used in sun-drying and salted-dehydration.

English name	Scientific name	Family	Local name
a. Dried fish:			
Chinese pomfret	*Stromateus chinensis*	Stromatidae	Rupchanda
Brown pomfret	*Parastromateus niger*	Stromatidae	Kalichanda
Silver pomfret	*Stromateus cinereus*	Stromatidae	Folichanda
Silver jewfish	*Johnius argenteus*	Sciaenidae	Lal poa, Pufa
Silver jewfish	*Otolithoides argenteus*	Sciaenidae	Rupa poa, Pufa
Silver jewfish	*Otolithoides brunnes*	Sciaenidae	Rupa poa, Pufa
Black jewfish	*Johnius diacantus*	Sciaenidae	Kala datina
Bombay duck	*Harpodon nehereus*	Synodontidae	Loitta
White grunter	*Pomadasys hasta*	Pomadasydae	Sada datina
Red snapper	*Lutianus johnii*	Lutianidae	Ranga choukya
Ribbon fish	*Trichiurus haumela*	Trichuridae	Churi
Indian mackerel	*Rastrelliger kanagurta*	Scombridae	Champa
Indian salmon	*Polynemus indicus*	Polynemidae	Lakkha
Four thread tassel fish	*Eleutheronema tetradactylum*	Polynemidae	Tailla
Silver belly	*Leiognathus bindus*	Leiognathidae	Taka chanda
Shad	*Tenualosa kanagurta*	Clupeidae	Jhatka
Sardine	*Sardinopsis sp.*	Clupeidae	Colombo mach
Jeweled shad	*Hilsha filigera*	Clupeidae	Choukya
Smooth back herring	*Raconda russelliana*	Clupeidae	Fatra, Kurraphasa
Sea catfish	*Tachysurus thalassinus*	Tachysuridae	Guizza, Kata
Anchovy	*Setipina taty*	Engraulidae	Tailla phasa
b. Salted-dehydrated fish:			
Silver jewfish	*Johnius argenteus*	Sciaenidae	Lal poa, Pufa
Silver jewfish	*Otolithoides argenteus*	Sciaenidae	Rupa poa, Pufa
Silver jewfish	*Otolithoides brunnes*	Sciaenidae	Rupa poa, Pufa
Sea catfish	*Tachysurus thalassinus*	Tachysuridae	Guizza, Kata

throughout the country. However, for commercial sun-drying, species selection depends on both availability and market demand. The marine finfish generally used for dried products in coastal region are given in Table 11.2 & 11.3.

Major marine fish drying centers in Bangladesh

Commercial marine fish drying is centered in 7 locations in Cox's Bazar district and in Charfashion of Vhola, in Alipur, Mohipur and Rangabali of Patuakhali and in Dublarchar of Sundarban. Dhalghata-Matarbari of Moheshkhali and Kutubdiapara Nagirertek of Cox's Bazar Sadar are the most dominant fish drying yards along the Chittagong-Cox's Bazar belt. Dublarchar of Sundarban is the largest marine fish drying center of the country. Drying centers are changed very often and drying activities are shifted to new locations depending on the improved physical facilities (communication, fish landing, electricity, etc.) and raw material availability. Present major fish drying centers and their locations are given in Table 11.4.

Table: 11.3. Marine fish species used in dried products

English name	Scientific name	Family	Local name
Dried shark fin			
Dog fish	*Scoliodon sorrakowah*	Carcharhinidae	Hangor
Hammer-headed shark	*Sphryna blochii*	Sphyrnidae	Haturi hangor
Black-finned shark	*Carcharhinus melanopterus*	Carcharhinidae	Kala hangor
Sawfish	*Pristis microdon*	Rhinobatidae	Karati hangor
Sting ray	*Himantura uarnak*	Dasyatidae	Haush
Sting ray	*Himantura walga*	Dasyatidae	Haush
Dried air bladder			
Silver jewfish	*Johnius argenteus*	Sciaenidae	Lal poa, Pufa
Silver jewfish	*Otolithoides argenteus*	Sciaenidae	Rupa poa
Indian mackerel	*Rastrelliger kanagurta*	Scombridae	Champa
Indian salmon	*Polynemus indicus*	Polynemidae	Lakkha
Sea bass	*Lates calcarifer*	Latidae	Coral
White grunter	*Pomadasys hasta*		Sada datina
Sea catfish	*Tachysurus thalassinus*	Tachysuridae	Guizza, Kata

Traditional sun-drying of fish

A more or less similar method is practiced for sun-drying of fish all along the coastal belt of Bangladesh. To draw a general picture, however, detailed process practiced in a representative drying center of Cox's Bazar has been presented.

Table: 11.4. Fish drying centers in the coastal area of Bangladesh

Location	Nature of entrepreneurship	Upazila/ District
Kutubdiapara, near Cox's Bazar town	Very large commercial, during glut period, *Killa*-based; also factory-based dried & salted-dried products	Cox's Bazar Sadar
Nunierchara in Cox's Bazar town	Factory-based dried & salted-dried products	
Shaplapur, Khuruskul	Small commercial, *Killa*-based	
Chowfalldandi	Small commercial, during lean period (opposite to Kutubdiapara)	
Ghotibhanga	Large commercial, *Killa*-based	Moheshkhali, Cox's Bazar
Sonadia	Very large commercial, *Killa*-based	
Dhalghata-Matarbari	Very Large commercial, *Killa*-based	
Gorokghata-Charpara	Large commercial	
Gorokghata Ghat	Small-scale, on the dyke	
Sairardel-Matarbari	Large commercial, *Killa*-based	
Ahmadiakata	Small commercial	
Khuiddartek	Commercial, *Killa*-based	Kutubdia, Cox's Bazar
Moheshkhaliapara	Small commercial	
Baraghope	Commercial, *Killa*-based	
Shahparirdeep-Jelepara	Large commercial, *Killa*-based	Teknaf Cox's Bazar
Jaillapara near Teknaf town	Commercial, *Killa*-based	
Gingira	Factory-based salted-drying	
Hatkhali	Large commercial	Bashkhali, Chittagong
Charfashion	Large commercial	Vhola
Alipur, Mohipur, Kuakata	Large commercial	Patuakhali
Rangabali	Very large commercial, *Killa*-based	Sundarban
Dublarchar	Very large commercial, *Killa*-based	

Kutubdiapara fish-drying center

Physical condition

Kutubdiapara of Cox's Bazar Sadar is the 3rd largest traditional fish-drying centre of the country after Dublarchar of the Surdarbans and Dhalghata-Matarbari of Moheshkhali. Kutubdiapara is an emerged sandbar (char) from the sea, that extends from the Zhauban along the coastal belt up to the Moheshkhali channel, in the North-west of Cox's Bazar city. A village named *Kutubdiapara* has been established near the fish-drying centre where the small-scale processors and the labourers of the yard live. It is so named because most of the dwellers have been migrated from Kutubdia Island who lost their homes at the sea. These people are mostly engaged with fish-drying activities.

In Kutubdiapara, sun-drying is performed within 95-100 acres of sand along the coast line. The total area is distributed among 350 entrepreneurs. Small entrepreneurs who do not have fishing boats, but purchase raw fish from large entrepreneurs, use 65-70% of the land. Large entrepreneurs numbering 50-60, who have fishing boats and dry their own fish, occupy the rest of the lands.

The well-off fishermen/businessmen owning boats are called "*Bahadder*". Each entrepreneur has a well-marked territory, fenced by bamboo with elevated bamboo racks, poles and bars where the fish is dried. The bamboo-marked territory is called "*Killa*" or "*Basha*". Sometimes large territory, operated by a *Bahadder*, is called "*Killa*" and a small territory used by a small entrepreneur is called "*Basha*"

To establish the rights of fish-drying activities and dried fish business, small entrepreneurs have formed a cooperative society in 1995 named "Nazirartek Fish Traders Multipurpose Cooperative Society". Starting with 104 members, it has now a total member size of 250. The society was registered in 2000 (Reg. No. 478). In a drying season, one society member can produce 10-20 tons of dry fish. A *Killa* owned by a *Bahadder* has a maximum capacity of

producing 50-60 tons of dried fish per season. However, due to scarcity of raw material the enterprises run far below of their capacity utilization. Exact data is not available, but information collected through personal communication says that in Kutubdiapara drying yard about 800-1000 tons of dried fish are produced by the *Bahadder*s alone each year. These *Bahadders* are not the members of that society. In 2000, total production by the members of the Nazirartek Cooperative Society was 1,400 tons (Nowsad, 2005a).

Fish is extensively dried from October to March. The extent of drying is abruptly reduced in the summer and rainy seasons. The fishers engaged in drying then look for other jobs. Some go to sea for fishing, some start small-scale drying or smoking of shrimp and some come to pull rickshaw. But when the next drying season starts, the fishermen rush to Kutubdiapara again. During the October-March period, most of the fish drying activities of the country is centered in Dublarchar, Matarbar-Dhalghata and Kutubdiapara.

Drying method

There is no fish landing jetty in Kutubdiapara. During drying season, 50-60 motorized boats and huge non-motorized boats land their catch on the shore daily. Generally fish is landed on a mat (10' x 20') made of split bamboo. The mat is kept on the sand and itself dirty with clay and sand. Large boats (10 tons capacity) operate at the sea for about 7 days. Small boats (0.5-2.0 tons capacity) return to the land within 2-4 days. The boats generally carry an insufficient amount of ice. For example, large boat carries only about 60-70 blocks of ice, each with 75 kg, which is not sufficient for 10 tons of fish to be kept chilled for 5 to 7 days. The number of ice-block carried in the boat is reduced further during January-February. Of course, although the boats are not often with full of capacity, the ice crystals are hardly found in the fish hold or with the fish while landing. Most of the ice are melted out by the time the boat reach the land. Temperature of fish often rises far above 10^{o}C. The quality of fish, therefore, deteriorates to a great extent when the boat land.

Improper handling of fish further accelerates spoilage. Fish is taken up from the fish hold to the deck by a basket and thrown to another basket held by two men standing by the side of the boat. The boat is anchored 15–20 meter away from the shore. On the way from the boat to the shore, the basketful of fish is dipped into the sea water. The fish is partially washed in this way. Finally, fish is landed on the bamboo mats kept on the sand. Due to such improper handling on board vessel and during landing, broken bellies or other signs of distortion are frequently observed in fish. A porter carries two baskets of fish on his shoulder, tied with the rope to the two load ends of a bamboo pole and earns for him Tk. 10 for each from the landing site to the drying racks of the *Killa*. Sometimes fresh fish are carried up to 2 km away from the landing sites.

Upon arrival at the *Killa* or *Basha*, the fish is kept on a bamboo mat. The mat is often unclean with dirt, clay, sand, and fish offal. The unwashed fish is mixed with salt. The ratio of fish and salt and mixing time varies according to the quality of fish. If the quality of fish is severely deteriorated, salt concentration is higher. But a higher salt content again reduces the price of dried fish. Therefore, a balance between the salt content used and the extent of deterioration is maintained to get a maximum price. Generally, 5-7% salt is sprinkled over the unwashed and unsorted fish. Mixing time varies from 2-5 hours. There is a belief among the local processors that salt can compensate for the deterioration of the quality that has already occurred in fish. Salt, however, hardens the fish and makes handling easier. Physical assessment shows that the quality of salt used is very poor. Generally, low-cost unpurified solar salts, grayish to blackish in color, contaminated with mud, sand and other adulterants are used. The price of a bag of 60-kg salt varied from Tk. 140-160 in 2003. Unclean salt is a source of contamination and quality deterioration in dried fish.

Salt-treated fish is sorted for different species and size according to the demand in the market. Species of high demand are pomfret, jewfish, tassel fish, Bombay duck, ribbon fish and *Metapenaeus*

shrimp (brown shrimp). Small low-priced species are dried in mixed lots. These include small jewfish, anchovy, shads, sardines, etc. Crabs, squids, puffer fish, other non-conventional fish and mollusk are dried separately and sold for fish meal.

After sorting, the fish are washed with sea water in a bamboo basket. The fish in the basket is carried to the nearby channel, dipped into the water and washed several times. The water of the channel is filthy and carries mud, sand, debris and even night soils. During high tide, there is sufficient water for washing but in low tide, water level of the channel goes down significantly making small pits/ditches of trapped water where the washing is performed. After washing, the fish is spread over the elevated racks for drying.

Ribbon fish and sharks, are tied up at the caudal end in pairs while two Bombay ducks are joined together with extended jaws and hung over bamboo bars. Some larger species like Indian mackerel, tasselfish, etc. receive pre-treatments like gutting and splitting the lateral muscle before drying.

Duration of drying

The fish are left hanging on bamboo bars or kept on the elevated racks until they dry. For uniform drying, fish is turned in both racks and hanging bars at short intervals. Generally, small fish spread in thin layer on the elevated racks takes a shorter time to dry. Larger and thicker fish take longer time. In winter, when the relative humidity is less in the air (60-65%), 2-3 days are sufficient for drying small mixed fish. Average duration during drying season for different fishes are – jewfish: 2-3 days; ribbonfish: 3-4 days; Bombay duck: 2-3 days. Of course, this duration varies if it rains or the sky is cloudy.

Drying of fish in special conditions

Split fish in ring or frame

To accomplish a uniform drying inside of the muscles of large and thick fishes, they are often sun-dried after necessary pretreatment. This entails dressing, gutting, washing, splitting of

lateral muscles, salt or spice treatment, etc. The lateral muscles of large fish like four thread tassel fish, sea bass or Indian mackerel are split into 8 to 10 strips of equal thickness. One ring encircles the abdominal cavity inside and helps the muscle strips to remain open as it gives a shape of a spindle or rocket shell. This special shape allows sunlight and air to enter inside and facilitates drying. Very often the belly flaps of large fish are widened by splitting the fish through the ventral lining and fixing the widened fish within a triangular bamboo frame. The fish is dried within the frame that gives a good shape of the product and reduces the chance of muscle shrinkage.

Drying on board vessel

The mechanized boat that makes a voyage for more than a week sometimes dry on board vessel some high priced high demand fish on hanging rope over the boat. Fish caught by the crews by angling or long lining during leisure time are also dried through this way. Such type of drying on board vessel covers a wide variety of species from pelagic sardine to demarsal pomfret. The quality of the product is good since it is almost free from fly and insect infestations, dust and other microbial contaminations. Consumers prefer it since there is no insecticides in the product. Some of the products, for example, ribbon fish dried on board vessel can be recognized by cut jaws and a transverse cut in the abdomen to remove gut. The jaws are cut out before hanging to avoid possible injury by the sharp teeth of the fish.

Drying on the sand

During glut period, if the price goes down and transportation becomes difficult, the quality of the raw material in landing sites deteriorates due to lack of attention. The fishermen generally spread such small fish on the sand for drying without any pre-treatment. In this process, blow fly and insect infestations and contamination are much higher than any other traditional methods. Most of the small clupeids and anchovies captured during glut period are sun-dried by this process.

Drying fish during the rain

In commercial fish drying, fish are generally dried in the sun. If it rains, the drying racks are covered by long polythene sheet. The sheets are removed when the rain is over. If it rains for days together, however, fish are shifted to the bamboo bars or racks kept in large open shed. Drying takes place by the action of wind only. In such operation, heavy salt treatment (10~20%) is prerequisite for maintaining the quality of the products.

Traditional storage of dried fish

For commercial scale storage, an elevated platform (18 inches from the earth) is made with bamboo inside the house. A box, either round or rectangular, is constructed on the platform with thick mat made of split bamboo, locally called "*gola*". The height of the *gola* is about 8-10 feet and the diameter is 6-8 feet. The size varies with the quantity of the product to be stored. Generally, dried fish is stored with powdered pesticides, like DDT or *Basudin*. At first, 0.25-0.50 kg DDT is spread on the bottom of the *gola*. Then the dried fish is arranged in a layer of about 18 inches thick. Powdered DDT or *Basudin* (about 0.25 kg) is spread again on the fish layer. Likewise, dried fish and DDT are kept in layers until the *gola* is full. Finally, a top layer of DDT is given and opening of the *gola* is closed by a mat made of bamboo. Heavy object like brick, wood or stone are kept on the top of the *gola* to keep a pressure on the dried fish inside. Product stored in such a way is checked for quality in every 2 months. If any infestation (beetles, mites or others) is found, stored product is again sun-dried for 1-2 days and restored with additional DDT. With such periodic checking, dried fish can be stored for 6 to 10 months. According to the local businessman, about 0.5 kg DDT is required for a 200 kg dried fish.

In some coastal villages, *Basudin,* a granular organophosphorous insecticide, is also used along with DDT for the storage of dried fish in gunny bags. Generally, 100 kg dried fish is stored in one gunny bag with nearly 100 g *Basudin*. At first, 20 kg of dried fish is kept

and a 20 g powder *Basudin* is spread over the fish. Again, another 20 kg of the product is put and a 20 g powder is spread over it. In such a way, dried fish and insecticide powder is kept alternately. Finally, the opening of the bag is sealed. The product is stored for 6 months. The condition is checked every after 2 months. If it is infested by beetles and mites, the product is repacked with more *Basudin* after sun drying again for 1-2 days.

Insect infestation in dried fish

Insect infestations are the real problems in dried fish in Bangladesh. Generally, two major infestations damage the products. i. larvae (maggots) of several species of fly (*Diptera*) infestation during the early stages of the drying; and ii. beetle (both larvae and adult) and mite infestations during storage and distribution. Because of negligence in prolonged storage, the extent of damage caused by beetle infestation in the country is much higher than blowfly infestation caused during processing where comparatively greater attention is paid.

The life cycles of all these insects involve four developmental stages, the egg, larva, pupa and adult (FAO,1981). The adult female, after mating, lay eggs on or inside the fish. The eggs hatch into small larvae that feed vigorously and develop rapidly. In all cases, most of the damage in dry fish is caused by the larval stage.

Blowfly infestation

Adult blowflies are attracted to the fish both visually, by the large amount of fish spread out to dry, and chemically, by the odours or volatile compounds released from the fish (Clucas, 2003). Larger fish are at most risk from gravid female blowflies during the raw material preparation and early stages of sun-drying when the moisture content is high. Moist condition makes the larvae able to feed upon the flesh and survive. Therefore, small fish which dry quickly are not usually attacked by the blowfly larvae unless the weather conditions prevent them from drying.

The adult blowflies usually lay their eggs in the gills, oral cavity and underneath of the fish. Eggs are also found to be laid in the crevices between muscle bands and in the abdominal or bony cavities in beheaded or split fish. Hatched out larvae, locally called *"lock"*, immediately congregate in feeding area of muscle and may make deep burrow into the flesh. This causes the fish to break up and make it more prone to subsequent infestation by other pests, especially beetle. Blowfly larvae hatched from the eggs laid upon other food sources like other fish, debris and rubbish around drying site may also crawl across onto the new fish to form new feeding packs. The larvae continue to feed upon the flesh until the fish is fully dried or they are pupated. To pupate, the larvae usually leave the fish and burrow into the earth beneath the drying fish. If the fish is dried very quickly, the larvae may either die off or leave the fish for other food source. Therefore, the amount of damage caused by blow-fly larvae depends largely on the speed of drying. During field study, limited blow fly activity was observed only on the first and hardly on the second day under clear sunny days, but until 3rd day in humid conditions (Nowsad, 2005a). Salt treatment reduces the rate of blowfly infestation. Damage can be heavy where salt is not used and drying condition is poor, as much as 25-30% under very humid conditions in Bangladesh (Doe, 1977; Ahmed, 1978).

Beetle and other infestations in dry fish

Heavy damage in dried fish is caused by beetle infestations mainly during storage and distribution. Certain other insects and mites, more often associated with other stored products such as cereal grains and flour, are also found on dried fish. *Dermestes* beetle, locally called *"Kaissha poka"*, appears to be the major insect although other minor mites like *Necrobia* spp., locally called *"Gune poka"*, can also damage the product. The level of losses due to *Dermestes* beetle is directly related to the length of storage. Losses are negligible for only a short storage up 2-4 weeks.

However, up to 50% losses by weight due to *Dermestes* attack have been recorded by many observers when unsalted dried fish is stored for about 6 months (Aref et al., 1965). During the field studies by the author, one batch of the unsalted product packaged in sealed polythene bag was found to be attacked by *Dermestes* beetle in a closed store room. First attack was noticed on the 44th day of storage and a 20% loss was recorded within the next 15 days. Other batches were unaffected till six months of storage under similar conditions, except that the final products were packaged in sealed polythene bag on the drying rack immediately after drying, while the former product (infested one) was kept open in basket at fishermen's home for several days before being packaged. The study suggests that infestation can be prevented if the product is packaged on the drying rack as soon as the drying is complete, giving no chance for the adult to lay eggs on it. However, there are also possibilities that the adults may lay eggs on raw fish before or during the drying process. In such case any suitable deinfestation treatment is necessary.

Within 12 to 40 hours of copulation beetle females lay oval-shaped eggs (1.3 mm long and 0.35 mm in diameter) in the cracks of the body wall muscles of the drying or dried fish (FAO, 1981). Laid eggs are hatched into larvae within 1-3 days at 25 to 35^{o}C temperature range (Paul, 1962). Beetle larvae differ from those of flies as they have a distinct head, 3 pairs of legs and the body is more or less hairy. The larva of Dermestid beetle is very hairy and at the posterior end of the body possesses two spines. The optimum temperature for larval development lies between 30 and 35^{o}C (Howe, 1965) and on an average, it takes 20 days for the larvae to pupate under favourable conditions. Under unfavourable conditions, however, larval period increases and number of moulding also increases. Cast (case of larval skin after moulding) are commonly found in infested fish. To pupate, the larvae burrow into the muscle tissue of dried fish. The larvae then become shorter, thicker and quiescent, and finally moult to become pupae. At favourable

conditions with temperature of 27°C the pupae are developed into adult within 6 days (Howe, 1965).

Application of pesticides in traditional dried fish

Various pesticides are often used in dried fish to control blowfly and beetle infestations. Most citable of them are DDT and *Nogos*. Both are banned for any use in Bangladesh. There is no control over the dosage used. The processors or labourers have no knowledge on pesticide action, dose limit and residual effects. For larger species in cloudy days pesticides are generally used in three stages:

i. just after washing before spreading on the rack;

ii. during the half-way of drying on the rack; and

iii. during storage in gunny bag or '*gola*'- a container made of woven bamboo mat.

The extent of pesticide use is sharply reduced in sunny days. If the storage time prolongs, processors check the condition of the stored products at certain intervals. If any further infestation is found, the product is treated with the pesticides again after a day of drying. In field level application during processing, *Nogos, Nuvacron, Endrin, Malathion, Dimacron*, etc. are popularly used, while in storage of the product, *DDT, Basudin* and *Malathion* are preferred ones. Most of the pesticides of first category and the DDT of second category are banned for any use in Bangladesh. Most of the cases, small fish are not treated with pesticides as they dry comparatively rapidly.

DDT (*Dichloro-dimethyl-trichloro-tetraethane*) is very extensively used both in the washed fish and stored products. In case of the raw material just after sorting and washing, DDT is used after dissolving some unknown variable amount (20 to 100 g) in little amount of water (10 to 15 litre). The solution is sprayed over the fish by a hand-sprayer. In case of the stored product, powdered DDT is sprayed over the fish in layers in gunny bags or '*gola*'. During

application people are not properly dressed and do not take any safety measures like wearing mask and gloves, etc. At first, 0.25-0.50 kg DDT is spread on the bottom of the *gola*. Then the dried fish is arranged in a layer of about 18 inches thick. Powdered DDT (about 0.25 kg) is spread on the fish layer. In this way, dried fish and DDT are kept in layers until the *gola* is full. Finally, a top layer of DDT is given and opening of the *gola* is closed by a mat made of bamboo.

Nogos (active ingredient- 1000 g *Dichlorovos* in 1 L) is used on fish spread on the elevated rack or hung on a bamboo frame. A small bottle of 125 ml labeled with producer's name (Novartis India Ltd.) is found in black market and applicable dose for crop and vegetables (10 ml for each 10 L water) is generally applied on dried fish with no concrete dose regulations. The price of a 125 ml bottle is Tk.73 in India, but the fishermen used to pay Tk.125 in Bangladesh in 2003. Generally, 1 full cap (10 ml) is dissolved in 8-10 L of seawater and the mixer is sprayed onto the fish.

Other organo-phosphorus compounds, *Nuvacron* (active ingredient: 400 g Monochrotophos in 1 L) from Novartis India Ltd. and *Basudin* (active ingredient: 100g *Diazinon* in 1 kg) are also used. Both *Nuvacron* and *Basudin* are permitted to control pests in crops and vegetables, but not allowed for direct application to foods. According to the processors of Kutubdiapara, *Nuvacron* is not as effective as *Nogos* to control blowfly and beetle infestations and hence its use is limited. *Nuvacron* is packed in 50 ml bottle and sold at Tk. 36/ in India and Tk.60/ in Bangladesh in 2003. The dose used to spray on the washed fish is as the same as that of *Nogos*. Due to lesser action, sometimes uncontrolled higher dosages are practiced. Generally, 100 g *Basudin* is applied to 100 kg dried fish in gunny sacks during storage. A 20 kg of dried fish is kept and a 20 g powder *Basudin* is spread over the fish. Again, another 20 kg of the product is put and a 20 g powder is spread over it. Similar to other storage with granular/powdered chemicals, dried fish and pesticide are kept alternatively.

Lethal and sub-lethal effects of pesticides

Use of unsafe pesticides and their excessive dosages in dried fish create serious health problems to the consumers (Khan et al., 2002). The level of DDT has been found to be 88.22 mg/kg in dried ribbonfish, 6.79 mg/kg in jewfish and 373.09 mg/kg in pomfret taken from Cox's Bazar (Khan and Khan, 1992), which are much higher than the FAO allowable limit of 0.5 mg/kg (Khan et al., 2002) or FDA approved tolerance, action and guidance level of 5 ppm (FDA, 1996) (Table 11.5). The DDT is deposited in the consumer's body in high concentration. Consumption of dry fish is more in Cox's Bazar compared to other districts. A study conducted on the dry-fish consumers of Cox's Bazar shows that a consumption of 27.09 g dried fish per day deposits a 1.3 mg DDT in the human body (Khan et al., 2002; Voumic, 2002). DDT deposition rate seems to be very very high, that needs further verification. However, the uncontrolled application of such unapproved insecticides in dried fish could be having serious consequences for consumers and dry fish processors/ labourers.

Table: 11.5 Tolerance limit[1] of pesticides used in dried fish

Trade Name	Active ingredient	Type	Application as per label on the bottle	Safe limit for fish[1]	
				ppm	Commodity
Endrine	Aldrine	Organo-chlorine	Crops, rice	0.3	All fish
Nogos	1000 g Dichlorovos/ L	Organo-phosphorus	Crops, rice, vegetables	0.25	Fish
Nuvacron	400 g Monochroto phos/L	Organo-phosphorus	Rice, jute, brinjal	0.25	Fish
Basudin	100g Diazinon in 1 kg	Organo-phosphorus	Rice and vegetables	0.25	Fish
DDT	Dichloro-dimethyl-trichloro-tetraethane	Organo-chlorine	Mosquito, insects	5.0	All fish

[1] Pesticide tolerance, action and guidance levels for food commodities approved by FDA (1996).

As stated before, the people using these potentially harmful chemicals are not equipped with protective clothing and other safety measures and do not understand the lethality of the chemicals they are using. The long term effects on the fishermen community are unknown but could be serious. Comparative analysis on prevalence of different diseases between the dry fish eater of Cox's Bazar and non-dry fish eater of Gaibandha showed that the prevalence rate of the diseases was more in the former district than the later (Sarker and Khan, 1997). Not a single pesticide is safe for health, but its extent of adversity depends on the nature of treatment, period of application and the dosages (Walker and Greeley, 1990). The effects are depended on the vaporization, dissolution and persistence characteristics of the pesticides. Generally organochlorine compounds are worst: persistency ranges from 7 to 15 years in nature. It deposits in fatty tissues and cellular lipids around the central nervous system. It prevents the ion flow in the tissue and disrupts the regular functions of central nervous system. Besides, the pesticides may restrict the function of an enzyme *acetyl-cholinestarase*, which is responsible for the transformation of nerve impulse within the nerve cells. The insecticides have immediate and long term effects in human health (Khan, 2002). Immediate effects include nausea, vomiting tendency, pain in lung, poor breathing, unconsciousness, etc. Cancer, liver damage, immature and ill-health child birth, pneumonia, heart attack, etc. are some of the long term effects.

Use of salt in dry fish

A pretreatment of salt is done in the fish during sun-drying. The amount of salt, however, does not exceed 3-7% of the raw fish in plain dried product (salt-free). People prefer the products that contain little or no salt. But in cloudy or rainy days fish require to be treated with 15-30% of salt. The excess salt adhered to the body surface is, however, removed from the fish before sun drying

through adequate washing. Small amount of salt makes the texture compact, reduces the effects of contamination, destroys some of the bacteria and helps release water from the fish so that drying becomes easier and quick. Salt also increases the weight of the dried products. Salt has a good access to the protein of fresh fish (Niwa, 1992). However, in most places, semi spoiled or low quality fish is partially salted before drying, aiming to keep the quality of the dried product by shortening of the drying period and minimizing further spoilage by fly infestation. The goal is partially achieved because the drying period is reduced and the salt is kept inside the muscle by getting dissolved at higher rate in high content of interstitial fluids those results from the drip due to self breakdown of muscles. Therefore, in practical situation, salt uptake is more in spoiled fish compared to fresh fish. Some of the salts enter inside the muscle, however, may be lost again as higher drip in early stages of drying (Nowsad, 2005a). It is, therefore, obvious that the salt uptake and release in spoiled fish are governed by the drip, not by the native nature of protein.

Benefit of salt application

1. Small amount of salt (5-8%) hardens the fish, reduces contamination, kills some of the bacteria and removes water from fish body so that drying become easier and quick;
2. Salt increases the weight of dried fish;
3. Salt protects the raw materials against spoilage;
4. Salt softens the texture and improves flavour of the product;
5. Salt eliminates odour from the product;
6. Salt deters insects, kills the eggs and larvae of insects and thus reduces insect infestations;
7. Salt quickens sun-drying as it removes water.
8. Salt up-take and concomitant water removal is higher in spoiled fish. Thus salt can camouflage the quality by bringing changes in the texture and flavour of spoiled fish.

Types of salt to be used in dried fish

In coastal areas, generally low-cost black solar salts (NaCl) contaminated with sand, mud, debris, bacteria or other marine salts are used in fish drying. For good quality dried products -

1. Clear and contamination free solar salt should be used;
2. Black salt mixed with clay or mud should not be used;
3. Coarse granular salt is better than fine salt. Fine salt hinders the water removal from the fish body as it quickly removes surface moisture, making the texture of body surface hard. Therefore, inner moisture often finds it difficult to diffuse out through the hard body surface.

Problems associated with traditional processing

i. Sun-drying of fish is performed mainly by traditional methods. Artisanal processors have serious lack of knowledge on process, sanitation and public health.

ii. Traditional sun-drying is absolutely dependent on the climate. Drying needs more time when the air is humid. Due to the influence of monsoon, the relative humidity of the air is higher in 4-5 months of the year. It is the biggest constraint of absolutely climate-dependent process of sun-drying.

iii. Species selection is not accurate. Fatty fish are more often sun-dried due to their abundance and low price. All species cannot produce good quality sun-dried products. Fatty species are very prone to oxidative rancidity even if drying is done very carefully. There is a tendency of fishermen to dry whatever they catch. This can not keep the quality standard of the products.

iv. Most of the times spoiled raw materials are used.

v. Fish used for drying are not properly handled on board vessel and after landing. Due to depleted stock and reduced catch size, estuarine and marine set bag nets (ESBN and MSBN) are the principal gears used to catch fish for drying. Hauling of MSBN is

done every after 5/6 hours since it is dependent on the change of the direction of water flow (high-tide and low-tide). Therefore, fishes entrapped in the cod-end undergo serious stress and become susceptible to spoilage. After hauling immediate icing is not done on board vessel. Moreover, these gears can catch almost every fish, from a centimeter to several feet in length, which pass through it. Except some larger commercial species, the rest are treated as 'lot' for the raw material of sun-drying. These are not generally sorted and washed before icing. Injured or damaged fish and that with torn up muscle or abdomen are not removed. This starts contamination from the very beginning of the process. In day-fishing boats, icing is not done at all. In motorized boats, icing is insufficient. Moreover, the raw material for sun-drying is handled as a second class item during hauling, loading in the fish chamber and unloading.

vi. Fish is not adequately washed and dressed before drying. This problem is very much associated with the small fish, which are sun-dried by spreading on the mat or concrete floor without washing, sorting or dressing. Adhered blood, slime and juice from the rotten abdomen contaminate the entire lot and thus deteriorate the quality.

vii. In on-shore landing sites, landed fish is first kept on bamboo mat on the sand and then transported to the drying yard. In case of small operation, the fish is brought to the fisher's house. In either case, fish is kept on the sand or soil for sorting and salt pretreatment. This is another critical step that opens the avenue for raw material contamination.

viii. In many cases proper cutting utensils are not used. The utensils like bucket, basket, mat, knife, etc. are not washed and cleaned before use. Therefore contamination occurs.

ix. In small-scale operation, sun drying is accomplished by spreading fish on the sand, mat or concrete bed. The fish are contaminated by dust or sand and pathogens. Even those kept on mats or concrete beds are likely to be contaminated by the dust kicked up when people walk across. It is also very difficult to protect such fish from rain water on the ground.

x. Due to inappropriate handling of fish or other reasons, sometimes a characteristic pungent flavour is developed in the dried products. This flavour persists in the fish even after cooking.

xi. Traditional dried fish is very hard. It does not reconstitute upon soaking for long time or even after cooking at high temperature. Although this hardy texture is not popular to some of the people of the country or to the international consumers, coastal and ethnic people highly prefer this special texture.

xii. Traditional dried fish becomes blackish due to inadequate process and spoiled raw materials.

xiii. Due to long time exposure to sunlight, nutrition is lost in the form of drip-loss.

xiv. If not properly dried, the moisture content does not go below the prescribed level (15-16%) in the product. High moisture level deteriorates the product quality and storage ability by facilitating the growth of bacteria, mold and yeast.

xv. In traditional drying, sometimes the fish that cannot be sold as fresh fish in the market are sun-dried. This specially happens in small-scale operation where due to scarcity of capital, the fishers take the option to purchase low quality raw material. Fish harvested by the country boat in day to day operation sometimes takes 8-10 hours to land. These small boats do not carry ice. In hotter months, this catch is more frequently deteriorated and sold at lower price. With the products prepared from spoiled fish, dishonest businessmen deceive the buyers, since it is apparently difficult to distinguish the quality of dried fish produced from fresh or spoiled raw materials. This mal-practice threatens the public health and sanitation seriously.

xvi. Fish is dried in open space. Therefore, contamination by bacteria and molds may occur. On the other hand, in most cases, fish is dried on the sand, dykes or embankments. These may serve as the sources of bacterial contamination. In improved cases, traditional mats made of split bamboo are used in sun-drying. These mats are not washed after each operation but kept outside where dogs, cats or other animal may graze. The solar salt used for pretreatment is of

low quality with lots of impurities and contaminants. These all provide the basis for contamination in traditional dried fish products.

xvii. The people engaged in sun-drying do not have minimum knowledge on public health and sanitation. They may carry pathogen, dust and dirt. They do not have knowledge on appropriate handling of fish. Therefore, fish is spoiled during the process; the product is contaminated and becomes unsafe for human consumption.

xviii. Due to long time exposure to the air, oxidative rancidity occurs in sun-dried fish irrespective to the lipid contents. Obviously, the rate and extent of rancidity will be higher in high-lipid fish.

xix. Indiscriminate use of unsafe insecticide is a serious threat to the public health of the country. Some serious health-hazard organo-chlorine compounds like *Nogos, DDT, Diaginon,* etc. have been used at uncontrolled doses during the process and storage to avoid blow-fly, mites and beetle infestations. The residual effects of such organic compounds in human organelles are well known.

xx. The finished products are not properly packaged. It is exposed to the air all along the marketing chain so that contamination and deterioration of the quality happen.

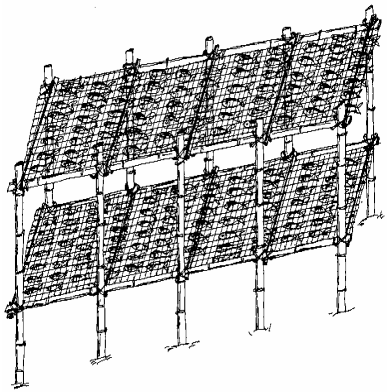
xxi. The dried fish is stored in improper and unsanitary ways. Dried fish is generally stored in spherical or square container made of woven bamboo mat, locally called *"gola"*. Sometimes it is stored in gunny sacs made of jute or plastic or in bamboo made baskets. These devices are vulnerable to environmental and biological conditions. For example, easy access of air helps develop rancidity, moisture absorption, infestation and contamination. The beetles and mites can easily come across to infest the products. Therefore, the quality deteriorates and the producers suffer from great losses. To minimize the loss, the fishermen use health-hazard insecticides that put the public health situation of the country in real danger;

xxii. Sun-drying is a lengthy process. Therefore, the quality of the product deteriorates in different steps.

Improvements of traditional sun-drying

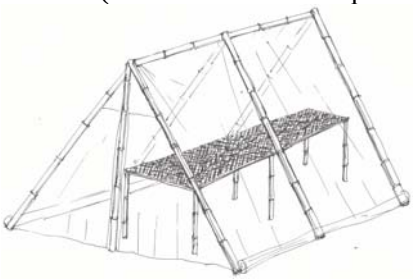
For the improvement of sun drying in Bangladesh, high cost-involved sophisticated equipment based technology is not required. Much of improvements for good quality products and higher storage life can be achieved by developing practices for maintaining proper sanitation and hygiene in processing area, protecting contamination and introducing adequate packaging. For improved quality dried fish, easy operable low-cost solar dryer can be constructed with cheap locally available materials. Production details of dried fish using solar dryer has been given in the next pages. The actions to be taken for the improvement of traditional sun-drying process have been discussed below:

- Traditional fishermen and processors should be trained up on improved sun-drying, sanitation and public health.
- Premium quality fresh fish should be used for drying. Spoiled fish those are unsellable in the market as wet fish should be rejected.



- Good handling of raw material on board fishing vessel should be ensured.
- Potable water should be used for washing of raw material.
- Clean space and containers should be used during landing and pre-processing.
- Use of clean mats, racks and cutting knives should be ensured.
- Each and every utensil should be washed after each operation.
- Elevated multi-staged or plain racks made of split bamboo or used fishing nets should be used for fish drying. Larger fish should be hung on the bamboo frame. Racks can be covered by nets to protect fish from flies, insects and birds.

- Use of insecticide in fish drying should be stopped completely.
- Product can be made soft and tender by soaking fish in brine or keeping several hours with good quality contamination-free solar salt (8-10% salt with adequate icing for 6-8 hours).

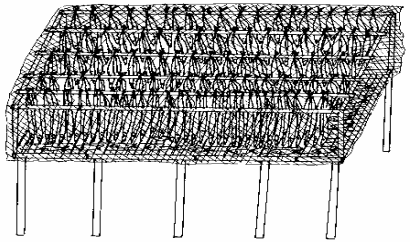


- Fish should be dried adequately to lessen the moisture content below 16%.
- To protect it from insect infestation a mixture of red pepper and turmeric can be used in dried fish. To protect fish from blow fly infestation box tunnel placed on elevated racks can be covered with mosquito nets. A devise developed for this purpose can be used (picture in the next page). Fish can be hung on bamboo bar in the covered box tunnel at night. This can restrict the entry of blow flies and other insects inside the tunnel. Blow flies can not see and move at night. As the fishes are hung on the bamboo bar in the box tunnel, they do not require turning up at regular intervals. This new process eliminates the chance of entry of flies. In small scale operation, fish can also be dried in solar tent drier (top picture).
- Dried fish should be packaged on the drying rack as soon as the drying is complete. If it is done so, adult beetles and mites will not get chance to lay eggs on fish. Dried fish must not be kept open or exposed in the room or store house. Packaging of dried fish should be done with appropriate packaging materials. Products should be wrapped by good quality polythene coated with polystyrene or polypropylene to avoid blackening and rancidity.
- Dried fish should be stored in a hygienic cool and dry environment.
- Appropriate and affordable measures can be adopted in drying fish during off season (like salt-dehydration, boiled or broiled dehydration, in-house solar energy operated mechanical drying, etc.)

Construction of box and ring tunnel to dry fish

1. Box-tunnel:

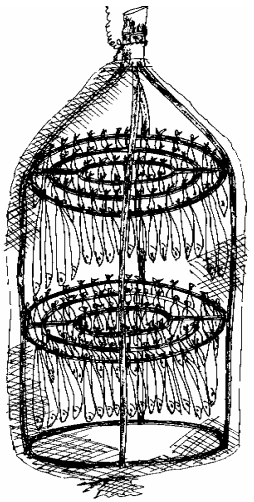
Construct a 20 x 4 x 3 feet high rack made of bamboo or wood or angle-iron. Fix a rhomboid shaped sloping tunnel (rear legs are 2.5 feet and front legs are 2.0 feet high) on the rack. Place several parallel bars along the long axis at the roof of the tunnel to hang fish. Sloping tunnel allows more sunlight while increases internal space for drying.



After hanging fish at night or before dawn, the entire tunnel is covered by mosquito net. The flies do not come in contact of fish during hanging, as they can not see in the dark. Turning fish at day time is not required as the fish are hung over the bars. This reduces a 10-15% labour cost.

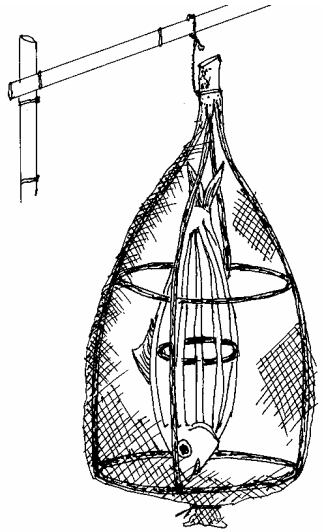
2. Ring tunnel:

A 5-6 feet long piece of bamboo is torn into 6 to 8 shreds of equal size, keeping a rear-end of the bamboo untorn. Several rings (outer rings) made of split bamboo or iron rod are tied up inside the shreds at regular distance to give a shape of a robust torpedo. Three to four rings of descending diameters (inner rings) are fixed after each of the outer ring inside the tunnel to which the fish are hung over. In case of drying small fish, inner rings are replaced by round thin-meshed sieves made of split bamboo. Small fishes are spread on these sieves inside the tunnel. The tunnel is covered by mosquito net and itself hung over a bamboo bar. Ring tunnel is found



effective in drying Bombay duck, ribbon fish, carp, pomfret, jewfish, etc. in both house-hold and small-scale commercial operations.

A tunnel with a 2-step outer ring having three inner rings after at each step costs about Tk.70-80 and can dry a batch of 20-25 kg Bombay duck or ribbon fish.



An improved process of fish drying

An improved drying process has been designed to maintain a definite time schedule so that the pre-processed fish can be hung on bamboo bars of the covered box tunnel at night and the fish are not required to turn up any more during drying at day time (Nowsad, 2005a). This has reduced the chance of entry of blow flies in to the tunnel, as they can not see and move in the dark. The following steps can be followed.

- ♣ Purchase fresh fish in ice at around 2:00-3:00 pm and keep in ice until further processing;
- ♣ For icing of fish use low-cost icing devise developed and introduced among the fishermen and processors of coastal area (chapter 8)
- ♣ Sort out the fish and remove the spoiled or torn-belly one;
- ♣ Gut the bigger species like jewfish, tasselfish, pomfret, catfish, etc., remove their gills and scales and finally, wash with clean water;
- ♣ Split the lateral muscle if the fish is thick (ribbon fish, jewfish, mackerel, etc);
- ♣ Wash thoroughly with clean seawater or tube well water. A 5-10 ppm chlorinated water may be used. A low-cost but effective sanitizer, chlorine dioxide (ClO_2) at a concentration of 0.2-0.5 ppm can be the best wash water;

- ♣ Mix with 10-12 % clean salt, ice the salted fish in ice box, perforated tank or containers covered with insulating material. Keep the fish iced and salted for 10-12 hours at night. This amount of salt and salting schedule will not make the product salty, but improve the texture and flavour of the product. Besides, it will prevent insect infestations during process and storage. Bombay duck can not be salted much. A 2-3% salt for a shorter duration (1-2 hours) is advisable. Bombay duck should be processed immediately;
- ♣ After salting wash the fish by soaking into a cemented tank for 1-2 minutes;
- ♣ Keep the washed fish on elevated rack or perforated trays at mid-night to let the surface water drain out completely;
- ♣ Do not use any pesticide. To protect fish from bacterial or mold contamination, sprinkle 0.2-0.3% calcium propionate powder on the moist fish (200-300 g powder for 100 kg fish);
- ♣ Red pepper and turmeric have pesticidal effects. These spice powders, at a rate of 1-2%, either mixed or separate, can be added inside the abdominal and gill cavities and on the body surface;
- ♣ Hang fish on parallel bamboo bars of specially devised box tunnel developed for small-scale fish processors of coastal region (picture). This is a 20 x 4 feet elevated rack made of bamboo or wood. On the rack, a rectangular slopping tunnel is placed. The tunnel is so shaped to increase effective light penetration area and allow uniform sunlight for all fish hung inside. Several parallel bars are arranged along the long axis inside the tunnel on which fish are hung. The entire tunnel is covered with fine mesh mosquito net. Fish should be hung before sunrise to avoid the entry of blow flies. As the fish are hung on bars, they do not require turning up at regular intervals. After adequate drying, dried fish should be taken for packaging directly from the tunnel.
- ♣ Ring tunnel developed for small-scale fish processors can also be used for fish drying. Very large fish, like mackerel, tuna, tailla,

etc. can be dried inside of the structure by covering a single split fish with mosquito net. For drying of smaller fish those can be hung over, like churi, loitta, jewfish, etc., several rings of descending diameters (3-4 rings) can be arranged one by one in two or three steps inside the tunnel structure. For drying very small fish like punti, katchki, etc. several spherical sieves made of bamboo-split instead of ring can be used. The structure is covered with mosquito net and hung on strong bamboo pool and bar (see picture). Turning up is not required and the dried fish shoul be taken directly after drying is complete.

- Check the dried fish one by one for any spoiled or damaged product and remove. After cooling pack them from the tunnel in polythene pouch or bags to avoid any cross infestation by beetles and mites. Covered plastic drum can also be used for temporary preservation (for only several hours).
- Cut the dried fish into adequate size on clean table and pack in good quality air-tight consumer package (polyester-polyethylene co-polymer or polypropylene coated polythene) immediately so that beetles and mites can not come in contact of the products;
- Store them in clean, cool and dry room.

Control of beetles and mites in dried fish

During the storage, dried fish is attacked by small hairy larvae of a small insect – beetle, locally called "*Kaissha poka"*. The adult *Kaishha poka* is about 0.5 – 1.0 cm long, which are easily found in the corner of the house and dark calm areas, or in the shade, here and there in unclean places. They have several thousand species. Adult can fly a little, but run fast. During or after fish drying, adult come across the fish and lay eggs in the gill, eye or oral cavity, in the cracks of body wall or back bone. Laid eggs are hatched into larvae within 1-3 days at congenial temperature (25^{o} to 35^{o}C temperature range). But if the temperature does not suit, eggs can stay 15 to 35 days for hatching. The larvae feed on dried fish. Within a very few

days (5-10) they can eat upon all the lots, if not interfered. This *Kaissha poka* is a real problem for the storage of unsalted dried fish. However, it is not difficult to control them or limit the extent of damage. They can be controlled completely if appropriate measures are taken in time. Some of the control measures are discussed below:

i. First, we should remember that it is an insect and as an easy and available means, insect needs pesticides for its complete control. However, we should not use pesticide in dry fish due to its serious negative effect on human health. The first and fore most tasks would therefore be, not to allow the raw material or products to be exposed to the insect or not to allow the insects to come in contact of dried fish. Maintaining increased cleanliness, proper sanitation and hygiene in sorting and preservation of raw material fish and in processing will substantially reduce the chance of infestation. Drying should be done in elevated racks covered by mosquito net, covered tunnel or trap where the adult insect can not enter. Dried fish should be packaged from the drying tunnel immediately after drying. In no way, dried fish is kept open during storage or retail sale. After trimming and cutting into adequate size, it should be packed in adequately sealed air-tight pouches immediately. Whole dried fish can be preserved in sealed/covered plastic drum.

ii. Salt can deter insects. *Kaissha poka* can not attack heavily salted (salted dried) fish. In case of unsalted product, a pretreatment of fish with 10-12% salt for 10-12 hours (improved process suggested) can reduce infestation. If adhered salt of the body surface is washed by dipping, this amount of salt will not make the product salty, but make a good textured high quality flavoursome dried product. To get rid of insects and health hazard insecticides we may also shift our food preference from unsalted to slightly salted, semi-salted or salted dried fish.

iii. Red pepper and turmeric have insect and bacteria repealing characteristics. Small amount of these spices (1-2%), separately or

mixed, can be administered to the fish during drying. This can produce products of new tastes. Spiced-dried fish can be preserved for long time.

iv. In case of commercial production, two measures can be taken: one is refrigeration storage and the other is irradiation of products. Dried fish can be stored in cold storage (3 to 5^{o}C). In adequate refrigeration storage insect and larvae will die off and the eggs will not fertilize. Another easy application is short term freezing of packaged product. If adequately packaged dried fish is frozen at –25^{o}C for 2-3 days before marketing, all adults, larvae and eggs of beetle and other insects will die off. This will completely eliminate the chance of insect infestations for ever. Care should be taken, however, to check absorption of moisture while taken out from the freezer. Although expensive, the freezing of dried fish before marketing can be done for greater security of products in affluent markets and can be used as an important part of the processing of dried fish for health conscious people.

v. The most effective means of eliminating insects and pests from dried fish is irradiation. It is a physical method of food preservation that involves exposing the dried fish to ionizing radiation, a most familiar form is the X-ray or gamma ray. In commercial application, Cobalt 60 emit gamma ray have strong penetrating power and is consequently used to treat bulk items like pouches or sacks of dried fish. Dried fish can be irradiated within final packaging as the process generates very little heat. This reduces the chance of reinfestation. The standard unit used for the measurement of radiation dose is Gray (Gy). A dose of 1 Gy is the absorption of 1 J of energy per kg of food. The unit is generally expressed as kGy, equivalent to 1000 Gy. At dose up to 1 kGy, insects infesting dried fish can be destroyed. Dried fish with a moisture content of 20% or below, a dose of 0.15 kGy can prevent insect larvae from developing into adult; at 0.25 kGy, the larvae

survive but stop feeding. For moisture levels of 20-40%, a minimum dose of 0.5 kGy is recommended to control damage by blow flies and beetles (Clucas and Ward, 1996). For bacteria and moulds, however, higher doses are required. It is essential that the dried fish is appropriately packaged and kept airtight to prevent further infestation. In contrast to chemical pesticides, irradiation leaves no toxic residue in food.

vi. De-infestation of dried fish can be achieved by fumigation, for example by vaporizing a toxic liquid in an enclosed environment to kill insects. Phostoxin and methyl bromide can be used for fumigation of dried fish. Fumigation should be carried out in an enclosed fish store or under gas-proof sheets in order to ensure a complete de-infestation of stored products. Prescribed dose is 24 g methyl bromide per cubic meter space for 24 hours period. Phostoxin is more effective than methyl bromide at a dose of 0.2 to 0.5 g per 50 kg fish for 2 days treatment (FAO, 1981). Since the chemicals used for fumigation are toxic to human, extreme care is necessary when fumigating any products. Experienced and trained personnel should carry out the process and careful protective measures should be taken. If effectively done, however, residual effects of fumigants are very less in dried fish compared to any pesticide application. Although in lesser quantity, these residues are toxic to man.

vii. Insects in dried fish can also be killed by heat treatment, for example treating dried fish in the mechanical oven, or use of solar drier for drying. A 40 minutes treatment at 70^{o}C can kill all insects (Szabo, 1970) although some beetle larvae are killed by exposure to 50^{o}C for 15-20 minutes (Proctor, 1977).

viii. Dried fish can be packed with intact *neem* leaves or *neem* powder. In such case the product may have a little bitter taste or changed colour, but *neem* can definitely deter insects.

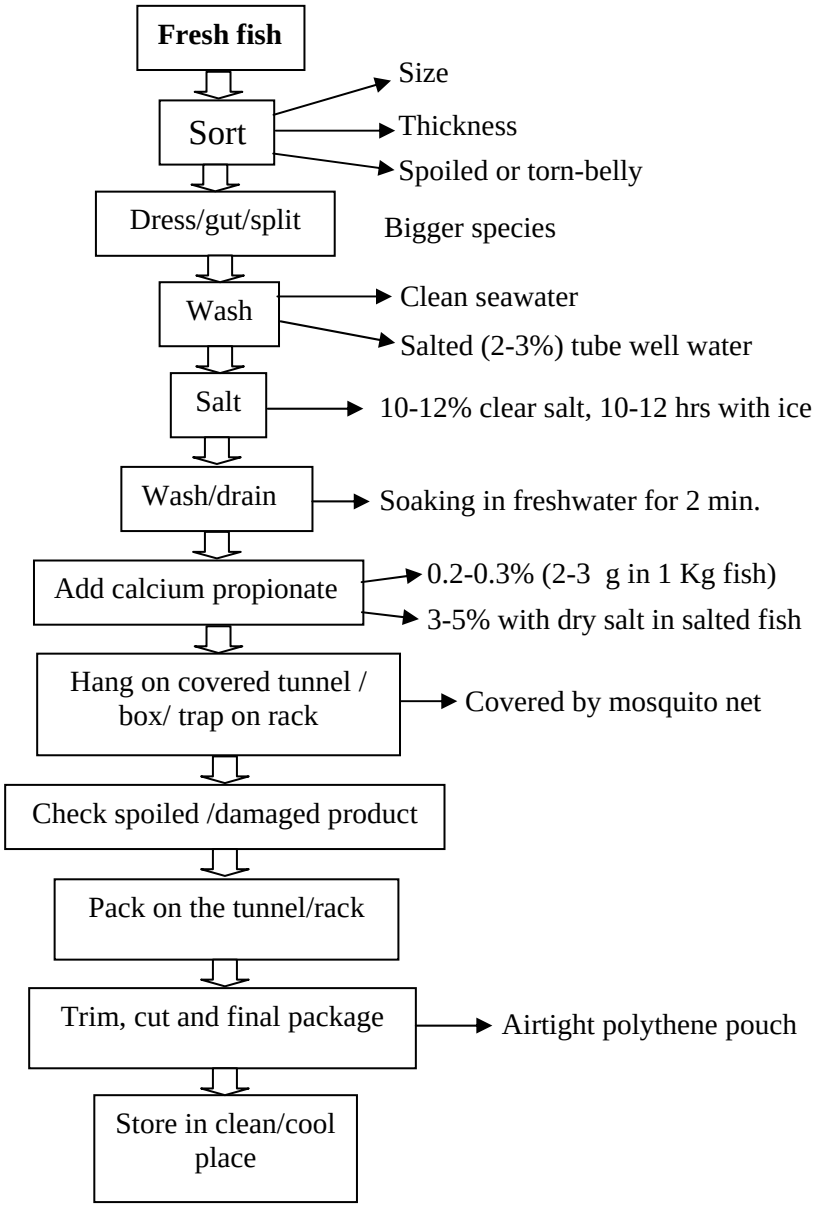


Fig. 11.3. Scheme for the preparation improved quality plain dried fish

Salted-dehydration of jewfish

Fish drying factories in Nunierchara of Cox's Bazar and Zingira of Teknaf generally process salted-dehydrated jewfish (poa, lal poa, choto poa, kala poa, etc.) and four thread tassel fish. The products are mainly exported to Hong Kong, Singapore and other Southeast Asian countries. Most of the factories operate on seasonal basis, depending on the availability of fish. Peak operation continues from April to October.

Salted-dehydration process

The jewfish to be used for salted-dehydration are mainly caught by hook and line, but seldom by marine set-bag net. The quality of raw material is good as the fish remain in adequate ice on board vessel for 4 to 8 days depending on the voyage. As soon as the fish is received, the abdomen is cut longitudinally along the ventral line from the anal aperture to the gill opening through the middle of the paired pelvic fins. The gut, air bladder, kidney tissues and gills are removed. Air bladder is processed separately. The dressed fish is thoroughly salted by solar salt: salt is pressed inside the abdomen, gill cavity, mouth and eyes and the fish is kept inside the salt in a wooden box for several days for ageing or maturation. Maturation depends on the freshness and size of the fish and season of operation. Fresh fish matures more quickly than the spoiled fish because of molecular binding of salt ions with oppositely charged protein molecules. Salt penetration is less in spoiled fish since the already degraded proteins can not bind salt ions. However, drips as a result of autolysis in the interstitial space may receive some salt in the spoiled fish but this does not contribute to the characteristic texture formation and flavour development of salt-matured fish. Maturation time is longer in

winter compared to hotter months. Generally, lal poa *Johnius argenteus* (200-500 g) needs to be kept in salt for 3 days in winter but 1-2 days in summer. Tassel fish *Eleutheronema tetradactylum* (3-4 kg) needs 10 days, while kala poa *Johnius diacantus* (5-10 kg) needs 15 days for maturation. The extent of maturation can be understood from the physical characteristics of the muscle of salted fish. Under full maturation, the muscle becomes soft and tender: it depresses under finger pressure. On the other hand, the fish in incomplete maturation remains hard and if pressed on the skin, the muscle swells up nearby.

In the pH of pre-rigor fish muscle, myofibrillar proteins loosely bind one another through oppositely charged NH_3^+ and COO^- ions, called salt-linkage (Niwa, 1992), which is insoluble in water. When sodium chloride comes in contact with the charged myofibrillar proteins, the intermolecular salt linkage is ruptured since the Na^+ and Cl^- ions bind the oppositely charged protein molecules. Because of increased affinity of protein molecules towards sodium chloride, this structure becomes soluble in water, which might be the reason for making the fish muscle soft and tender due to salt treatment.

After maturation, the fish is scaled and washed thoroughly with freshwater. For washing, salted fish are dipped into a concrete tub while agitating frequently to remove all excess salt. The fish are transferred to two more tubs to ensure effective washing. In each tub, fish is kept for 30 minutes. Washing time and frequency of washing depend on the amount of salt uptake by the fish. Generally, premium quality fresh fish holds more salt. After 3rd washing, the fish is transferred to a 4th tub where the fish is dip-bathed for 5 minutes into a solution of a powdered chemical (might be an insecticide), which the local processors named “medicine”. The chemical is used to protect the products from blow fly, *Dermestes* beetle and mites infestations as well as microbial contaminations during the process and storage. The chemical is unknown to the local processors as the foreign technicians are reluctant to disclose the active ingredients. However, ants and cockroaches were observed to

be died off by the application of such chemical collected from a factory of Teknaf. Foreign technicians closely monitor the drying process. More or less a similar dosage (about 1 g chemical in 10 L water) is used in all processing factories. After a dip-bath in such chemical solution, the fish is spread over the trays made of bamboo for sun drying. A complete sun drying requires about 4-5 days in winter and 5-6 days in summer. After drying, the fish is kept in a wooden basket and transported to Cox’s Bazar from Teknaf or other remote places. After sorting, the product is packed in polythene-polypropylene bag and then finally packaged in wax-coated card board master carton for shipment.

Sorting, grading and shipment of salted dehydrated fish

Sorting is done on the basis of the size and quality of the product. Foreign technicians cross check all processing, sorting, packaging and quality evaluation steps. The salted dehydrated fish are sorted and graded on the basis of size as follows:

i. L (No. 1)
ii. M (No.2)
iii. S (No. 3)
iv. S (No. 4)
v. S (No. 5)
vi. S (No. 6)
vii. X
viii. XX
ix. XXX and
x. ‘0’ for not packaging

Under such grading system, the products up to 8 grades are exported. The last 2 grades are sold in the domestic market.

Fish drying in solar fish dryer

What is solar dryer?

Solar dryer is an environment friendly technology operated by renewable energy where sufficient heat is generated from the sunlight to dry agricultural goods. There are several designs of solar fish dryers. However, to construct solar dryer for large-scale drying of fish, a long tunnel kept on long elevated rack is covered by polythene. One forth of the tunnel inside is covered with a black painted steel sheet to generate heat. Rest of the space is used for spreading fish. To expel out hot and moistured air from inside one or more fans run by solar cell are used. High heat and air flow help fish to dry quickly.

Benefit of using solar dryer in fish drying

- It is an environment friendly hygienic process of fish drying operated by renewable natural energy;
- Fish can be dried very quickly. Drying period can be reduced by 1-2 days from that of the conventional methods;
- High heat generated inside can kill insect eggs or larvae, so chance of insect infestation is less;
- The product is completely dust and sand free since covered by polythene;
- High nutritional and keeping qualities are ensured.

Background of developing a new solar fish dryer

One of the problems markedly evident in traditional sun drying is the contamination of raw materials and products during different stages of handling, transportation, sorting, processing and marketing. Traditional sun drying is done in open space, either on earth/mats or on racks, those serve as the basis of contamination by sand, dust, bacteria, molds and insects. Lengthy traditional process further deteriorates the quality. For the products of required quality

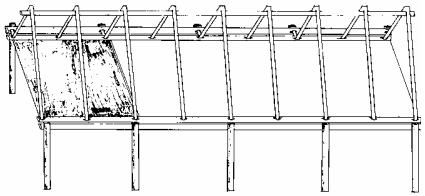
introduction of a suitable solar dryer has been thought to be an alternative. However, an effective model of such dryer is required to design and develop considering the common men's accessibility, operational/technical suitability, output quality, commercial viability, economic sustainability and social acceptability. A tunnel type *Hohenheim* solar dryer developed in Germany was field tested in Bangladesh in order to assess its suitability in drying of mangoes, pineapples and fish (Bala, 1997; 2000; Bala and Hossain, 1998; Bala and Mondol, 2001). The cost of the drier is extremely high for both large- and small-scale operations. A tunnel structure of about 60 feet long, that can dry a maximum of 150 kg fish at a time, requires about Tk. 80,000/- to construct. This seems to be very costly to compete with a traditional elevated rack in commercial *Killa*-based fish drying operation that can dry as much as 400 kg fish at a time within the identical time period, but costs about Tk.2000/ only for its construction. The cost of solar dryer can be reduced by improving the design and using locally available cheaper materials. It is only then the coastal fishing community can afford and implement the solar drying techniques as a viable and sustainable means over traditional practices. A major problem in the dried fish in such *Hohenheim* type dryer is *case hardening*, where the outer surface of the fish is heavily dried and burned out but the inside tissue remains soft and un-dried. This mainly happens due to excessive heat generated inside the tunnel for slow passing out of highly moistured air. In spite of the use of two fans for this purpose, the *case hardening* problem was repeatedly noticed at every operation both in the field and laboratory. All these issues need to be properly addressed during designing a suitable solar fish fryer.

Development of a low-cost solar dryer

The works done so far on solar fish dryers in different countries have yet to demonstrate consistent advantages over conventional sun drying in a commercial situation (FAO, 1981). In the ECFC project of FAO in Bangladesh a low-cost solar drier was developed through

participatory stakeholder-based approach with locally available low-cost materials, which accelerated the drying process, improved the quality of the products and eliminated the need for insecticide use (Nowsad, 2003).

The design consists of a relatively simple bamboo/wooden structure with a total cost of around 2,500 Taka. A platform is constructed 3.5 feet above the ground. This platform is made either of wood, bamboo or steel and is 4 feet wide by 20 feet long. On the top of the platform, a further steel or bamboo frame tunnel is constructed. The tunnel is triangular in cross section, the base being 3.5 feet with a short upright of 18 inches at the back and the long slope (1:2.5) downs to the front up to the base of the tunnel.

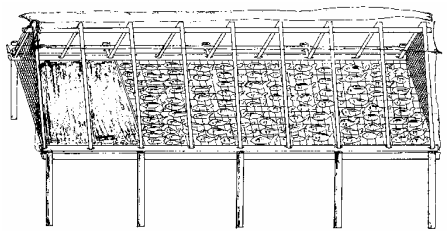


On top of one end of the platform, a galvanized iron sheet, painted black, is laid. In the case of the 20-foot long platform, this covers 4 feet of the surface. This black surface is designed to act as heater for air being brought into the drier and so is sited at the end that is catching the prevailing wind. The remaining length of platform is covered in split bamboo mats to take the fish for drying. Polyethylene sheet is wrapped around the triangular frame covering it on top, under the platform and up the back. The sheet is tied for strength to further bamboo poles and held down to the frame with fishing twine. The two ends of the resultant triangular tunnel are not covered with polyethylene but with fine mesh mosquito net to allow air entry but stop entry of flies.

Efficiency of new solar dryer

Getting sufficient heat inside, the solar dryers used for drying fish in tropical region is not very difficult. It may happen, if not handled carefully, that temperature goes rise to 60^{o}C or high at zenith sun or soon after. Fish flesh denatures at 60-65°C due to the

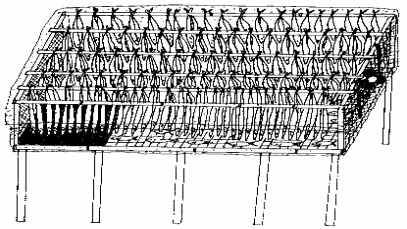
activation of some protease enzymes in the muscles. Therefore, it is important that the temperatures during drying do not reach 60^{o}C interface. Cooked at such temperature and then dried product has a brittle texture but different flavour compared to plain-dried fish. Brittle products are difficult to transport and store and less acceptable on the market. The new solar dryer is able to achieve temperatures between 50°C and 55°C relatively easily. The temperature does not rise further in sunny days due to several windows covered by the mosquito nets can be operated at hot hours. It may be, however, possible under the conditions of more higher temperatures (during May, June, July, August, September) to dispense with the galvanized iron sheet heat absorber in the base of the dryer that still obtain acceptable temperatures. Removing heat absorber would reduce costs further. It will also free up additional space inside the drying tunnel for fish.



Successful design of a solar dryer depends on the device that ensures easy movement of air through the tunnel for the removal of highly humid air produced from moisture coming from the fish. As it is shorter in length (20 feet) and the rear triangular ends of the tunnel are open with mosquito nets and is oriented to air direction to allow most of the prevailing wind to enter, the present device does not encounter any major problems of adequate air movement through the tunnel or any condensation inside at the initial stage of drying. Shorter length allows a shorter distance for air movement before expulsion from the drier and in addition allow more flexible operations. Depending on amount of fish to be dried, 3-4 dryers with a total construction cost of Tk. 12,000 to 15,000 can be used side by side. The support poles are not buried into the ground but resting on the ground surface so that the platform could be oriented as per wind direction. This facilitates air to enter through one end and escape through the other.

Design further modified for more effective operation

To make this low cost solar dryer more effective in operation, some modifications have been made. Triangular tunnel on the top of the rack has been replaced by a rectangular/rhomboid sloping tunnel. From the roof of the rectangular tunnel, a series of parallel bamboo or iron-rod bars are arranged along the long axis of the tunnel on which fish are hung. Due to this hanging arrangement, fish are not required to turn up at day times. Keeping the other conditions same, provision of a small fan is kept for acceleration of air flow where natural air convection is less. Depending on the requirement of temperature inside, number of black iron sheet can be adjusted. Instead of iron sheet, black polythene sheet can also be used. This modified design has reduced the chance of entry of flies and other insects. It has also reduced the brittleness of muscles due to cooking on contact surface of fish. One of the problems with solar dryer is cooking of muscles due to excessive moistured hot air generated inside at the initial stage of drying. This mainly happens if spread fish are not turn up at regular intervals. This problem is solved as the fishes are hung on the roof bar. A sloping roof is constructed to allow more sunlight to enter at uniform fashion. Thus quality of the products is further improved by this modified design.



Process at a glance for drying of fish in solar dryer

Following steps can be followed to obtain good quality solar dried products:

- ♣ Use premium quality fresh fish;
- ♣ Dress, scale, eviscerate and bleed fish, if necessary;
- ♣ Wash fish thoroughly with salted (2-3%) tube well water or clear sea water;

- ♣ Add 10-12% dry clear salt and keep fish in ice for 8-10 hours. In case of Bombay duck, however, amount of salt and pretreatment period should be much less. It is better to initiate drying of Bombay duck as soon as possible. A 2-5% salt can be added in this case.
- ♣ Wash by soaking into clean tube well water for 2 minutes;
- ♣ Drain water and let the surface moisture dry in elevated rack for 2-3 hours;
- ♣ Do not use any insecticide. To protect fish from bacterial and fungal contamination, sprinkle 0.2-0.3% calcium propionate powder on the fish (200-300 g powder for 100 kg fish);
- ♣ Rub turmeric and/or chilly powder depending on the product;
- ♣ Hang fish evenly on the parallel bars of the tunnel at night or before sun rise so that no flies can enter;
- ♣ Check the insulation of the dryer is working well, take corrective actions;
- ♣ Check any condensation of moisture inside the polythene sheet;
- ♣ Always orient the tunnel towards wind direction to pass out inside hot air smoothly;
- ♣ Check the fish not being cooked or case-hardened: take corrective measures;
- ♣ Dry the fish until it becomes adequately dried;
- ♣ Pack them in airtight polythene pouch or closed container from the tunnel and keep in clean cool place.
- ♣ Pack them in consumer package (air tight thick polythene pouch: polyester-polythene co-polymer, polypropylene coated polythene, etc.) immediately. Do not keep the products open in the basket.

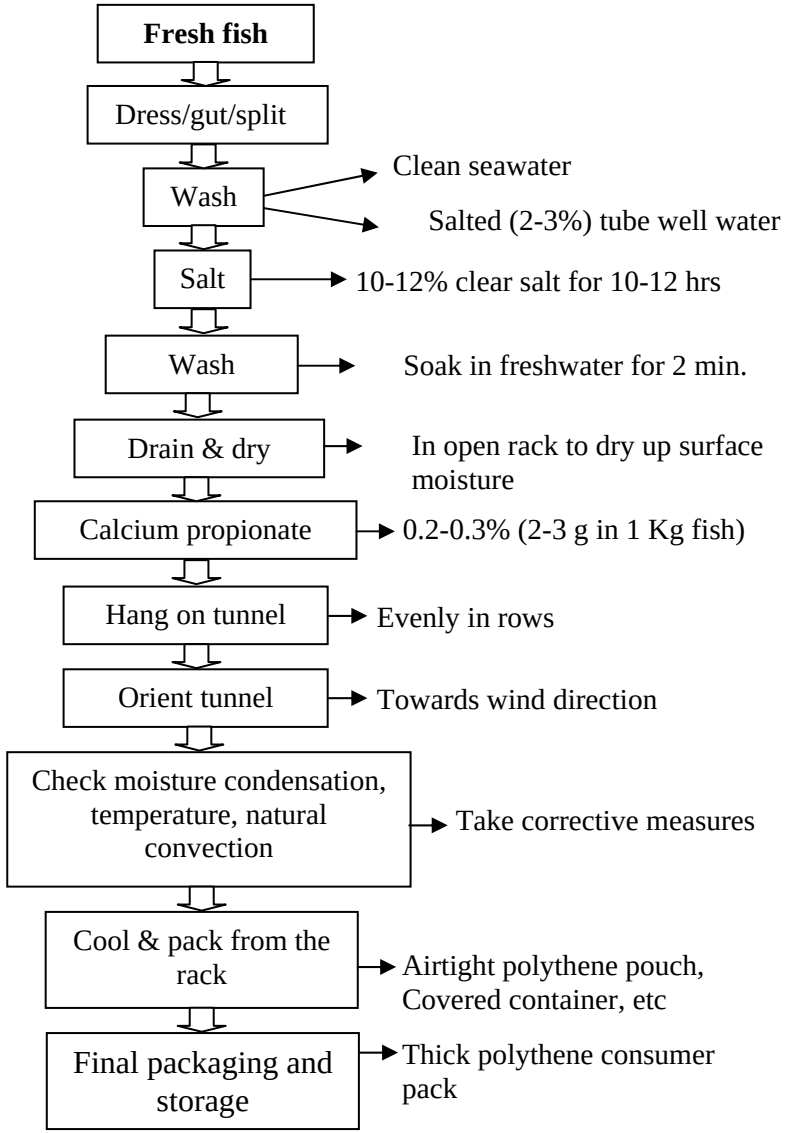


Fig. 11.4. Scheme for the drying of fish in solar dryer

Distinguishing products in the market

Dried fish products prepared from spoiled fish can be differentiated from the products from fresh fish through analyzing the qualities given in Table 11.6.

Table 11.6. Characteristics of dried fish prepared from fresh or rotten raw material

Sl. No.	Dried products from fresh fish	Dried products from spoiled fish
1	Whitish in colour	Grayish in colour.
2	Skin is shining and glassy	Original skin is lost or distorted; rough surface.
3	Fresh fishy and dried-fish flavour	Pungent-spoiled flavour
4	Slightly salty-sweet in taste	Bitter in taste
5	Substantial shrinkage in the muscle occurs: dried fish becomes shorter in size than that of original fresh fish.	Fish becomes longer than the original one after drying. This happens due to the enlargement of vertebral column.

Generally, local consumers prefer unsalted plain dried products. But salts are required to be incorporated in dried fish for various reasons as explained earlier. Most of the plain dried products are treated with health hazard pesticides also. Careful buyers can easily distinguish between the salted and salt-free and pesticide used and pesticide-free products. Following tables show the physical quality differences of such products.

Table 11.7 Characteristics of salted/salt-free dried fish

Sl No.	Dried fish added with salt	Dried fish added without salt
1	Surface of product moist and cold due to reabsoption of moisture from the air	No such reabsorption happens, surface dried and smooth
2	Texture soft, sign of finger press recognizable	Texture hard and elastic
3	Salty in taste	Mostly blunt taste, occasionally mild salty
4	Heavy in weight	Light in weight
5	Skin dull or blackish	Skin shinny

Table 11.8 Characteristics of pesticide used/pesticide-free dried fish

Sl No.	**Dried fish treated with pesticide**	**Dried fish without pesticide**
1	Skin smooth and shinny	Skin of fresh product shinny and smooth but not as much as that treated with pesticides; skin of old products not smooth as signs of insect bites frequently observed
2	Devoid of characteristic dried fish flavour	Characteristic dried fish flavour persists all around
3	Bitter in taste at the tip of the tongue	Mostly blunt or slight salty in taste
4	Little or no live flies or insects around; little or no beetle inside the basket or container	Blow flies flying all around the products; adults, pupae or casts of pupae are found in the basket

Facilitation sheet-6

12a

Smoking of Fish in Coastal Villages

Activity:1 How does wood smoke preserve fish ? (from the difference between sun-drying and smoking of fish)

The participants are divided into 2 groups. Group A will raise a point that is related to the principles of sun-drying (for example, sun-drying of fish is done by the action of sunlight and wind). Group B will correlate or deviate the raised point (by group A) with/from that of smoking. Group A will again raise another point related to sun-drying while Group B will try to correlate with or deviate from that of smoking. Through such cross-cutting arguments of two opposite groups, a difference between sun-drying and smoking of fish will come out. How does wood smoke preserve fish will also be understood from the discussion. Finally, the facilitator will explain the role of wood smoke in the preservation of fish.

Activity: 2 Quality of the products under exclusive smoke (cold smoking) and under fire and smoke (hot smoking)

Some products are produced by smoking only, like smoked salmon, but some other products for eg. smoked shrimp, smoked hilsa, etc. are produced by the combined action of fire and smoke. Group A will find out the characteristics of the product produced by exclusive smoking (mostly cold smoking), while Group B will find out the characteristics of the product produced by both fire and smoke. The findings will help them to differentiate between cold smoking and hot smoking. Group leaders will present their findings. One group will ask question to another group. The facilitator will explain the difference between the two smoking methods.

	Group A **Characteristics of cold smoking**		**Group B** **Characteristics of hot smoking**
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 3 Smoking of shrimp in coastal villages and its constraints

Group A will explain the traditional smoking of shrimp, while Group B will outline the constraints of traditional process. The group leaders will present their results and initiate question-answer session. The facilitator will participate to fill up the gaps of information during group discussion.

	Group A **Traditional shrimp smoking**		**Group B** **Constraints of traditional process**
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 4 Improvement of the existing process

Group A will identify the critical control points in the traditional process line where improvements are needed, while Group B will

show a flow diagram of an improved process. After presentation before the participants, a question-answer session will start. Facilitator will conclude by briefing on an appropriate method of fish smoking in local context.

Activity: 5 Use of appropriate kiln in shrimp smoking

Wastage of fire wood is high in traditional smoking. Besides, smoking is not uniform as it is done in open kiln. It also takes longer time compared to various controlled kiln. Therefore, effective kiln should be used in shrimp smoking. Group A will find out the constraints of traditional kiln, while on the basis of identified constraints, Group B will suggest the adequate features of an improved kiln. Facilitator will initiate a lively question-answer session.

Activity: 6 Role of different stakeholders in improving the traditional process

The participants are divided into 2 groups: boat owners and fishermen/processors. Each group will discuss on what they should do to improve the existing smoking process. The group leaders will present each of the group's finding. One group will ask question to other group. The facilitator will sum up the discussion and define the exact role of stakeholders in improving the smoking of shrimp and fish.

Stakeholder	Measures to be taken for improvement
Boat owners	1.
	2.
	3.
	4.
	5.
Fishermen/ Processors	1.
	2.
	3.
	4.
	5.

Information sheet-8

12b

Smoking of Fish in Coastal Villages

Group exercise: 6
Field demonstration: 3

Introduction

Mainly *Metapenaeus* shrimps (*Lailla icha*, *Harina icha*) are smoked during the monsoon months in the coastal villages of Bangladesh. The season of smoking of shrimp lasts only for three months: July, August and September (Sraban-Asshin), due to larger catch of small shrimp in these months. Smoking is practiced not only to impart desirable colour and flavour, but also to accelerate the drying process. Smoking is generally combined with a period of sun-drying. Generally, a hot-smoking technique is applied. The long storage life of smoked shrimp is due more to drying and cooking than to the preservative values of the chemical compounds deposited on the body from the smoke. Shrimps are less available in winter. Moreover, the consumers do not prefer smoked shrimp produced in winter.

Some other smoked products produced in the past are smoked catla (*Catla catla*) and smoked Hilsa (*Tenualosa ilisha*) in Barishal, Barguna and Teknaf areas. But these products are not available now. This may be due to depleted harvest, increased availability of ice and higher market price for fresh fish.

Small shrimps (Chaga, Harina, Lailla and Chaumma icha) are extensively smoked along the coastal areas in Puran Rangabali, Kaich-chabainna, Barabaishdia and Chotobaishdia of Khepupara of Patuakhali; Khach-chupia of Vola; Amtoli and Patharghata of Barguna; Cila, Vhogi and Chalna of Khulna and Raenda and Sharankhola of Bagerhat. Tarasghata, Batakhali, Maizeghona and Khojakhali are major coastal villages under Chakaria Upazila of Cox's Bazar where shrimps are smoked on commercial basis. But the extent of production is lesser in Cox's Bazar compared to the Sundarban areas.

How does a wood smoke preserve fish?

Smoking is a method of preservation that combines six important effects in fish/shrimp muscles (Horner, 1992):

i. Drying: Fires producing smoke can generate heat and dry the fish and thus reduce the water activity so that microorganisms can not survive;

ii. Cooking: Hot smoking cooks the flesh and thus destroys enzymes and kills bacteria;

iii. Preservation: Wood-smoke contains compound like phenol that can kill bacteria;

iv. Anti-oxidation: Wood-smoke contains compound that acts as antioxidant, such as phenol;

v. Colour: Smoking imparts on the products highly acceptable bright brown or reddish colour;

vi. Flavour: Wood smoking imparts effects of highly relished characteristic smoke flavour.

How can wood smoke function?

Wood smoke is a mixture of gases, vapours and droplets. Droplets are the visible part of the smoke. Vapour contains required preservatives, germicides and antioxidants. Fish takes up vapour during smoking. The rate of uptake depends on moisture level on the surface of fish and the flow of smoke (Clucas and Ward, 1996). Moisture content on the surface of *T. ilisha* or *C. catla* is higher compared to shrimp, so the rate of uptake of substances from the smoke is also higher in those fishes. Shrimp is covered with shell and hence, has less moisture on the surface compared to wet fin fish. Preservative and anti-oxidative effects are probably less in smoked shrimp compared to that in fin fish. Therefore, heat of the fire is more important than the smoke in smoked shrimp.

Cold smoking, "*warm smoking*" and hot smoking

In cold smoking, the temperature of the smoke is maintained at 30 to 40^{o}C; it never rises to high level where fish flesh is cooked (Clucas and Ward, 1996). Some of the cold-smoked products are produced at a temperature of 8 to 10^{o}C. Cold smoking is mainly done in cold countries. If this technique is adopted in tropical fish, comparatively higher temperature of 55 to 60^{o}C is applied, because proteins of tropical species are denatured at higher temperature. The process can be called *warm smoking*.

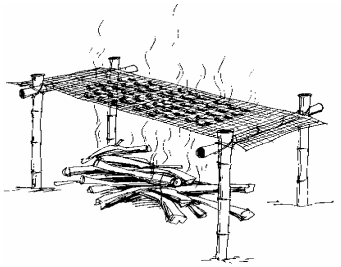
In hot smoking, the fish is generally cooked (80 to 90^{o}C). Traditional smoking of fish in many tropical countries is of this type where fish are sun-dried and heavily smoked with both wood smoke and fire. A comparison between the cold smoking and hot smoking is given in Table 12.1.

Table 12.1. Difference between cold smoking and hot smoking

Cold smoking	Hot smoking
Desired temperature is around 30 to 40^{o}C during smoking. Sometimes, more lower temperature is used.	Desirable temperature is around 80 to 90^{o}C.
Chemicals received from smoke play a major role in preserving fish and keeping quality.	Fish is cooked and dried at high temperature. Chemicals of the smoke play lesser role.
Flameless smoke is more effective for this type of products. Flame is not desirable.	Both flame and smoke are equally necessary.
Slow burning of wood produces much smoke.	Rapid burning of wood produces only flame. Adequately designed kiln can produce both smoke and flame.
Saw dust is the best since it does not burn but smokes	Clean dry wood is the best.
Products are marketed at refrigeration temperature (2 to 5^{o}C).	Products can be preserved and marketed at room temperature for a short while.

Conventional process of shrimp smoking - 1

(In coastal villages of Cox's Bazar, Chittagong and some villages in the Sundarban)



- Sand or brown shrimp (*Lailla icha /Harina icha)* are washed in basket and sun-dried for 4 to 6 hours.
- No pre-treatment with salt is done during drying.
- Smoking of semi-dried shrimp is done in the evening or at night.
- For smoking shrimp is spread over small-meshed tray made of split bamboo. Fire and smoke are generated by open oven underneath of the tray or rack.
- First, flame is produced by fire wood and plant leaves to dry and cook the shrimp.

- ♣ Then, smoking is done for 2 hours to develop colour and flavour.
- ♣ Flame develops bright red colour; excess smoke may blacken the product.
- ♣ Smoked shrimp is cooled overnight to protect appendages and other body parts from breakage; otherwise weight loss in the final product is severe.
- ♣ Smoked shrimp is kept in bamboo basket and stored at room temperature. The product is sold within 10 to 15 days.
- ♣ In some coastal villages of the Sundarban, shrimp is washed with freshwater and thinly spread over the elevated racks (1.5 to 2 feet high) made of fine meshed bamboo split for drying with the flame.
- ♣ Shrimp is dried with the flame for 2 hours and then smoked for 1 hour.
- ♣ Fire and smoke is produced by dry wood. Semi dried or green wood are not used, because these make a black appearance in the final product.
- ♣ Whole smoking process is completed within 3 hours. Therefore, the products become ready to consume within half of a day.
- ♣ Smoked shrimp is cooled, kept in bamboo basket and stored at room temperature.

Conventional process of shrimp smoking –2

(Puran Rangabali, Kaich-chabainna, Barabaishdia and Chotobaishdia of Khepupara of Patuakhali; Khach-chupia of Vola; Amtoli and Patharghata of Barguna; Cila, Vhogi and Chalna of Khulna and Raenda and Sharankhola of Bagerhat):

- ♣ Mainly *Chaga*, *Harina/Lailla* and *Chaumma icha* are smoked in these coastal villages.
- ♣ Shrimps are washed with tidal water.

- ♣ Then these are dipped into boiled water for 2 minutes (a basketful of shrimp is dipped into a half-drumful hot water kept boiled previously).
- ♣ Blanched shrimp is spread over the small meshed bamboo racks kept under the shed (15’ x 45’) and flame is produced underneath of the rack.
- ♣ Mainly tender plants of *Shundari* or *Goran* are used for fire production.
- ♣ Firing associated with smoking, instead of exclusive smoking, is done for 5-6 hours. Shrimps are turned after 2-3 hours. Thus, a bright red colour is developed on the product.
- ♣ The products are cooled for 6-8 hours and packaged in special baskets made of a plant leaves (*Hogla pata*). The opening of basket is closed by stitching.
- ♣ Smoked shrimps are transported to Chittagong via Chandpur or Khulna through steamer, train and truck. Some are (about 25%) transported to Sayedpur of Rangpur.

Problems associated with conventional smoking of shrimp

i. Raw material shrimps are not always fresh.
ii. The place for sorting is not often clean. Very often it is done on the ground. Sometimes unclean woven mat is used.
iii. Washing of shrimp is not done properly. Purchased shrimp lot is directly spread over the mat for drying or smoking. Sometimes, washing is done with unclean channel or ditch water. Use of salt water sometimes creates problems as it blackens the product.
iv. Various pesticides are used during processing and storage to protect the products from insect infestations.
v. Direct fire or flame often makes the product brittle.
vi. The woods and leaves used are not always finely dried or of good quality. Unclean and semi green woods or leaves often serve as the basis of contamination in smoked products. Moreover, green wood can not develop bright red colour which is prerequisite for selling at a good price.

vii. No appropriate packaging of final product is visible. Products in open basket are susceptible to insect and bacterial attack and moisture reabsorption from the air.

viii. Smoke/flame is produced by open kiln or oven. This often causes a considerable wastage of fire wood and makes the process lengthy.

ix. Smoked shrimp is stored, transported and marketed by bamboo baskets. Crispy and fragile products lose much of its weight through breakage of legs, shells, rostrum and appendages.

Improvement of the smoking of shrimp

Following measures should be taken for the improvement of traditional shrimp smoking in Bangladesh.

- ♣ Use fresh good quality shrimp for smoking.
- ♣ Handle shrimp properly on board fishing vessel and during transportation.
- ♣ Sort the shrimp according to the species and size and remove the spoiled one.
- ♣ Use clean space and container for sorting.
- ♣ Wash thoroughly with clean salt-free tube well water. A 0.5 ppm chlorine dioxide (ClO_2) or 5-10 ppm chlorinated water would be the best washing solutions.
- ♣ Drain out the excess water and dry the surface.
- ♣ Dry the shrimp for 4-5 hours on elevated racks under bright sunlight.

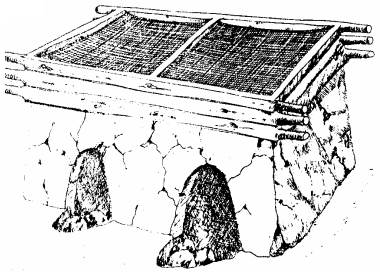


Fig. 12.1. Chorkor oven

- ♣ Smoke semi-dried shrimp for 3-4 hours. For smoking, use effective earthen oven to minimize the wastage of firewood. A permanent earthen kiln used to smoke fish in different countries of Africa (Fig. 12.1) can be used for shrimp smoking. A modified device of

African *Chorkor oven* can be constructed inside the house or outside at very low cost. Size of the oven may vary depending on the size of business operation. For a small-scale operation, a medium sized oven can be used. At first, a 2 x 4 x 3 feet high earthen oven having 2 mouths at uniform distance is constructed. Top ends of the rectangular oven are made uniform and parallel to the base so that no smoke can escape. Now, equal size wood-framed fine meshed woven tray made of split bamboo is arranged on the top of the oven one by one. Exclusive bamboo should be used for the woven mesh. Iron or other metal wire should not be used. Semi-dried or surface dried shrimps are spread uniformly on the trays. Number of trays varies between 5-8 depending on the extent of operation or smoke production. Smoke is produced by finely dried wood. As it is mostly a closed oven, the amount of smoke production is very high which directly passes through the trays. Arrangement of the trays should be changed at regular intervals (top one to the bottom, next top to next of the bottom one and so on) to allow uniform smoking to all the trays. This improves the quality and shelf life of the product. At a time, 40-50 kg shrimp can be smoked through 1-8 trays. So, this is a very cost-effective device. This type of modified earthen oven has been introduced in smoking of shrimp in the coastal fishing villages of Chakaria.

Several other types of effective kiln can be used for shrimp or fish smoking considering the nature of the process and awareness level of the processors. A oil drum can be very effectively modified into smoking kiln (Fig. 12.2). In the inside of the drum, several wire meshed trays are arranged one after another that hold shrimp/fish to be smoked. Bottom of the drum is connected to a metallic oven through a feeder pipe. Smoke is produced by saw dust. A chimney is placed at the top of the drum.

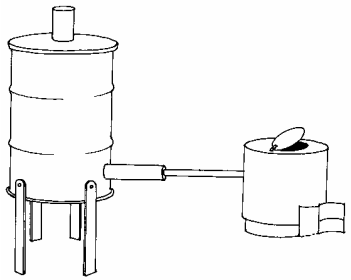


Fig. 12.2. Modifed drum kiln

- ♣ Use finely dried clean wood for smoking.

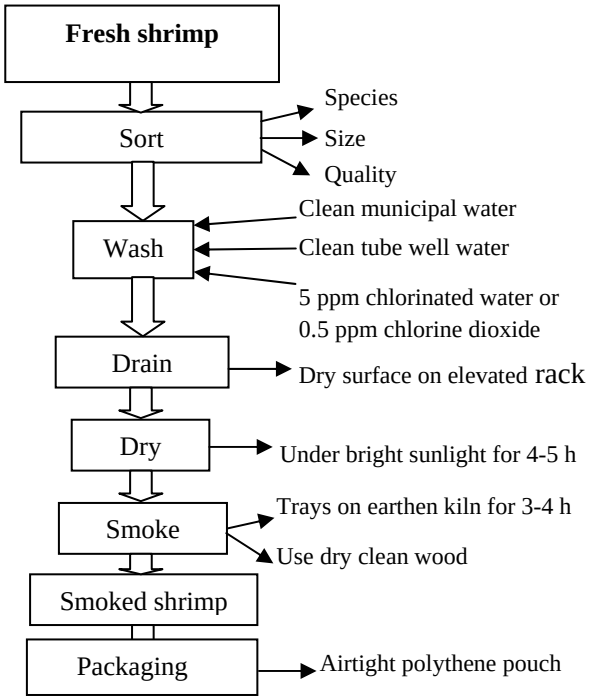


Fig. 12.3. Scheme for the preparation of improved quality smoked shrimp

- ♣ If necessary, use calcium propionate at recommended dose (0.1-0.2% by weight of shrimp) to protect from bacterial and fungal contamination.
- ♣ Pack the smoked product in airtight polythene bag from the rack after cooling and keep in cool and dry place.

Smoked *Hilsa*

Smoked *Hilsa* (river shad: *Tenualosa ilisha*) has been a popular product in some coastal districts like Cox's Bazar since ancient times. With present day's reduction of the catch and increased availability of ice, the extent of smoking of the species has been reduced significantly. Higher price paid for wet fish might be another

reason for such reduced smoking. This product is no longer found in the market. But local people of Teknaf have been found to prepare this delicate dish at home for own consumption. Brilliant colour and delicious flavour have made it one of the cherished food items in this area.

Smoking process

Smoking was done mainly in January and February in Teknaf and September and October in Chakaria and Moheshkhali. For smoking, the fish is scaled and gutted and then thoroughly washed with clear sea water. Washed fish is split through dorsal lining to widen and expose the anterior part to smoking, keeping the ventral lining of the fish intact. After 3-6% salt treatment, split fish is fixed in between two triangular frames made of split bamboo. The fish is so fixed in order to handle and turn it easily on fire or smoke that allows uniform smoking. Sometimes, fishes are framed by triangular fine mesh made of split bamboo. Bamboo mesh is used mainly to frame small *Hilsa*. Now, the framed fish is kept on the narrow-meshed smoking rack made of split bamboo in such a way that the anterior split portion of fish receives smoke directly. The smoking rack is placed 2.5 feet above the earthen oven. Smoke is produced by local woods. No flame but only smoke is allowed and if any fire breaks, it is stopped. Fire burns the flesh and develops a brittle texture of muscle that comes out of the bones. But exclusive smoke makes the texture rigid and elastic that is relished by the consumers. Green or semi green woods are used for intense smoke. Smoking is done in a two-step process. In the first step, smoking is done for 4-5 hours. For good quality and longer shelf life, the product is again smoked for 2 hours after 2-3 days of first smoking. Due to such repeated smoking, the bones are softened. The final product becomes brilliant red inside (split part), while the upper surface (skin part) remains transparent. Products within the triangular frame are stored

or marketed as such. Storage is done in open-mouth big basket made of bamboo split, locally called *lai*.

Improved recipe for smoking of *Hilsa* at a glance:

- ♣ Use premium quality fresh *Hilsa.*
- ♣ Wash the abdominal cavity and outer surface thoroughly with 5-10 ppm chlorinated tube well water.
- ♣ Split fish through the dorsal lining to open and keep the anterior surface flat.
- ♣ Dip in 3-5% NaCl solution for 5 min to give the skin a shinny/glazy appearance.
- ♣ Drain out the salt solution and dry in the indirect sunlight for a hour.
- ♣ Dry in direct sunlight on net covered elevated tunnel for 2 hours.
- ♣ Frame the fish and keep on clean smoking rack.
- ♣ Use finely dried clean wood for smoking: do not use green wood or tree leaves.
- ♣ Smoke slowly for 6 hours; turn several times for uniform smoking.
- ♣ Keep the fish flat on basket overnight, press from the top by stone or brick to release out water and fat.
- ♣ Smoke again for 5 hours on the next day until all lipids drop out and colour develops.
- ♣ Package in polythene pouch and store in cool place.

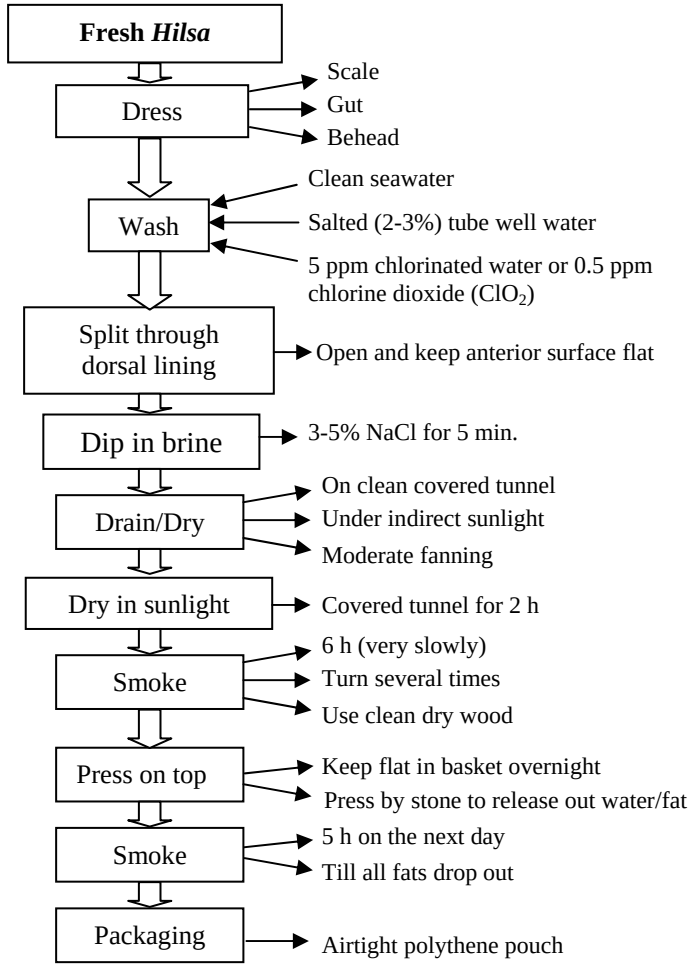


Fig. 12.4. Scheme for the preparation of improved quality smoked Hilsa

Conclusion

Smoking of shrimp has occupied an important position in the artisanal fish processing of Bangladesh because of its delicacy and high price. On the other hand, there were some other delicate

products like smoked *Catla* and smoked *Hilsa*, which have already gone to the oblivion memory because of the easy availability of ice and development of other low-cost improved preservation methods. Due to a well categorized affluent market of smoked shrimp, although confined to greater Chittagong and its neighbouring districts, there are ample scopes for improvement of its quality and add value. Use of premium quality raw material and efficient kilns, adequate handling and sanitation in the process and airtight polythene packaging for storage and distribution can significantly improve the quality of the smoked products.

Once popular '*smoked Hilsa'* and '*smoked Catla'* can be revived to keep up the heritage of the nation. Improvement in the quality and adequate but lucrative packaging might be necessary to regain their importance in the competitive markets.

Facilitation sheet-7

13a

Salting of Fish in Costal Villages

Activity: 1 How does table salt preserve fish? (from the difference between sun-drying and salting of fish)

The participants are divided into 2 groups. Group A will raise a point that is related to the principle of sun-drying (for example, sun-drying of fish is done by the actions of sunlight and wind). Group B will correlate or deviate the point with/from that of salting. Group A will again add more points for sun-drying while Group B will try to correlate with or deviate from those of salting. By this way, a difference between sun-drying and salting of fish and the principles of salt preservation will be understood. The divergence and convergence between salting and sun-drying can also be understood from the discussion. Finally, the facilitator will explain the role of sodium chloride in the preservation of fish.

Activity: 2 Ripening and quality of the dry and wet salted *Hilsa* products

Both dry and wet salting of *Hilsa* are practiced in the coastal villages. Another process is salt-fermentation of *Hilsa* (semi-fermentation). Samples of different salted products from the market will be supplied. Group A will evaluate the ripening stages of dry and wet salting, while Group B will assess the ripening of salt-fermented products. The findings will help the participants to differentiate the characteristics between the products. Group leaders will present their findings and answer the questions.

	Group A Ripening qualities of dry and wet salted products		**Group B Ripening qualities of salt-fermented products**
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 3 Traditional salting process and their constraints

Group A will explain the existing processes of dry and wet salting and salt-fermentation of *Hilsa,* while Group B will find out their constraints. The group leaders will present their findings. One group will ask questions to other group. The facilitator will detail the salting of Chandpur/Lakhmipur and Cox's Bazar and outline the constraints and limitations of these processes.

	Group A Processing steps of traditional salting		**Group B Constraints of traditional process**
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 4 Bacteria and mold attack in salted products

Group A will identify any off-flavour and prominent or off-colour in the supplied salted products with probable causes. Group B will point out the measures the processors generally adopt or should follow if any off-flavour/colour is developed. Group leaders

will present their observations and answer to the questions from the other group. The facilitator will explain the control measures against contamination due to bacteria and molds.

Group A Types of off-flavour/colour		Group B Possible control measures	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 5 Improvement of the existing process

On the basis of the constraints of different salting methods discussed, Group A will identify the control points where adequate interventions are needed for improvements, while Group B will draw a flow diagram of improved salting of *Hilsa* on the flip chart. One group will ask question to the other group. Facilitator will discuss an improved process in detail.

Group A Critical points where improvement is required and how		Group B Major steps of improved salting of *Hilsa* in flow diagram	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 6 Role of different stakeholders in the improvement of existing process

The participants are divided into 2 groups: boat owners and fishermen/processors. Each group will discuss what should they do

to improve the existing salting process. The group leaders will present each of the group's findings. The facilitator will sum up the discussion and present an improved process for salting of *Hilsa*.

Stakeholder	Measures to be taken for improvement
Boat owners	1.
	2.
	3.
	4.
	5.
Fishermen/ Processors	1.
	2.
	3.
	4.
	5.

Information sheet-9

13b

Salting of Fish in Coastal Villages

Group exercise: 6
Result demonstration: 3

Introduction

Salting is a process of fish preservation where the water content is reduced by the penetration of salt, whereby the activity of most of the spoilage bacteria is stopped or reduced. Two basic principles describe the mode of action of salting as well as its importance in preservation of fish: i. removal of water from the deepest part of the flesh quickly enough to reduce water activity; ii. penetration of salt quickly enough in the deepest part of the flesh to lower the water activity. A concentration of 6-10% salt in fish tissue can prevent the action of most spoilage bacteria.

Very often salting is done in combination with sun-drying and smoking for variety of fish species. But in case of fatty fish like various shads and herrings, salting is the only choice of traditional fish preservation (Nowsad, 2005a). In coastal Bangladesh, a very popular, high valued fatty species- river shad, *Tenualosa ilisha,* is plain-salted during the period of plenty (July-September).

Importance of salting in Bangladesh

i. Salting is a simple and low cost fish preservation technique;
ii. It does not require any equipment or machinery, it can be done everywhere;
iii. Salt is easily available and salting can be done throughout the year, especially during monsoon when other low-cost preservation like sun-drying is not possible;
iv. It keeps the fish eatable for long days compared to other preservation methods;
v. Salted fish is easy storable, transportable and marketable;
vi. Characteristic texture, flavour and colour of the product are relished by many people;
vii. Some of the salted-dehydrated fish are exported to other countries.

Quality of commercial salt

On the basis of source and production method, commercial salts can be divided into 3 types:

i. Salt produced by evaporating water of the sea or salt lake through sunlight and air is solar salt;
ii. Underground salt reserve pumped up as brine and extracted through evaporating by heat is brine salt;
iii. Natural salt reserve on earth is crushed in different manners is rock salt.

Solar salt, produced by the evaporation of seawater is extensively used in salting of fish in Bangladesh. The use of other two salts is not observed. Solar salts used are of many different grades and types depending upon the purity. High quality salt contains 99.9% NaCl; low quality salt may contain only 80% NaCl (Clucas and Ward, 1996). Besides water, sand, clay, dust and calcium and magnesium salts are the major impurities of solar salts.

Calcium and magnesium chlorides, even if present in small quantities, reduce the NaCl uptake by the fish and removal of water

from the body. Magnesium chloride is hygroscopic that absorbs water and makes the fish more difficult to dry and keep dry. However, calcium and magnesium salts give a whitish appearance to the product, which is relished by the consumer, but excess amount leads to bitter taste and flavour and a brittle texture.

Solar salt contains large number of salt tolerant bacteria (up to 10^5/g) that causes pink spoilage on the surface of the product. It is not easy to sterilize the salt or add preservatives to control the growth. However, as they are obligate aerobes, they cannot grow if the fish is fully immersed in brine.

A mixture of large and fine grain salt is more appropriate for dry-salting. Use of fine grain salt directly to fish causes a problem in the product called "salt burn". Fine salt causes a rapid removal of water from the surface and makes it hard. This prevents further penetration of salt to the inside. Fine grain salt readily dissolves in water and is good for wet salting (Clucas and Ward, 1996).

Therefore, salt to be used in fish should contain at least 95% NaCl, be free from sand, clay, mud and salt-tolerant bacteria and be as dry as possible.

Quality of fish that affects the uptake of salt and the removal of water

Four major components of fish those regulate the uptake of salt and removal of water are:

i. **Fat content:** the higher the fat content, the slower the salt uptake.
ii. **Thickness:** the thicker the fish, the slower the diffusion of salt to the center.
iii. **Freshness:** the fresher the fish, the slower the uptake of salt.
iv. **Temperature:** the higher the body temperature, the faster the uptake of salt.

Types of salting

Almost all usual methods of salting are practiced in Bangladesh. The methods are more or less related to that described by Horner (1992). These are as follows:

a. Dry-salting or *kench curing*: Generally fish are split, opened out flat and placed in layers interspersed with layers of salt. The liquor that exudes is allowed to drain away. Although the *kench curing* is used mainly for white and non-fatty fish, due to its simplicity, however, an important fatty species, *T. ilisha*, is salted by this technique.

b. Wet-salting or *pickling*: The technique is used mainly for long term preservation of fatty species by immersing into concentrated brine solution. The fatty *T. ilisha* is extensively salted by this process. Immersion retards O_2 access whereby rancidity reaction. Some rancidity is, however, desirable for characteristic flavour.

c. Mixed salting: At first dry-salting is carried out in a tin or container. The exudates liquor is allowed to run away. The split fish is then soaked in concentrated brine that floats in solution for 8-10 days. Ripen products are taken out and dried a little in the sun.

d. Preparatory salting (salted-dehydration): Fish are scaled, eviscerated and soaked in dry salting vat for a duration depending on the types and size of the fish (2-10 days). Salted fish is soaked in fresh water tank and thus pre-processed for a long sun drying. Salted-dehydrated jew fish is an important product of this type.

e. Brining or sprinkling grain salt: Sometimes brining is done for flavouring and glazing or for delaying spoilage. Sprinkling of grain salt is practiced as pre-processing of fish. The preservation is effected by other techniques, such as drying or smoking. Fish are treated for several minutes in 3-5% brine. Brining/sprinkling of grain salt is also done for long periods for preservation with salt prior to drying.

Comparison between different salting processes

1. Dry salting

Advantage

i. Easy process;
ii. Salt retards bacterial growth;
iii. Salt absorbs and removes water directly from fish muscle cells, thus protects fish from spoilage;

Disadvantage

i. Amount of salt is very high in the final product;
ii. Salt mixing is not uniform in fish body, so preservation is not adequate;
iii. Physical structure of fish disrupts, muscle shrinks and colour changes;
iv. Extracted water pollutes environment.

2. Wet-salting

Advantage

i. Salt penetrates uniformly in all parts of the body;
ii. Physical structure is not changed, no shrinkage of muscle occurs.

Disadvantage

i. Pieces of fish float on the surface of brine, come in contact of air and deteriorate quality due to aerial oxidation;
ii. Lid can not be opened until the process ends, so maturation can not be measured;
iii. Water removed from the fish body dilutes the concentration of brine.

3. Mixed salting

Advantages

i. Pretreatment with dry salt removes water from the body, so concentration of brine is not reduced further;

ii. Physical structure is not changed;
iii. Salt penetrates uniformly inside.

Disadvantages

i. Pieces of fish float on the surface and quality deteriorate due to oxidation.

***Maturing* or *Ripening* in salted fish**

'*Maturing*' or '*ripening*' is a physico-biochemical process where a characteristic texture and flavour is developed in salted product due to complex autolytic, enzymatic and microbial actions. In either of dry or wet salting, salt uptake and water removal do not continue indefinitely; sodium and chlorine ions form a water binding complex with proteins which exerts an endosmotic pressure that eventually balances the exosmotic pressure due to surrounding brine and an equilibrium is reached. Under this equilibrium state, within 8 to 15 days of salting, depending on the species and size of fish, a *maturing* or *ripening* occurs in salted products (Horner 1992). Having lost up to 20% of its weight through exosmosis of water to the brine, *Hilsa* regains original weight through salt uptake within 10-12 days. The enzymes responsible for maturing is derived mainly from the digestive system of the fish, the fish muscles and bacteria growing on the fish and in the salt. The products of proteolysis and lipolysis are also predominant in the ripened products. Lipolysis and oxidative rancidity play an important role in the flavour development of even low fat, salted white fish products. The products of Maillard browning reactions also make a significant contribution to the flavour of wet salted fish (Jones, 1962). In dry-salted *Hilsa*, any browning is undesirable and can render the product unfit for sale.

Salting of *Hilsa*

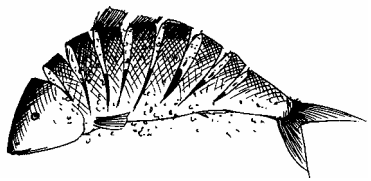
Hilsa is the only species in Bangladesh that is commercially processed by salting. Two to three methods of salting are practiced as per demand in different areas. In Chandpur, Noakhali and Barishal, both dry, wet and mixed salting are done, while in

Chittagong and Cox's Bazar, a special salting leading to partial anaerobic fermentation is a preferred process.

Dry-salting of *Hilsa*

Hilsa harvest in Bangladesh comprises mainly of estuarine and coastal catches from Chandpur, Laxhmipur, Vola towards Barguna and off-shore catches off Chittagong, Cox's Bazar and Barishal. Due to better transportation and marketing of fresh *Hilsa* in Chittagong-Cox's Bazar and Barguna-Barisal belt, extensive commercial salting has not been established in these areas. On the other hand, due to remote and mostly inaccessible locations, large-scale commercial salting of *Hilsa* has been developed along the belt of Char-Alexander, Haimchar, Haidergonj, Nilkomol, Moizzartek and Ramgoti.

In dry-salting, solar salt and turmeric powder are sprinkled over the fish. Salted fish are kept in a dry basket or perforated tin and the exudates are allowed to run away through the bottom holes.

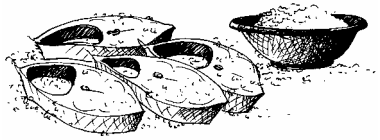


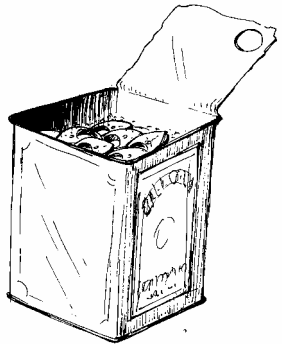
Dressing and cutting: The fish is scaled and the fins and gills are removed. The fish is cut transversely from the dorsal to the ventral by a sharp knife or '*Boti*' in such a way that the chunks remain attached at the ventral region. The thickness of the piece ranges from 0.75-1.0 cm. Sometimes one triangular chunk from the shoulder is removed to widen the space between the chunks to ease spreading of the fish on the surface. This also helps to ease the mixing and penetration of salt as well as removal of water. Head portion, however, remains intact with the body. The entrails are removed from the dorsal opening.

Salt mixing: Salt is added to the fish in sufficient amount, in its gills and mouths, in eyes and abdomen and in between each chunk. One part salt is used for a four-part fish. Along with solar salt, a small amount of turmeric powder is used to develop a colour in the product. Turmeric has got preservative value too.

Maturation or ripening: Salted fish are arranged one after another in crescentic fashion in a bamboo basket that allows the exudates to run away from the fish. A mat covers the basket. The basket is kept in the house in cool and dry place. Ripening occurs within 7-12 days, which is detected by the colour, flavour and the condition of the product. Most of the salted *Hilsa* in Haimchar/ Laxhmipur area are kept in empty mustard or soybean oil containers. The containers are kept arranged one after/on another in a large room. The exudates come out of the bottom hole of the container often accumulate on the floor and make the environment unhygienic and unpleasant.

Storage: Storage is done in either bamboo baskets or tin containers. In bamboo basket in cool and dry condition, dry-salted *Hilsa* can be kept for 3-4 months with little changes in sensory properties. However, there are chances of contamination in every step of processing and the processing itself is not hygienic. The raw material used is mainly of low quality and hence, the overall quality of the final product is not up to the mark.





Wet-salting of *Hilsa*

In this method, the fish is dressed as described before but the head is completely removed from the body. The dressed fish is either cut into small chunks or kept intact and salted either in brine or in dry solar salt. For brine salting, the whole fish or chunk is kept in a previously prepared saturated brine solution. Additional salt is incorporated to maintain the saturation of the brine as blood, slimes and other exudates of the fish body dilute the brine.

In case of the fish in dry solar salt, the fish is kept in a leak-proof tin container with alternate salt and fish layers. Sufficient salt is given at the top layer. The tin is covered and kept for a few weeks in a cool and dry place. The exudates come out of the fish body due to salt penetration dissolves the surrounding salts and make a concentrated salt solution in which the fish floats. The ripening comes in within 7-10 days. In either of such wet salting processes, the removed water, blood, slimes and other exudates can not pass out but directly mix with the brine solution, thus forming a complex biochemical high salt mixture that helps to develop characteristic texture, colour and flavour of the wet-salted product.

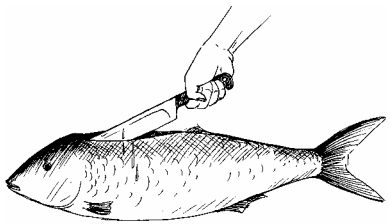
The keeping quality of wet-salted *Hilsa* is longer compared to dry-salted one.

Salt-fermentation of *Hilsa* in Chandpur

In Kachua and Matlab of Chandpur, dry-salted *Hilsa* is kept in earthen pot. Airtight pot is kept underground for 2-3 months. Before filling, the pot is prepared well by polishing with mustard oil several times and subsequently by sun-drying. Turmeric powder is sometimes used with salt during fermentation. A semi-fermentation in the fish tissue takes place, as the muscle softens but the fish remains intact after 2-3 months with the development of a characteristic texture and attractive flavour.

Under-ground salting of fish in Chittagong/Cox's Bazar

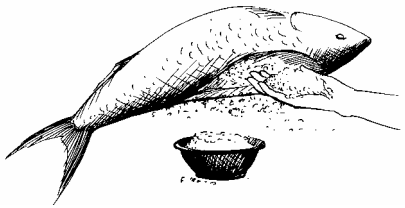
For traditional salting, mostly partially spoilt *Hilsa* that can not be sold fresh is selected. Undressed, unwashed *Hilsa* is cut longitudenally along the base of the dorsal fin from the lumber region up to the cranium. For this purpose, the fish is kept flat on a flat uniform surface and the tip of a sharp knife is inserted through the base of dorsal fin up to abdominal cavity.



The knife is extended, parallel to the surface, to the front up to the cranium and to the back up to the lumber region and the entrails is taken out through dorsal opening. The fish remains intact along the ventral line. Salt is put inside the fish muscle and in the abdomen through the dorsal opening. Sufficient salt is pressed in the gills, eyes and mouth and on the body surface. A 2 x 2 x 3 feet deep hold is dug in the floor of a shed where rain water can not enter. The underground hold is protected all around inside with a mat made of split bamboo, locally called *"Chatai"* and a polythene sheet. Salted fish are kept in layers in an orderly fashion in the hold and sufficient salt is given in between layers. When the hold is filled up with fish, it is covered by a final layer of salt and a mat is placed on the top. The top surface of the hold is covered with a clay layer of about 1 feet and heavy objects like stone, wood-block, brick, etc. are kept on the surface to press the fish from the top. The mouth of the hold is always maintained 1-1.5 feet high from the floor. As the hold is dug under a shed it remains protected from the rain. Open shed (no fence around) also keeps the underground hold cool and dry. The exudates come out of the fish due to salt uptake are absorbed by the surrounding soil. After 1-1.5 months, the flesh becomes slightly reddish and off-flavours due to pre-processing spoilage disappear with the development of a characteristic attractive flavour. The final product becomes more flattened, wider and longer than the unsalted one.

Salt-fermentation of fish in the basket in Cox's Bazar

Salting in the underground hold generally requires a large quantity of fish. To process small catch, however, *Hilsa* is salted and aged by semi-fermentation in bamboo basket instead of earthen hold. *Hilsa* is prepared as the same way as in the case of underground hold and kept in layers in polythene sheet with sufficient salt all around. Finally, the polythene is tied up well and kept in a woven bamboo basket for 1.5 to 2 months. A small mat



covers the basket and heavy stones or bricks kept on the top press the fish inside the basket to release exudates. Polythene sheet that covers the fish is punctured at the bottom to allow exudates to drain out. The product is opened after 1 month and more salt is added if required. The products are sold in Chittagong and Cox's Bazar markets.

Problems associated with the salting of *Hilsa* in Bangladesh

Hilsa is a dark-fleshed high lipid species. Icing is an effective short-term preservation method for the fish. Sun-drying is not an appropriate preservation method for the species because of atmospheric oxidation or rancidity problems. Long term chilling and freezing are not useful due to rapid spoilage of dark muscles. Considering the constitutional nature of the species, comparative advantage and acceptability of different fish preservation methods, socio-economic conditions and food habit of the local consumers, salting seems to be the best suited method for the preservation of *Hilsa*. There are, however, many problems associated with the process and the products as follows:

i. The producers do not follow the regulations regarding public health and sanitation.

ii. In glut period, the fish only those are spoilt or partially spoilt and can not be sold in the fresh wet fish market are used for salting.

iii. The fish or the cut pieces are not washed before salting in most of the cases.

iv. The raw material is contaminated by pathogens or other bacteria during scaling, gutting, dressing and cutting by unclean knife, container or tools.

v. Low quality solar-salt is used that inhibits the development of good texture, attractive colour and nice flavour of the product.

vi. Salt:fish ratio is not properly maintained. So rancidity occurs in fish during dry salting.

vii. Sometimes excess salting may denature protein and impact upon the sensory and biochemical properties of the final product.

viii. In wet salting, cut pieces are often floated on the surface of the brine that may come in contact of air and become rancid.

ix. Semi-fermented *Hilsa* is not always well protected and covered in the underground hold. Rain water and mud may enter and insects and rodents may attack and spoil or contaminate the products.

x. Packaging and storage are not appropriate and hygienic. Very often rancid off flavour develops in the products those are kept in the basket for long time.

Suggestions for the improvement of salted *Hilsa*

i. *Code of Practice* should be prepared and adopted for each of the salted products in accordance with *FAO Code of Conduct* and *Codex Alimentarius Commission*. Regulation should be developed for correct salt:fish ratio by the appropriate authority which all processors should follow.

ii. The fishermen, processors and allied personnel should be trained up on public health and sanitation and improved processing.

iii. Good quality fresh fish should be used. The spoiled one or those very close to spoilage should not be used. All fish should be properly iced before salting.

iv. Sufficient chilling should be ensured during the period of plenty.

v. Sometimes, partial spoilage is necessary for the fermentation process to develop the required level for consumer acceptance. This can be a different product. However, in such case the process should be hygienic and proper sanitation should be maintained.

vi. Sufficiently dried good quality solar salt should be used. It must not be contaminated by sand, clay or mud.

vii. In wet salting, the pieces of fish should be kept submerged in the salt solution. For this purpose, a weight (metal bar or glass piece) can be used on the top of the floating pieces. Perforated metallic or glass containers can be used to hold the cut pieces inside the brining vat.

viii. Very sharp knife should be used while dressing the fish. All utensils should be very clean.

ix. Durable, airtight and sustainable packaging like polypropylene coated polythene, polyester-polythene co-polymer, etc. should be used.

x. The product should be stored in low temperature (<10^{o}C) and low humid (<75%) conditions.

Spoilage of salted fish and control measures

Spoilage of salted fish and their control measures have been reviewed by Horner (1992) as follows:

i. Pink spoilage

The spoilage bacteria for the salted products are halophiles which essentially require salt for growth and can not grow and survive unless a 10% salt is present. These bacteria, viz., *Halobacterium salinaria, H. cutirubum, Sarcina morrhuae and S. litoralis*, are responsible for the *pink spoilage* in the product. It is so called because of the pink colour of their colonies and consequent reddish appearance of the salted fish. They are obligate aerobic and not found in wet-salted products due to unavailability of oxygen in the brine. They are thermophilic and optimally grow at the temperature of about 42^{o}C.

Control measures: Pink spoilage can be recognized by a pink sheen on the surface of the product. The colonies can be easily

rubbed off without damaging the fish. Storage in low temperature below 10^{o}C can prevent germination and growth of such bacteria. Sulphur dioxide vapour treatment or dipping the infected fish in sodium metabisulphite solution can prevent recurrence.

Pink bacteria themselves are non-toxic and can not cause food poisoning upon consumption.

ii. Dun spoilage

The excessive growth of a mold, *Wallemia* spp., on the surface of the salted fish often causes a brown discolouration, called *dun spoilage*. These molds, obligate osmophiles rather than halophiles, can grow within a wide range of salt concentration, between 5-26%. *Dun* molds can not grow inside the muscle and hence, do not decompose flesh but make the surface unpleasantly discoloured so that the products become less saleable.

Control measures: Dun molds can be brushed off the surface but growth will rapidly recur. Storage in low temperature and humidity and in dry, cool conditions may be the best preventive measures. Old and rotting wood or bamboo always harbours *Wallemia*. Therefore, wood and bamboo should be avoided in salted or dried fish stores or the product should be kept well covered. Appropriate packaging can be used. Dipping cured product in vegetable oil halves the rate of moisture uptake from the humid environment during May to October and thus can reduce the chance of bacteria and mold contamination.

iii. Reddening

Redness appears in the salted and dried fish products during storage. A bacterium named *Torula sweetmeri* is responsible for such reddening. Storage in low humidity (<75%) prevents the reddening of the product. Washing with 10-15% chlorine can remove the bacteria and hence, the redness.

iv. Salt-burn

A halophilic mold *Sporandonum* sp. is responsible for grayish or clay appearance of the salted fish that makes the surface dry and rough, almost a similar effect that happens in the skin in case if the salting is done by fine grain salt. This problem is also often called *salt-burn*. It occurs when salt concentration is reduced due to increased humidity in storage. Elevating salt concentration up to 25% would decrease humidity and remove the molds.

v. Rancidity of lipid

Salted fatty fish becomes rancid if exposed to air in storage. Although the rate of oxidation is very slow, after couple of weeks the product becomes un-consumable.

In case of wet salting, the pieces of fish should be kept submerged in the brine. For this purpose, a clean weight like stone, wood piece, metal or glass bar, etc. can be kept on the top of the floating pieces. Container can be specially made with an additional submerged cover plate with a lock in side that can hold the product submerged. Additional perforated metallic or glass containers can be used to hold the cut pieces inside the brining vat.

All sorts of salted products should be packaged in airtight laminated polythene pouch (polyesterine coated polyethylene film).

How to produce good quality dry salted *Hilsa*?

The traditional recipes of the salted fish products have been developed in the country over the years and accepted by the local consumers. Proper handling of the raw material, improved hygiene and sanitation in the process and improved packaging and storage as stated above can sufficiently improve the keeping quality and shelf life of the traditional products. However, to incorporate new dimension in the taste and quality of the salted fish, following recipe developed and field tested in the coastal area can used:

1. Use good quality fish.
2. Bleed, wash and ice, if carried to the port or salt the fish at sea.
3. Scale, split and remove gut, liver and gill.
4. Wash with freshwater and then soak in 10% brine for 60 min and drain.
5. Dip in a dry-salt stack in a shallow box (salt all around, at least 30% salt).
6. Fill all scores, rub well in.
7. Make even piles in salting vat with sufficient salt around.
8. Leave for 10-15 days depending on the size of the fish.
9. Wash with 10% brine for 2 minutes, remove all salt crystals.
10. Drain and set to dry: dry in the shade, not directly in the sun.
11. Pile them under pressure at night and dry at day time until drying is complete.
12. Use greater pressure and longer press time towards the end of the drying period.
13. Continue to alternate drying and pressing until no further weight loss occurs.
14. Package in laminated thick polythene pouch/bag.
15. Store in cool place or in low temperature ($<10^{o}$C).

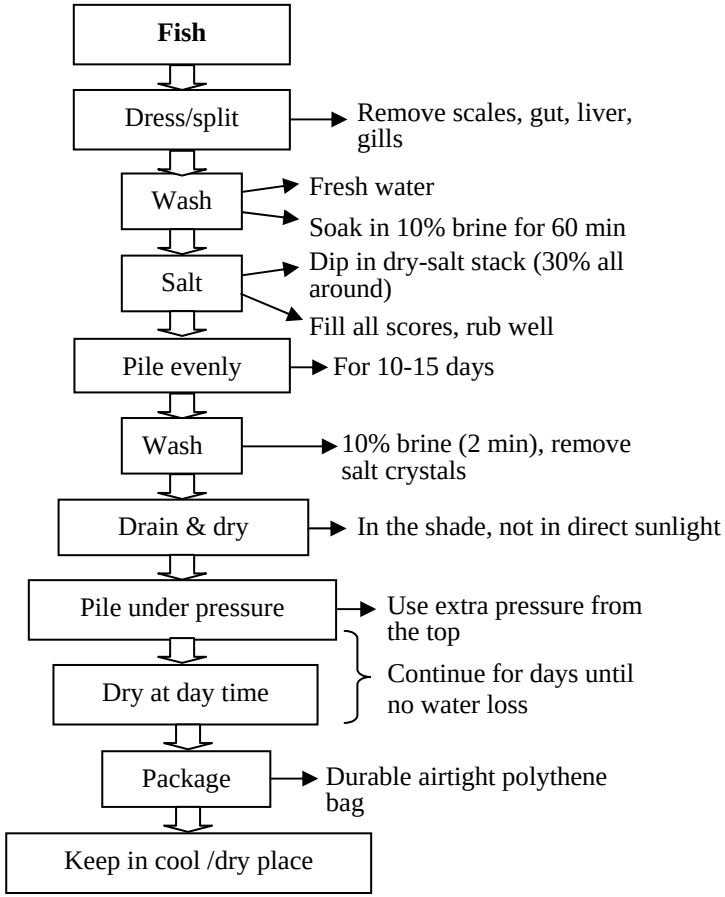


Fig. 13.1. Scheme for the preparation of improved quality salted fish

Facilitation sheet-8

14a

Fermentation of Fish

Activity: 1 How does *Shidhal* or *Nga-pi* keep nutritional quality of fish? (Fermentation is different from salting or salted-dehydration of fish)

Shidhal is a semi-fermented fish product made from Jatpunti. *Nga-pi* is a fermented fish paste produced from minute shrimp or fish.

The trainees are divided into 2 groups. Group A will raise a point that is related to the principles of salting process (for example, salt removes water and kills micro-organisms, thus protects the product). Group B will correlate or deviate the raised point with/from that of *shidhal* or *Nga-pi* (salt-fermentation). Group A will raise another point related with salting mechanism and Group B will try to correlate with or deviate from those of fermentation. By this way, a difference between the processes of salting and salt-fermentation will come out. How does fermentation preserve nutritional quality of fish will also be understood from the discussion. Finally, the facilitator will explain the role of salt and cellular and bacterial enzymes in the fermentation of fish.

Activity: 2 Quality of raw material for *shidhal* and *Nga-pi* preparation

Raw material quality is not often maintained during *shidhal* or *Nga-pi* preparation. Local perception is that the spoilt shrimp can make *Nga-pi* as good as the fresh shrimp. Local people are often unable to differentiate between fish *fermentation* process and *spoilage* of fish. Sometimes, for special flavour development in some specialty *Nga-pi* products, ethnic consumers prefer certain level of spoilage of raw material. However, being a separate product, that should be done under complete control of the process where adequate levels of sanitation and hygiene have to be ensured.

The participants are divided into two groups. Group A will point out the demerits of the consumption of *shidhal* or *Nga-pi* prepared from spoilt fish/shrimp, while Group B will point out the merits of consumption of *shidhal* or *Nga-pi* prepared from fresh fish/shrimp. Group leaders will present their findings according to the following chart. The importance of fresh raw material will come out by the discussion. Finally, the facilitator will explain the importance of freshness of raw material.

	Group A **Demerits of rotten raw material**		**Group B** **Merits of fresh raw material**
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 3 Measures to be taken to keep the freshness of shrimp

Icing destroys the colour of the small shrimp; expected colour can not be achieved if *Nga-pi* is prepared from iced raw material. However, to keep the quality and nutritional value, some other suitable preservation methods should be used.

The participants are divided into two groups. Group A will write how they can keep the small shrimp fresh on board vessel for *Nga-pi* and Group B will point out the methods of good handling of shrimp during unloading and transportation. Group leaders will present their findings/observations according to the following chart and answer the questions of the opponent groups.

Group A Good handling of fish/shrimp on board vessel		Group B Good handling during unloading and transportation	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 4 Types of salt to be used in *Nga-pi* or *shidhal*

The local processors mostly use low quality black salt. Group A will discuss the problems associated with the use of poor quality salt, while Group B will analyze the benefit of good quality white salt. The facilitator will sum up the discussion.

Activity: 5 Existing process of *Nga-pi* and its constraints

Group A will explain the existing process of *Nga-pi*, while the other group will find out the constraints of existing process. The group leaders will present their findings. The facilitator will contribute to fill up the gaps of discussion.

Group A Existing process of *Nga-pi*		Group B Constraints of existing process	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 6 Existing process of *shidhal* and its constraints

Group A will explain the existing process of *Shidhal*, while the other group will find out the constraints of existing process. The group leaders will present their findings. The facilitator will contribute to fill up the gaps of discussion.

Group A Existing process of *shidhal*		Group B Constraints of existing process	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity: 7 Improvement of the existing process

Group A will find out the processing steps for *shidhal* where improvement is needed, while group B will do the same for *Nga-pi*. Both the groups will draw flow charts of improved processes. One group will ask question to the other group. Facilitator will explain the improved process in detail.

Activity: 8 Use of elevated rack for drying of raw materials

Small shrimp or fish for *Nga-pi* are dried on split bamboo mats put on the earthen dyke along the coastline in the Rakhaing villages in Cox's Bazar. Punti is also dried on earth or mat on the ground in different parts of the country for *shidhal.* Group A will discuss about the demerits of drying fish or shrimp on the mat on earth and Group B will highlight the merits of using elevated rack for drying. Group leaders will present their results.

Group A Demerits of drying fish on mats on earth		Group B Merits of drying fish on elevated racks	
1		1	
2		2	
3		3	
4		4	
5		5	

Activity 9: Keeping the place and equipment hygienic and contamination-free

Group A will discuss about the demerits of unclean and unhygienic place and equipment, while Group B will discuss the

merits of cleanliness and hygienic conditions. Group leaders will initiate a question-answer session to find out measures for keeping all the utensils and place clean and contamination free.

Activity 10: Role of different stakeholders for improved product

The participants will be divided into 2 groups: boat owners/fishermen and *shidhal/ Nga-pi* processors. Each group will discuss what should they do to improve the existing *shidhal/Nga-pi* process and write the results of discussion in the following chart. Group leaders will present their results. One group will ask question to the other group. The facilitator will sum up the discussion and present improved processes of s*hidhal* and *Nga-pi* that also include appropriate packaging and storage of the products.

Stakeholders	**Measures to be taken for improvement**
Boat owners/ fishermen	1.
	2.
	3.
	4.
	5.
***Shidhal/Nga-pi* Processors**	1.
	2.
	3.
	4.
	5.

Information sheet-10

14b

Fermentation of Fish

Group exercise: 10
Method & result demonstrations: 6

Introduction

Fermentation has been a popular technology for the preservation of fish in Southeast Asian countries from time immemorial. Fermentation of fish takes place as a result of the action of exogenic and endogenic enzymes, the latter being naturally present in the guts and intestine of fish. Fermentation may be defined as the transformation of organic substances into simpler compound by the action of enzymes and microorganisms. Digestive enzymes are highly proteolytic and active at low pH, but visceral and digestive tract enzymes are active at near neutral pH. Various cereals and plants are added during production of several fishery products in Southeast Asian countries. One of the advantages of fish fermentation is that fish of all types and even marginally spoiled materials can be used. It is, therefore, one of the best ways of preserving fish particularly in the tropical countries and specially in glut seasons. We have a very popular semi-fermented fish product, s*hidhal*, made from small freshwater silver barb, *Puntius shophore* and *Nga-pi* from small marine shrimp and fish. Fermentation technology makes these species popular during their bulk harvest. Fermentation techniques can equally be applied to other underutilized species or industrial species.

Types of fermented fishery products:

i. Products primarily involving enzymatic hydrolysis.
ii. Products preserved by microbial fermentation.

Microorganisms capable of growing in the fermenting media, although may not be effective in accomplishing the process of protein digestion, are capable of supplying both lipolytic and proteolytic enzymes. There is no role of microorganisms in fish sauce fermentation as living bacteria rapidly die off in high salt medium and are not replaced by large population of halophiles. Consequently, there can be no contribution from bacterial enzymes to proteolysis. However, there are strong evidences to suggest that the microorganisms capable of growing in the medium contribute substantially to its characteristics aroma and flavor as molds perform in developing very definite flavor and color in “Katsubushi”, a smoke-cured dried form of skipjack tuna.

Different fermentation processes result in 3 distinct types of products:

a. fish largely retains original form: cured texture and aroma, as in *shidhal* of Bangladesh
b. original fish reduced to the form of paste: red/brown, salty, as in *Nga-pi* of Bangladesh
c. flesh is reduced to a liquid: salty taste, cheese like aroma, as in fish sauce.

Amano (1962) divided fermented fish products into 3 categories according to the processing technologies applied as:

i. traditional products mainly fermented by the action of enzymes present in flesh and entrails to which salt is added;
ii. traditional products fermented by the combined effects of flesh and gut enzymes supplemented with microbial

enzymes supplied in the form of starter culture on flesh and entrails added with salt;

iii. non-traditional products manufactured by accelerated fermentation, acid ensilage and chemical hydrolysis.

According to this classification, *shidhal* and *Nga-pi* of Bangladesh fall in the fist group.

Adams et al. (1985) divided the traditional fermented fish products according to the substrate used in the fermentation process as:

i. Products made from fish/shrimp and salt;

ii. Products made from fish/shrimp, salt and carbohydrate.

However, substrate or added ingredients only cannot represent a true classification of fermented fish products.

Saisithi (1987) proposed a complete classification based on both the type of substrate and the source of enzymes used in the fish fermentation process as:

i. traditional fermented fish in which the fish is fermented by the combined action of fish enzymes and bacterial enzymes normally present in the fish/ salt mixture;

ii. products in which the fish and a carbohydrate mixture are fermented mostly by bacterial enzymes normally present in the fish/salt/carbohydrate mixture;

iii. products in which the fish is fermented mostly by fish tissue enzymes and the carbohydrate is fermented by yeast and molds added in the form of starter culture.

Fish and shrimp flesh is the only available substrate for fermentation in *shidhal* and *Nga-pi*. The addition of salt reduces the water activity and protects the product from spoilage micro-organisms. The enzymes for the fermentation process come partly from the flesh and digestive system of fish/shrimp and partly from the bacteria naturally present in the fish/shrimp and in the salt. In producing *shidhal* and *Nga-pi*, only partial gut enzyme hydrolysis is

allowed, otherwise a complete hydrolysis will change the texture of the end product into fish sauce. In *Nga-pi* processing, excess liquid formed during salting process is drained off through the plant leaves over-wrapped. This reduces the internal enzyme activities in the flesh and water activity for bacterial growth (Nowsad, 2005a). Partial drying also prevents full hydrolysis of shrimp/fish tissue.

Table 14.1. Classification of fermented fish products

High-salt > 20% →	Liquid separation, fish sauce
	Residue or no separation, cured fish
	Comminution or fish paste, partial drying
Low-salt : 6-20% →	Lactic acid fermentation
	Acid pickling and low temperature
	Partial fermentation by protease, cured
Low-salt < 6% →	***Shidhal, Nga-pi***
No salt →	Dried bonito fermentation
	Alkali fermentation

Table 14.2. High-salt fermented fish products

Country	Fish sauce	Cured fish	Paste
China	Yu-lu	-	-
Indonesia	Ketgap-ikani	Pedah	Trassi
Japan	Shott suru	Shiokara	-
Cambodia	Nuoc-mam	-	Prahoc
Korea	Jeot-kuk	Jeotkal	-
Malaysia	Budu	-	Beladan
Myanmar	Ngan-pya-ye	-	Nga-pi
Philippines	Patis	Bagoong	Bagoong
Sri Lanka	Blood pickle	Jaddi	-
Thailand	Nampla	-	Kapi
Vietnam	Nuoc-mum	-	Mam-ca
Hong-Kong	Fish sauce	-	-
Africa	Fossik	-	-

Table 14.3. Low-salt fermented fish products

Country	Lactic acid fermented	Acid pickling	Enzyme fermented
Norway	Rakeorret	-	-
England	-	Tidbits	-
Germany	-	Schnell maatjes	-
Japan	Narezushi	-	-
Korea	Sikhae	-	-
Malaysia	Bekassam	-	-
Philippines	Brong-isda Balao-balao	-	-
Thailand	Pla-som, Pla-ra Pla-chom	-	-
Vietnam	Mum-tom	-	-
Bangladesh, Myanmar, India	-	-	*Shidhal, Hidal, Nga-pi*

Preparation of fish sauce

Fish sauce is the most important fermented fishery product as it is produced and consumed in large quantities in all most all Southeast Asian countries. Salt is the main constituent, comprising

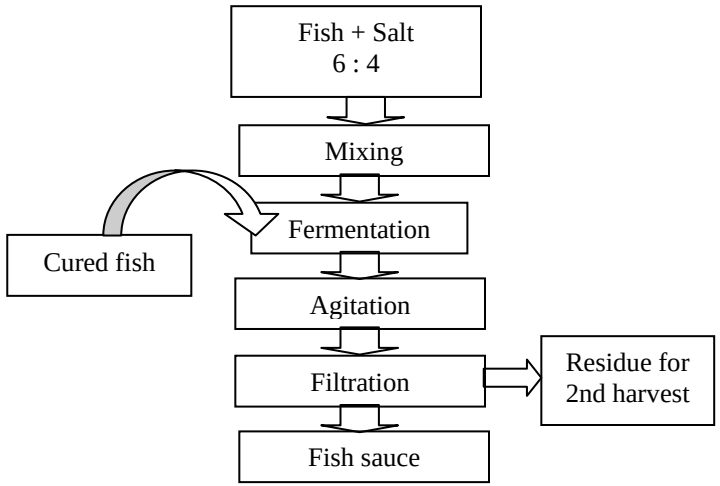


Fig. 14.1. Scheme for the preparation of fish sauce

up to 30%. Protein comes next, varying from 6–12%. The processing of fish into sauce involves hydrolysis of fish protein to peptides and amino acids that are water soluble. The time of sauce fermentation varies from 6 months to 1 year. Aging is an important step and helps to develop the aroma characteristic to sauce.

Specialty fish sauce: Nuoc-mam/Nampla

Nuoc-mam is by far the most favorite sauce of the Southeast Asians. It is produced in large quantities in Vietnam, Thailand and Cambodia, from where it is also exported in bulk to other Asian countries.

The species used for the production of *nuoc-mam* are predominantly anchovies (*Stolephorus* spp). Other clupeoids are also used, but the sauce obtained from anchovies is rated superior. Processing methods varies widely from country to country and from manufacturer to manufacturer. In large scale manufacture, whole unwashed fish is piled into large wooden barrels or cement tanks. Fish and salt are mixed in the ratio 6:4 and arranged in layers. After 3 to 4 days, the liquid containing blood and salt, called blood pickle, oozes out. This is removed and kept aside in bottle. The fish is then mixed well. Sometime mixing is done by trampling, in present times often mechanically with a shovel. The tanks are covered with coconut leaves over which two semi-circular bamboo layers are set. The blood pickle is poured over the system until a 10-cm layer is formed at the top. The fish paste remains in this condition for 6 months to 1 year. The clear sauce formed floats on the top of the tanks. The liquid is the *nuoc-mam* and it is siphoned out, filtered and preserved. A second harvest is usually achieved by adding fresh salt and water to the system, but the overall quality as well as protein content of the second harvest is very poor.

Quality of fish sauce

Fish sauce obtained from anchovies and *Cynoglossus* have golden yellow color and pleasing odor. First harvest sauce produced from sardine has low pH of around 6.0 and pH goes down further (5.0) during second harvest.

Table 14.4. Yield of fish sauce from tropical fish

Fish used	Yield of sauce, ml/kg wet fish	
	First stage	Second stage
Sardinella longiceps	660	230
Stolephorus commersonii	840	140
Sphyraena sp.	600	210
Cynoglossus sp.	350	110
Saurida tumbil	510	220

As sauces are formed by extended fermentation for over a year, various chemical changes take place. Total solids and total nitrogen increase up to 8 months and then become steady. Total volatile nitrogen increases up to 4 months and then decreases or becomes stationary. Trimethylamine decreases gradually with times where as, total volatile acid number increases. Of all the chemical indices, volatile acid number appears to be the best quality criterion for measuring the process of maturation of sauces, provided utmost care is taken in its measurement. A fermentation period of 8 months is sufficient to get a good quality sauce and prolonged fermentation after 10 months causes little increase in yield or quality.

Semi-fermented fish - *Shidhal* or *Chepa* of Bangladesh

Introduction

Shidhal is a cured semi-fermented fish product where partial hydrolysis of protein is accomplished by endogenous enzymes. Generally, a freshwater small silver barb, *Puntius sophore,* is used as raw material of *shidhal* during its bulk catch during the winter season. *Shidhal* has a very special type of characteristic flavor and used as flavor enhancer or condiment in the main dishes, relished by the great variety of people of the sub-continent with special preference attained in central and Northern part of Bangladesh. The protein is partially hydrolyzed due to low moisture and salt levels since the raw material is sun-dried before fermentation.

Shidhal, also called *Chepa,* has been playing an important role in gratifying the tongue of most people of the middle, Northeastern and Southeastern parts of Bangladesh. Although eaten by everybody, *shidhal* is highly relished by the people of greater Sylhet, Mymensingh and the hilly districts. Even if any extreme averse man once eats *shidhal* by excelling its hideous odour, he might have developed madly addiction due to its unforgettable taste. *Shidhal* has unique magic power to attract the consumer. Such attraction is never observed in any other food-stuffs in Bangladesh. For this, associated with peoples' increasing affection to traditional foods, demand of *shidhal* has increased many folds and hence, the production and marketing have increased at a level much higher than ever before. Processing zone has been expanded to the new areas, but the processing method remains traditional. Still the fish are processed under unhygienic conditions.

Different products under similar names

Semi-fermented *P. sophore* is generally known as *shidhal, chepa or shidhol sutki*. It is also so named in different handouts, class notes or books for undergraduate and graduate courses. It is, however, called *hidol* in the villages of greater Mymensingh, Sylhet, and Comilla. The term *shidhal* may be an elite version of *hidol*. In Chittagong Hill Tracts, it is called "*Berma*". Although fermented *chepa* and *shidol* or *shidhal* are synonymous, but the s*hidhal* and "s*hidil"* are two different fisheries products in Bangladesh.

Shidhal, chepa or *hidol* is a partially fermented product processed from moderate sized barb (*P. sophore*) which is mostly available in ponds, river, lakes, beels and depressions of Bangladesh. On the other hand, *shidil* is a different type of storable dried and ground paste or powdered fishery product in the North Bengal, particularly in Rangpur, Nilfamari and Dinajpur districts. For the manufacture of *shidil* first the small fishes like punti, darkina, taki, tengra, meni, baicha, shol, kholisa etc. are dried in the sun during the winter. Wild esculent leaves,

stems or roots are also dried at a time. Dried fish and esculents are crushed together into powder in a wooden mortar and pestle. Crushed powder is screened if needed. During crushing, dried chilli, other spices and salt are added. The mixture is further dried for several hours and preserved in porcelain or glass jar.

In another method, dried small fish is mixed with semi-dried esculent stem or leaf and then turmeric powder, garlic and mustard oil are added. The mixture is ground to a paste by a wooden mortar and pestle. The ground paste is shaped into small round cakes and dried in the sun for 2-3 days under cover with cotton cloth. Sometimes, little anaerobic fermentation is allowed in closed container that gives extra flavour and taste. These esculent mixed dried fish powder or cakes are also known as *shidol* but very often *shidil* in Dinajpur, Rangpur and Nilfamari area. Upon mixing with fresh onion, green chilli and mustard oil, this powder or cake is transformed into a delicious paste, locally called *vorta*. *Vorta* is taken as condiment with boiled rice. While cooking fish curry, *shidil* is often dissolved in its juice to enhance the thickness, taste and flavour of curry. Sometimes, *shidil* cakes are wrapped by banana leaf and grilled or fried in oil and eaten with rice. *Shidil* is stored at room temperature and served to supply protein nutrition during lean season or famine in monga-striken Northern part of Bangladesh. The production has been, however, reduced significantly due to scarcity of small fish.

Processing area

Since the ancient time, a huge quantity of common barbs have been harvested from the haor, baor, beel, canals and low lying water bodies of the greater Sylhet, Comilla and Mymensingh districts. To utilize huge catch of this popular species, a very effective processing technique of partial fermentation has been developed in this region during the winter. *Shidhal* has long been produced in haor areas of Moulovibazar and Sunamgonj and fish landing centers of Mymensingh, Kishoregonj, Netrokona, Kuliarchar and Mohongonj. Due to success of fish culture in

flood plain areas, the production of *Puntius* has also been increased in such seasonal water bodies. Presently, *shidhal* processing has been expanded in such flood plain fishery areas too. Notable of them are Daudkandi, Faridpur and Jessore.

Species for *shidhal*

Several types of small silver barbs are found in Bangladesh, like shar punti (*P. sarana*) jat punti (*P. sophore*), tit punti (*P. ticto*), etc. Recently, English silver barb or raj punti (*Barbones gonionatus*), a very fast growing species, is introduced from Thailand and being extensively cultured in the inland water bodies. Jat punti or simply called as punti, a medium size fleshy, thick-flattened, elongated and oily species, is found best for *shidhal* preparation. Other species like bigger size tit punti or smaller raj punti are also used as adulterants. A great difference is observed between the quality of *shidhal* produced from flat, thin and less fleshy tit punti and thick fleshy and oily jat punti. Sharpunti, though oily, is expensive and never used in *shidhal.* There are reports that small size raj punti are mixed with jat punti in producing *shidhal*. Thai raj punti is a thin and flattened species with more pin-bones compared to jat punti. Taste of the products would be quite different if examined meticulously. Now a days, some other low-cost fatty species like anchovy, *Sardinella*, faissha, etc. have been used in *shidhal* processing in different places. But the taste and flavour of these products are completely different from the *shidhal* made from jat punti.

Conventional processing method

In winter when the water body ceases to narrow pit, huge quantity of *Puntius* sp. are captured by draining out of the water. The fishes are sun-dried and anaerobically fermented to produce *chepa* or *shidhal*. The fish to be fermented is eviscerated before sun-drying, but not scaled or washed. The earthen container, locally called “motka” is well prepared beforehand the fish is kept. The ‘motka’ is dried in the sun for some days and vegetable oil is coated inside the container several times. Finally, fish oil stripped out from

raw material fish is again coated in side the container and dried for maturation. Sun-dried *Puntius* has a moisture level less than 20%. A small amount of water (3-5%) is sprinkled with salt granules over the dried fish which are symmetrically arranged in such special type of earthen containers `motka' prior to fermentation. The water is added until the raw material is softened to a certain degree that gives the best final product with good texture and aroma. The fish are arranged in layers, and in each layer, salt and water are sprinkled over the fish. The container is fixed underground and the fish is filled and packed tightly in the container as far as possible giving no chance of air to retain. The opening of the container is sealed with banana leaf and polyethylene paper. After the mouth is completely closed and sealed with mud, the container is fixed inside the ground keeping only the mouth above the ground level. The container is kept in this condition for 3 to 4 months. The final product achieves a good texture with no trace of melting any part or formation of liquid. The container is taken out of the ground and kept at room temperature for marketing of the product. The shelf life of the product thus prepared may extends up to 1 year.

Preparation of s*hidhal* in Kulierchar, Kishoregonj

To produce *shidhal* in Kulierchar, the following steps are generally followed:

- Harvested jat punti are transferred to the drying yard by bamboo made basket without chilling or icing;
- Fish are not washed before sun-drying; clay, sand or dirt are adhered to the fish;
- Very often scales are not removed, gill remains intact with the fish;
- Abdominal oils are collected by pressing the belly with thumb and index finger. Bigger species are transversely cut through the pelvic region to release oils. Oils mixed with entrails are then preserved in a tin container. This oil with gut content is allowed to decompose for 2-3 days until the fresh oils come out at the top layer. The content

is heated for hours while oil goes up and the gut content is deposited at the bottom. Clear oil is separated by decanting to another container. Remaining oil is allowed to cool to solidify. Solid oil is taken out easily and bottom deposits are rejected. Collected oil is used to polish the earthen vat where fermentation of fish is to be performed. Rejected gut contents are used as feed or fertilizer in fish or poultry husbandry.

- After collecting the oil, fish are spread on the soil, bamboo split mat or elevated racks for sun drying. Sometimes 4-5% salt is mixed with the fish before drying. However, *shidhal* without salt is more popular than the one with salt. Most of the salty *shidhal* are produced in greater Mymensingh and Sylhet, while salt-free *shidhal* are produced in the middle-western part like Faridpur and Jessore. Fish is dried for 4-5 days while moisture content comes down to approximately 20-25%. Dried *Puntius* is either stored in polythene sac for future processing or immediately used to allow fermentation process.
- Dried *Punti* is taken in a bamboo made basket and soaked in the river water to wash rigorously for 30-60 minutes. Thus, it eliminates wastes, reabsorbs water, becomes soften and gets ready for fermentation. A 25 to 30% weight gain occurs due to soaking. Soaking time depends on the size and quality of the dried fish. Moderate sized good quality dried fish if soaked for 30-40 min. can yield uniform and adequate fermentation. Rigorous washing removes all scales and dirt from the fish. Sometimes, instead of washing of dried fish, water is sprinkled over the fish. This can regulate the fermentation process.
- Washed fish or those sprinkled with water are put in the earthen vat. The vat is a round shaped wide-mouth pot with a capacity of 50 kg fermented fish. The vat is prepared beforehand by polishing fish oils inside and outside walls several times and then drying in the sun for 3-4 days. The vats thus dried and matured do not allow

any air or moisture to pass through the pores of earthen wall. Generally, oil polishing is continued until the wall absorbs no oils. The quality of *shidhal* largely depends on the preparation of the vat;

- The vat thus prepared is then fixed in the ground to prevent movement while pressing fish in it that might damage or break the vat. Water treated dried fish of uniform size are arranged in layers in the vat. Most preparations do not use salt, but sometimes a little amount of salt is sprinkled over each layer of fish. After placing fish in layers in the vat, they are pressed by leg to remove entrapped air in between the fish. The workers/processors put right leg in the vat and press fish continuously by moving foot and toes. Human sense and touch help to exert adequate pressure that can also understand the extent of air removal for anaerobic fermentation without damaging and cracking the earthen vat. Damage or crack due to pressure can also be prevented as the vat is kept fixed in the earthen hole. After filling fish up to the neck a layer of salt is given on the top. The mouth is covered, first with a piece of polythene and then by a lid made of tin or steel. The entire mouth is sealed with clay or mud after that. Sealed vat is kept in the earthen hole under the shed or in dark cool room for aging or fermentation.

Fermentation process

Sealed vat with fish is kept in the earth or dark room to allow anaerobic fermentation. The fermentation generally takes place for a period from 3-6 months depending on the nature of the products. The enzymes present in fish muscles or that released from the bacteria present in fish or salt catalyze the fermentation process in fish tissue. As a result, the texture is changed and a characteristic flavour and colour are developed by such partial fermentation. Body tissues are broken down to soft cells but still remain attached to the frame. Otherwise, complete fermentation might transform the tissue into fluid mass, which is popularly known as fish sauce. *Chepa* or *shidhal* is not a product of

complete fermentation. Fermentation is controlled as it is accomplished by the body or bacterial enzymes only. Even within the limit of this partial fermentation, the extent of fermentation required to obtain a desired quality depends on the nature of the product and the demand of the consumers. Fermentation process is regulated by the soaking period or water sprinkling also. Soaking fish for more than 30 minutes allows more water to absorb, resulting rapid fermentation. Fish soaked for longer time may disintegrate the muscle. Therefore, highly soaked fish are not kept anaerobic for more than 2-3 months. Longer soaking may increase the weight but reduce the quality. The processors often maintain a balance between the quality and profit.

Demand of *shidhal* varies from place to place depending on the quality of the product. The consumers of Mymensingh and Sylhet often like pungent flavoured soft textured products. This typical quality characteristic comes from a moderate level of partial-fermentation. Tribal community like highly pungent flavoured soft textured torn-belly products, while the general consumers throughout the country want fine smelled, good shaped intact products. In terms of the level of fermentation, later two products are extreme opposite if compared to the former one, which can be considered as moderate. Fermentation period often regulates the business. Long time fermentation disintegrates the muscles resulting significant weight reduction in the final product that threatens the business in widely spreading general market. Processors, therefore, make a balance by increasing the soaking time and decreasing the fermentation period. On the other hand, since the market value of such product is less in Mymensingh and Sylhet, a comparatively better quality product is produced for this region. Rotten punti, if fermented, disintegrates very rapidly, even if low-scale fermentation is accomplished. This product may mislead the consumer. However, the difference between the characteristic flavour of good quality *shidhal,* flavour of spoilt fish and the nature of muscle rupture can detect the product

prepared from fresh or rotten raw materials. Generally, high level of salt is used in case of rotten raw material.

Constraints of existing process

Fermentation of *Puntius* to produce *shidhal* is a traditional process. Proper sanitation and public health measures are completely lacking in both fish handling and processing. The constraints of the existing process can be summarized as follows:

- Harvested fish are not iced during transportation and preprocessing. Very often the raw material fish are spoiled. Physical appearance and sensory parameters can not detect the quality of fish until or unless the quality degradation cross the 50% limit. Only after 50% spoilage of a fish, sensory attributes like odour, physical appearance, gill and eye conditions, muscle texture, etc. can detect the quality. It means that up to 50% of spoilage, a fish is still considered to be apparently fresh through such parameter reading. About 100-160 kg of fish are transported by a single bamboo basket at a time. Again, the pressure exerted by the top fishes on the bottom fish eventually deteriorates the quality of the 50% of the fish in the basket. Due to use of such rotten fish, desired texture, colour and flavour are not achieved in the final products. Poor raw material decreases the market value, as well as the shelf life. Most of the processors are ignorant about the impact of low quality raw material on product shelf life.
- The fish are not washed after harvest. They remain unwashed even after scaling, gutting or oil collection. Parts of entrails remain attached to the abdomen while collecting oils. These along with gut enzymes deteriorate the quality of fish.
- The fish are kept piled on the soil/sand, on unclean mat or racks while collecting oil. Mats or racks used for fish drying are not cleaned after each operation. Therefore, serious bacterial contamination occurs. Wind action, human activity or grazing of animals spread dust and dirt on the fish. Drying on sand and mat also contaminate raw materials;

- Processors and workers do not follow regulation of sanitation and public health. Unclean hand, body, clothes often serve the basis for contamination;
- Fish are not often dried well before fermentation. Dried fish are generally stored in polythene sac for 2-6 months before fermentation. Harmful insecticides like DDT, Basudin, etc. are used during storage;
- Adequate soaking time is not maintained which may cause uncontrolled fermentation;
- Fish are pressed in the vat by a bare leg. Sweat, dirt, dandruff, dropping hair, etc may come in contact of the product during processing. Pressing by leg is completely unacceptable from both the ethical, aesthetic and hygienic point of view;
- Fermented products are stored and transported in polythene sacs or bamboo baskets. These all are not very useful methods. Moisture is reabsorbed in the open products at different stages of storage, transportation and marketing. This deteriorates the quality and reduces the shelf life of the products;

Improved methods for *shidhal* processing

The quality and shelf life of *shidhal* can be improved by improving the methods of handling, practices of processing and adequacy in packaging, such as:

- Fish should be washed with tube well water after harvest and iced adequately in appropriate ice box. Low-cost ice-box developed for transportation of iced fish can be used for this purpose;
- Scales, fins, gills and gut should be removed;

- Fish should be washed again after collecting oils. Oils should be collected and preserved in clean container;
- Earthen vat should be cleaned, dried and oil-treated adequately. In case of insufficient fish oil, other animal or vegetable oils can be used;
- Fish should be dried on the rack or in box or ring tunnel covered by the mosquito net to prevent blow fly and other insect infestations and also contamination from sand or dust. Harmful pesticides should not be used;
- To prevent dried *Puntius* from insect attack 1% red chilli powder can be spread over the fish while drying or during storing;
- Fish should be dried very well so that the moisture level is reduced to 16-18 %;
- Adequately dried fish should be soaked in water for not more than 20-25 minutes. Fish in the vat should not be pressed by leg. Right hand wearing gloves can be an alternative. To get a good result, a roll of used clean clothes tied up on the tip of a wooden pole can be used for pressing;
- Fermented *shidhal* should be packaged in high density polyethylene, polypropylene packet for storage, transportation and marketing. This type of packaging will protect the product from bacterial contamination, moisture reabsorption and rodent or insect attacks;
- Packaged products should be stored in clean, dry and cool place.

Process of *Nga-pi*

Nga-pi is a fermented fish product in which the original fish is reduced to the form of a paste. The fermentation involves the breakdown of wet protein into simpler substances which are

themselves stable at normal temperatures. This breakdown is partial and is controlled by the addition of salt. Typically, the fish or shrimp are ground to a paste with a little amount of salt. The paste is subjected to alternate sun-drying and grinding before being packaged to mature in an air-tight container. The moisture content of a typical paste varies from 35 to 50%. Therefore, almost half of the water present in the fresh raw material will have been lost during processing. A good quality *Nga-pi* is produced from *Acetes* shrimp with small proportion of *Mysid* shrimp. The yield varies from 40 to 50% of raw shrimp. A typical analysis of good quality *Nga-pi* is : pH 7.6-7.8, moisture 27-40%, ash (including salt) 20 – 24 %, salt 13 – 18 % and protein 30 - 40% (Clucas and Ward, 1996).

Preparation of *Nga-pi* in the Rakhaing villages of Cox's Bazar

i. Smaller *Acetes* and *Mysid* shrimps are mainly used for the preparation of *Nga-pi*. Sometimes white fish fry, fingerlings, small fish and other bigger shrimps are also used for different products.

ii. Unsalted and un-iced small shrimps are carried to the processing site (dyke of Warter Board) by bamboo basket from the boat. Sometimes rickshaw van is used for transportation. Mats made of split bamboo are kept on the slope of the dyke. Small amount of salt is spread over the mat (roughly 1 kg salt for a 12 x 20 feet mat) and then shrimps are spread in thin layers over it. Salt treatment varies with the types of shrimp. *Acetes* and larger shrimps do not require such pretreatment with salt.

iii. Shrimps on the mat are dried in the sun for the whole day. To protect from blow fly infestation, pesticides may be used, mainly during the rainy season. There is no fixed dose, a common practice is 10 ml of '*Nogos*' diluted to about 10 L of water. The solution is sprinkled over the shrimp by hand sprayer. Semi dried shrimp is ground in wooden mortar with salt at the following night. The amount of salt varies from 1 to 2 kg per 40 kg shrimp (2.5 – 5%).

iv. On the following day, salt-ground paste is dried in the sun for the whole day and ground again at night. Salt is not added during second grinding. In this way, the product is dried again on the 3rd day and finally ground into paste with no further salt incorporation.

v. The final paste has got a deep-grayish to blackish appearance. No color is incorporated. Final paste is shaped to a globe and wrapped by large leaves of a local tree called "*Mospata*". Wrapped *Nga-pi* is packaged in light basket made of bamboo-split, locally called "*Khachi*". A dough of 20 kg is packaged in one *Khachi* and kept for about 7 days for aging (fermentation). The final product is generally sold within a week or sometimes stored for several months for good price.

vi. According to the local processors, *Nga-pi* produced in such method can be kept for about 6 months.

Market of *Nga-pi*

The main markets of *Nga-pi* are Khagrachari, Rangamati and Alikadam. Businessmen from these places come to the Rakhaing villages of Cox's Bazar to buy the products. Local producers do not carry their products to the remote market places for sale. A small quantity of *Nga-pi* is produced and sold in Nagirartek (Kutubdiapara) fish drying yard of Cox's Bazar Sadar. Good quality products are reported to have been exported to the Eastern Provinces of India and Myanmer.

Desired quality of raw material shrimp

Acetes and *Mysid* shrimps are widely used in *Nga-pi* preparation. Other smaller low-cost shrimp and small fish like anchovy, sardine, ribbonfish, etc. and fries and fingerlings of commercial fish are also used. A special type of set bag net called "Ming Jal" having very minute mesh size is used to catch *Nga-pi* raw material. This gear is set in the estuary and coastal water along the tidal current that can

catch object of any size passing through it. *Nga-pi* net is considered as one of the most destructive fishing gears so far, that devastates the living aquatic resources and biodiversity of the coastal ecosystem.

Acetes shrimp produces best quality product. Fresh raw material should be used for good quality product. However, local processors do not have clear understanding on the quality of raw material. Most of them believe that rotten fish/shrimp can equally produce good products, as good as fresh one. Spoilt fish/shrimp increases the weight of the final product. This is another reason why they often hide the truth in support of their interest for using the spoilt raw material.

So, remember that –

- Fish or shrimp to be used for *Nga-pi* must be very fresh;
- *Nga-pi* prepared from spoilt fish/shrimp may sick the consumer;
- Fish/shrimp mixed with mud/clay should not be used;
- If certain extent of spoilage is needed for any specialty product, it should be done under controlled, sanitized and hygienic conditions.

How can we keep the raw material fresh?

- The harvests of very fine meshed estuarine set bag nets, locally called "*Ming Jal"* are used in *Nga-pi* processing. These special types of gears are fixed in shallow waters along the direction of tidal current. Clay, sand, mud, debris, seaweed, etc. enter the bag of these gears and are mixed with small fish/shrimp. To avoid this unwanted entry, the net should be fixed several feet above the bottom. The harvest should be separated from mud/debris and be washed thoroughly with clear sea water;
- Other large and small organisms like fish, snails, mollusks, squid, cuttlefish, etc. should be separated from *Nga-pi* raw material as soon as the gear is lifted;

- A thorough second wash should be done after sorting;
- Washed raw material can be kept in cooled fish hold. Thus, direct icing can be avoided in order to keep the colour of the product bright;
- A 4-5 % clear salt should be sprinkled over the cleaned fish/shrimp.

Good handling of fish/shrimp on board vessel and during transportation

- Small shrimp/fish mixed with salt should be kept in small drums or boxes in fish hold. Bulk salting will deteriorate the quality of the shrimp which are kept at the bottom of the stack;
- In any case, shrimp/fish can not be kept under sunlight;
- Clean container/basket should be used to unload and transport the raw material;
- All utensils should be washed and kept clean after each use.

Quality of salt to be used

Very low quality black salts are generally used in *Nga-pi* preparation. As the salt is sprinkled over the stack of the raw material, very often remaining debris are found on the stack when salt is melted or absorbed.

- Black salt contaminates the product and may cause serious illness;
- Black salt can not bring desired level of fermentation;
- So, always use clear white salt.

Drying of shrimp/fish

- Do not sun-dry shrimp or fish on the mat kept on earth;
- Always use elevated (3-3.5 feet high) racks to dry shrimp/fish.

Maintaining sanitation during *Nga-pi* preparation

During preparation, different spoilage and pathogenic bacteria may contaminate *Nga-pi*, if proper sanitation is not maintained.

Bacterial contamination deteriorates the quality and reduces the shelf life. Therefore, always –

- Use clean container/basket/rickshaw van for transportation of raw material and product;
- Thoroughly wash bamboo mat/container/basket/rickshaw van after each use;
- Keep the washed utensils and mats on the racks or roofs so that animal can not graze on them;
- Always use clay and contamination-free clean salt.
- Use clean wooden mortar to pound shrimp or paste. Wash mortar and pestle after each use and keep it dry at elevated place so that dog/cat can not touch.
- Use coarse polythene sheet around the pounding place. Do not put ground paste on the earth;
- Do not pick up raw material or paste from the earth that is dropped during pounding;
- *Nga-pi* is a food. So it should be treated like other food items like rice, curry, etc. Wash both hands with soap and ware gloves before handling *Nga-pi.*
- Packaged *Nga-pi* should be stored at elevated rack made of bamboo or wood inside the house. Do not store it in polythene on the ground;

How long shrimp/fish should be dried for *Nga-pi*?

- Salt ground shrimp paste should be dried up to such a level that the particles can be separated by finger press;
- Water content of the final product should be less than 30%;
- To achieve desired drying, *Nga-pi* should be ground and dried alternatively for at least 3 days;
- For drying, raw material should be spread thinly on the mat;
- Small amount of salt can be spread on the mat before the raw material is placed to avoid sticking small shrimp/fish to the mat.

Table: 14.5. Benefit of drying small shrimp/fish on elevated rack

Demerit of drying shrimp/fish on mat on earth	Merit of drying fish/shrimp on rack
1. Drying process is slow since less air flow on the earth surface	Drying is quick as air flow is high
2. Only surface of fish receives air flow and sunlight	All around the body surface receives air flow and sunlight
3. Fish come in direct contact of clay/mud. Situation is worse in rainy season	No chance of contamination by clay/mud
4. Sand/dust kicked off by pedestrians or car/rickshaws directly blown to fish	Blow of sand/dust over the fish is less
5. Dogs and cats graze and excrete on fish	No chance of grazing by animal
6. Drying place is dirty with human and animal excreta and difficult to keep clean	Elevated rack is clean and easy to keep clean
7. Difficult to work on the mat on earth	Easy to handle and work as it is elevated up to the pelvic girdle of the worker

How much grinding is desirable?

- In order to get good quality *Nga-pi*, raw material should be finely meshed so that the carapace, shell, back bone, bones and other hard particles are disappeared;
- Grinding would be uniform and fine if other big fish, crab, snail and bivalves are removed beforehand;
- Fine is the pounding, uniform will be fermentation and better will be product quality.

Do not use any pesticide

- Pesticides are poison. Use of any pesticides in *Nga-pi* or dried fish is prohibited;
- Along with the pests, insects or harmful bacteria, pesticides also kill desired bacterial fauna and hinder fermentation process;

- Desired products are not possible if any sort of insecticide/pesticide are used in *Nga-pi*;
- To avoid contamination, use good quality fresh raw material and good salt and keep the place, environment and materials/utensils clean and hygienic.

Packaging of *Nga-pi*

In the traditional process, a mass of 20 kg *Nga-pi* is shaped into a circular block or globe. The globe is then wrapped with *Mochpata*, a large leaf of a mountainous tree. Finally, the wrapped material is kept in a very thinly woven basket made of split bamboo before being stored for aging or transportation. Generally, packaged block/globe is kept at home for 7-10 days for fermentation. Water is removed from the product due to the action of salt. Plant leaves have the ability to absorb water.

- After necessary fermentation, *Nga-pi* wrapped by *Mochpata* should be packaged by appropriate method;
- For retail sale, this can be packed in airtight polypropylene coated polyethylene pouch;
- For bulk packaging, *Nga-pi* paste first packaged in poly-bag can be master-packed further in wax-coated cardboard carton.

Constraints of existing process

- ♣ The handling of raw material on board vessel and its transportation are not proper, which may lead to contamination and spoilage;
- ♣ Small shrimp/fish are not properly washed with seawater. They are sold as it is harvested with mud and debris and directly taken to spread on the bamboo mat for processing;
- ♣ Raw materials are mixed with huge number of spawns, fries fingerlings and juveniles of finfish, small fish, penaeid and other shrimps, crabs, cephalopods and other unwanted

mollusks and arthropods that may impose serious negative impact on the nature and biodiversity;

- ♣ The products are contaminated by the adhered spoilt paste of unwashed mats, sand, dust, animals, low quality salts, etc.;
- ♣ Working environment, places and utensils are not clean and hygienic;
- ♣ The products are not finely meshed or crushed into paste;
- ♣ Ripening or maturation time is not adequate;
- ♣ Color of the product is not attractive;
- ♣ Packaging is vulnerable for handling, transportation and storage.

Suggestions for quality improvement

- Careful handling on board vessel and during landing can keep the small shrimp/fish fresh for longer time;
- Larger shrimps, fish, mollusk, arthropods, etc. should be sorted out so that only *Acetes* or *Mysid* shrimp remain;

- After sorting on board vessel, small shrimp should be washed with seawater to remove any undesirable material like, dirt, mud, rubbish, algae, etc.;
- Washed material should be stored with 5% clear salt in cold room;
- Fishermen should be encouraged to salt the small shrimp (5%) as soon as it is harvested and washed at the sea;
- Salted raw material should be kept cool indirectly (keeping in cool container, etc.) on board vessel or during transportation and should not be exposed to the sun at any stage;
- A 4-5% good quality salt can be sprinkled on the drying mat before spreading to avoid sticking to the rack;

- Drying of shrimp should be done on elevated bamboo racks (3.5 feet high) to protect it from dust or animal grazing and to dry rapidly;

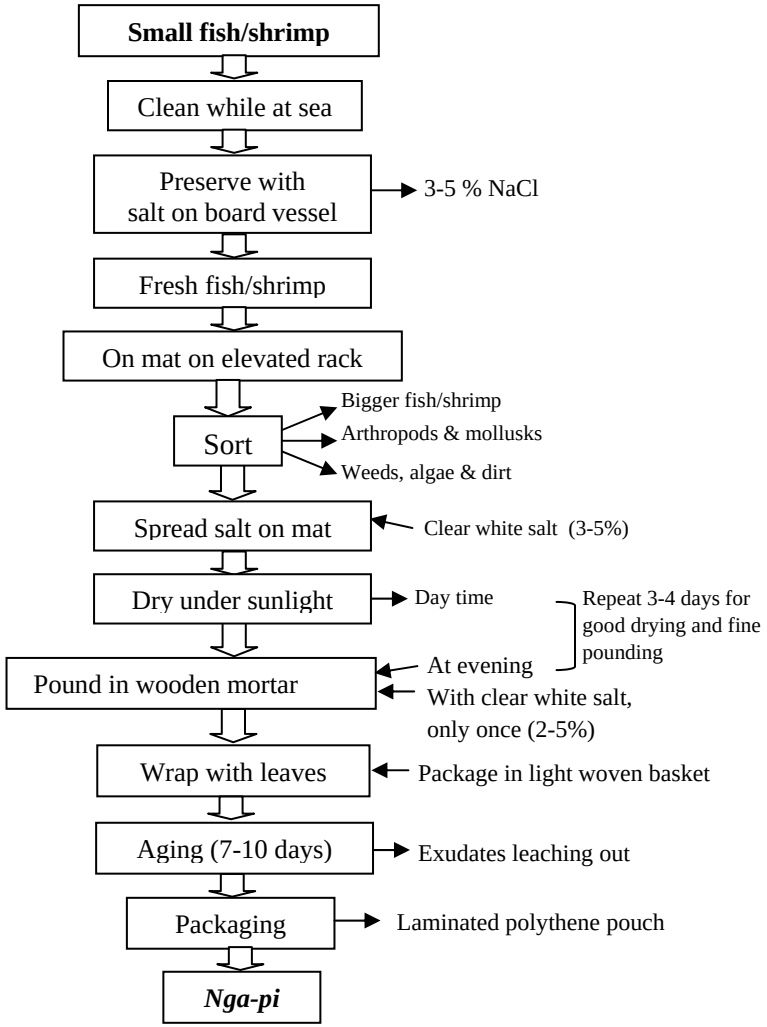


Fig. 14.2. Scheme for the preparation of improved quality Nga-pi.

- Use of pesticides should be strictly prohibited. Food grade preservatives, like calcium propionate or calcium-magnesium-propionate can be used directly on the paste or mixing with salt. Recommended dose is 0.1-0.2 % propionate powder for direct application on shrimp/fish. A 3 part calcium propionate mixed with 97 parts NaCl can be used during pounding.
- Semi-dried shrimp should be ground with good quality salt in a clean wooden mortar;
- To accomplish uniform anaerobic fermentation, the dried and ground paste obtained after 3 successive days of operation can be filled in a covered wooden box under pressure to exclude all air and prevent oxidative rancidity. Initially the paste can be allowed to ferment anaerobically for 7-10 days;
- The paste may be dried and ground further until the desired texture is obtained.
- The final product should be packaged in airtight container after wrapping by polythene sheet or laminated paper;
- All utensils should be washed and cleaned and kept out of the reach of animals.

Conclusion

Production of *Nga-pi* is the only livelihood of about 10,000 coastal Rakhaing fishermen who produce such relished dish for about 2.5 million tribal people of Bangladesh. The life and health of such people are directly related to the quality of the product. There are ample prospects of exporting *Nga-pi* to other countries if the adequate quality is maintained. It is, therefore, deemed urgent need to improve the quality of *Nga-pi* in order to secure the lives and livelihoods of tribal people.

Facilitation sheet-9

15a

Packaging of Fish and Fish Products

Activity: 1 Why packaging is needed in fish and fish products?

The participants will be divided into 2 groups. Group A will find out the benefit of packaging of fish and fish products and Group B will point out the problems they have to encounter if the products are not packaged well. Group leaders will present the findings. Facilitator will initiate a question-answer session.

Group A Benefit of packaging	Group B Problems of inadequate packaging

Activity: 2 Packaging materials

Group A will discuss about the types of packaging for different fish products and Group B will outline packaging materials should they use for the products. Two groups will fill up the following chart and group leaders will present those before the participants. Group discussion will continue till the facilitator draw a conclusion highlighting the important points.

Products	Group A Nature of package	Group B Packaging materials
Wet fish		
Frozen fish		
Dried fish		
Salted-dehydrated fish		
Smoked fish/shrimp		
Salted/semi-fermented ilish		
Chepa, Shidhal		
Nga-pi		
Fish mince products		
Battered/breaded products		

Activity: 3 Packaging / regulatory requirements

Group A will outline the information should they provide on packages of different products and Group B will identify the problems they may encounter if the information is not adequately mentioned. Group leaders will present their findings. Group members will ask questions. The facilitator will discuss the details of packaging/regulatory requirements.

Products	Group A: Ranges of information needed on the package	Group B: Problems to face if adequate info is not provided
Wet fish		
Frozen fish		
Dried fish		
Salted-dehydrated product		
Smoked fish/shrimp		
Salted/semi-fermented ilish		
Chepa, Shidhal		
Nga-pi		
Mince products		
Battered/breaded products		
Canned fish		

Information sheet-11

15b

Packaging of Fish and Fish Products

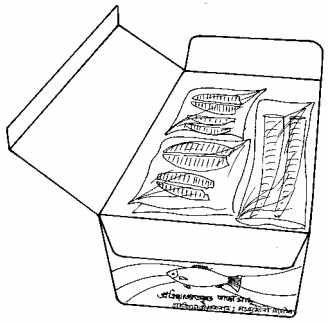
Group exercise: 3
Field demonstration: 1

Introduction

The success of a product can not be determined right at the end of production line. The product has to pass through a process called packaging which is the means through which it reaches the markets and ultimately consumers. Packaging provides information which are important to the consumer i.e, product identity, its origin, how to use and store it; and nutritional information among others. Good packaging also enhances efficient mechanized handling, distribution and marketing, thus eliminating labour cost which would have to be absorbed into the price of the products. Packaging, because of its diversified designs and the types of materials used, in most cases helps to promote the products.

Role of packaging

The way food products are packed depends greatly on the varied needs of the consumer. Where perishable products such as fish is concerned, convenience, protection as well as attractiveness accorded by the packaging materials used, play an important role in



the actual sales of the product. Packaging of any product plays four major functions as containment, protection, utility and communication.

The most important function of packaging, however, is the protection it offers to the products. Among other functions, packaging should:

- protect the products against dirt, chemical (moisture, odor) and biological agents (insect, micro-organisms), adulteration, tempering, contamination, damage, etc.
- help ease the distribution and during product display on shelves, boxes, etc.
- serve as a means of communication and provide information on the products, whether as requirement or to attract consumers;
- help to add value to the product especially with high quality and attractive packaging;
- help product promotion to increase product range;
- help to minimize the cost of product;
- help to extend shelf-life of product.

Packaging requirement

The materials commonly used for packaging of fish and fish products are as follows:

- Split bamboo baskets, plant leaves in mats, wood in boxes;
- Paper or board in boxes, cartons;
- Rigid materials like can;
- Glass container like jars;
- Plastics like bags, pouches, films, sheets, jars, boxes, etc.

For determining better packaging methods and materials for some final fish products, the first and foremost aspects which need to be evaluated are the factors that will affect the products. Generally, answers of the following questions are needed.

- Does the product require protection of oxygen and any other gases?
- Is it sensitive to light?
- Is this requiring preservation of aroma and moisture?
- Will it be frozen? If so, at what temperature?
- Does the product have sharp edges or points?

Some other points related to marketing should be considered as well as follows:

- Is the product going to retail sale or wholesale?
- What are the legal requirements for the product in relation to packaging?
- How much can be afforded in packaging?
- What kind of packaging would appeal and is best suited to the product?
- What kind and how much information is needed to put on the packaging?

Different types fish packaging

There are four common types to fish packaging as follows:

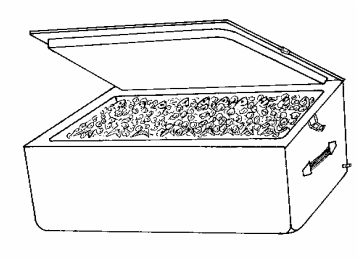
1. Bulk packaging for fresh fish
2. Wholesale packaging of fresh, frozen or other processed fish
3. Retail packaging of fresh/frozen or other processed fish products
4. Air freight packaging

1. Bulk packaging of fresh fish

After landing, fish are loaded to woven bamboo basket, wooden or plastic boxes and iced. Now a days, wooden and woven bamboo baskets are replaced by plastic boxes all over the world because they

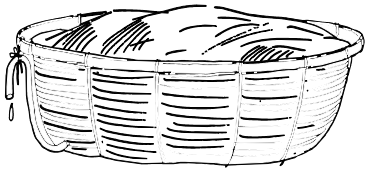
are more hygienic, lighter and stronger. Material used for plastic boxes are low density polyethylene, high density polyethylene and polypropylene.

An ideal fish box should be-



i. of a suitable size to handle any type of fish comfortably;
ii. easy to manage, carry and clean;
iii. designed with proper insulation to maintain temperature if iced fish is loaded;
iv. designed to allow draining out of melted water if iced fish is loaded;
v. protect the fish from crushing, spoilage, environmental pollution and pilferage;
vi. easy to store and effective for transporting chilled fish; available at a reasonable cost.

For handling and transportation of artisanal catch in Bangladesh, an effective low-cost ice box is constructed from easily available low-cost local materials. Woven bamboo basket presently used in fish transportation throughout the country is transformed into insulated ice box very simply and cheaply. The contraction details have been given in chapter 9.



In such modified ice box fish can not come in contact of bamboo splits of the basket, since they are wrapped all along with polysacs and plain polythene sheet. Thus there is no chance of contamination in fish from the split bamboo that generally harbours bacteria and contaminants. It is easy to clean and keep clean too.

Plastic container used in shrimp processing plants has been modified to use in transportation and preservation of iced fish. At first, the box is insulated by placing styrofoam sheet in between two

layers of side-walls, bottom and the top. A screw-tap is installed at the base of one side-wall to drain out melted water. An insulated lid is fixed at the top. This type of plastic ice-box can be manufactured in any ordinary plastic factory. Commercial fish traders can use this type of durable but lighter ice box to transport wet fish through trucks, ships and other vehicles.

2. Wholesale packaging for fresh/frozen fish

The fresh or frozen fish which are not going for shipment or to the processing factories but to the wholesale market for retail distribution by caterers or retailers should be packaged with due considerations.

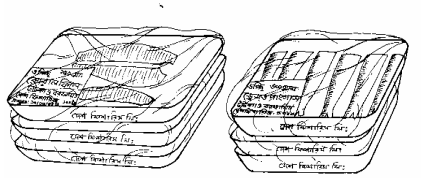
Clucas and Ward (1996) gave details of such fish packaging in tropical countries. Traditional packaging materials for fresh and iced fish are wooden or woven bamboo boxes. However, above mentioned modified bamboo basket can also be used for local transportation. Now a days, fibreboard boxes and corrugated board cartons waxed or coated with polyethylene are used for storage and transport of wet fish from port to fish monger, caterer or institution. The most common packaging of frozen fish is the interlocking, printed, polycoated and corrugated fibreboard carton. Expanded polystyrene and corrugated polypropylene boxes are also used for fish and shellfish distribution. The boxes are delivered pre-printed and flat and are folded or stitched in situ. When the box is filled with fish and ice, it is sealed with polypropylene or metal tape. These boxes are non-returnable and capacity varies between 3-28 kg. They can also be used for freezing wet fish, storing wrapped or unwrapped frozen fish and storing individual quick frozen and cured fish products or with cellophane-wrapped and cartoned products ready for retail distribution. Frozen fish blocks can be packed in polyamide/polyethylene laminated bags. Polyamide gives strength so that it reduces the chance of tearing bags by sharp edges of frozen blocks.

Block frozen shrimp, peeled shrimp or other frozen shellfish and fish are packed in fibreboard carton with a liner and then the whole pack is plate frozen.

3. Retail packaging of fresh/frozen fish and fish products

Packaging of fresh/chilled fish

In traditional fish markets, wet fish are sold with or without surrounded ice crystals. In modern shopping corner, fresh or chilled fish is packed using styrofoam trays wrapped with cling film. Film is either of polythene or polypropylene. Tray can also be produced by polyvinylidene chloride or polystyrene. This is one of the cheapest and most readily available packaging materials in the fish market (Clucas and Ward, 1996). With proper packing and handling, this type of packaging can be quite attractive. However, this type of packaging can not protect the product from –



loss of moisture and aroma;

drip from the fillet;

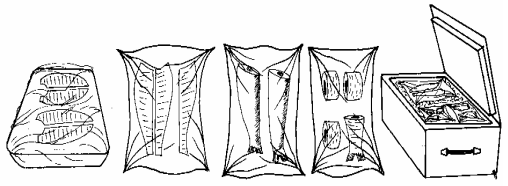
contamination (micro-organism, odor from other products, etc.);

mechanical and physical damage;

oxidation, etc.

The problem of drip from the fillet of fish with cut surfaces can be counteracted by dipping the fish into a solution of sodium tripolyphosphate. Polyphosphate will bind the water and prevent its subsequent loss and shrinkage.

Sometimes chilled fish are packed in modified atmosphere of nitrogen, carbon dioxide and oxygen to extend storage life. Materials used for modified atmosphere packing must be completely impermeable to gases in order to maintain appropriate gas mixture in the pack. Vacuum packaging is also done that requires high gas protective packaging film like polyvinylidene chloride or polyester.



Removal of oxygen reduces aerobic bacterial spoilage, lipid oxidation and subsequent rancidity.

Packaging of frozen product

Frozen fish and fish products can be packaged by laminated plastic bag or pouch, clear plastic bag, etc. sealed and put inside carton boxes. There are three common types of plastic packaging materials available in the market. These are :

Polystyrene

Polyethylene

Polypropylene

In choosing the plastic materials and cartons for fish products, it is to be emphasized that the materials –

ii. should protect the products from moisture and aroma loss, oxidation and rancidity and other odors from permeating into the product;

iii. should not become brittle and torn during storage and display at temperature below -18^{o} to -25^{o}C.

Some of the examples of commonly used packaging materials for frozen products are-

i. Polystyrene trays over-wrapped with polyethylene/ polypropylene film;

ii. Polyethylene bag;

iii. Plastic bag inside carton box;

iv. Waxed paper box.

Aseptic packaging

Cans provide one of the most important aseptic packaging of fish products in retail distribution. Most of the pelagic fish like sardine, mackerel, tuna, etc., salmon and some shellfish are canned for many decades. Retort pouches are recent development of aseptic packaging of fish products that serve as same function as can.

4. Air freight packaging

All fresh, frozen, live fish and shell fish are air freighted from one country to another or one place to another within the country. In air freighting, the same considerations given to the packaging of any perishable food should be given to the packaging of fish. The air freight container should be highly insulated, easy to handle, heavy to give physical protection to the products, and watertight to protect contamination. Various types of containers made of metals, fiberglass and expanded polystyrene are used.

Modified atmosphere packaging

When the products are treated with the mixture of gases like carbon dioxide, oxygen and nitrogen, during packing to extend the shelf life is called modified atmosphere packaging (MAP). Packing of fish in special mixtures of gases may extend the shelf life by up to 30%, provided that the temperature is kept below $+2^{o}$C (Clucas and Ward, 1996). This is of value to super market chains and other distribution systems in extending the high quality of life of the fish and products.

If the proportion of these gases is accurately controlled at the time of packing is called “Controlled Atmosphere Packaging (CAP). Generally, MAP is achieved by placing the fish in a plastic bag or sleeve, which is flushed with the gas mixture immediately prior to sealing. The plastic bag or sleeve must have a low permeability to the gases used. Usual MAP process line has the system to produce thermo-formed base trays from a continuous roll of the plastic film into which the fish is placed. After the fish is placed in the tray, it then moves along a conveyer belt to a section where a vacuum is drawn in the tray and the void is filled with the appropriate mixture of gases. A film lid is then heat-sealed to the top edge of the tray, completing the process.

The composition of gas mixture varies depending upon the composition of fish- weather the fish in the pack is lean or oily. Oxygen sustains basic metabolism and minimizes the possibility of

anaerobic spoilage; carbon dioxide inhibits bacterial and mold activity; and nitrogen is chemically inert and prevents rancidity, mould growth and insect attack by displacing oxygen. For lean fish, a ratio of 30% O_2, 40% CO_2 and 30% N_2 is recommended. Higher levels of CO_2 are used for oily and smoked fish with a comparable reduction in level of O_2 in the mixture, with the gas mixture ratio becoming 0% O_2: 60% CO_2: 40% N_2. By excluding oxygen, the development of oxidative rancidity in the fish is slowed.

The gas supply to the machine is normally taken from cylinders of pure gas and mixed in correct packing ratio on the machine itself. It is important to control both the ratio of the gas mixture, and the volume ratio of fish to gas. A minimum volume ratio of 1:3 (fish:gas) is recommended.

CO_2 permeates packaging films up to 30 times faster than N_2 and is more fat-soluble and water soluble: its solubility increases as temperature is lowered. These factors lead to a reduction of pressure within the pack, resulting in a tendency for the pack to collapse.

Dissolution of CO_2 into the surface of the fish muscle can reduce the pH and sufficiently lower the water holding capacity of the proteins. This result in unsightly drip within the pack, which is often absorbed by placing a cellulose pad beneath the product. The resultant pack has the advantages of retaining any drip and fishy aromas within the package while allowing the customer to view the fish prior to purchase.

The use of MAP for shell-on crustacean appears to inhibit the development of blackening of the shell (black spot), at higher chilling temperatures of 5 to 10^{o}C.

MAP-chilled fish is a most attractive proposition both to the retailer with extended shell life in store and the customer with cleanliness and convenience; however, the quality is depended upon very carefully controlled temperatures throughout the production, transportation and storage of the raw material and products. The

generous use of ice on the fresh fish, accurately controlled chilled storage (less than 2^{o}C) and air conditioned packing rooms are essential to the achievement of maximum shelf life extension. Following recommendations should be considered when using MAP:

- Use only fresh fish;
- Ensure fish temperature is below 2^{o}C prior to packing; pack under cool condition and move finished pack to chill store (<2^{o}C) as soon as possible after packing;
- Check that the gas mixture being used is suitable for the fish in the pack;
- Check the gas mixture on a regular basis;
- Use refrigerated transport capable of holding the product between 0 to 2^{o}C during distribution;
- Check that the product temperature is between 0 to 2^{o}C on arrival at the depot or retail store;
- Store at 0 to 2^{o}C in display cabinet (or chill store), which should be monitored regularly to ensure this temperature range is achieved;
- Ensure that shelf life particulars on the label, for example, sell by and use by are within the achievable limits for that particular product.

Printing quality of fish packages

In selecting an appropriate packaging material for any fish products, specification and advice should also be sought from the supplier of the packaging material. Along with its protecting nature, the packaging material should also have good printability and saleability. Now-a-days, there is a printing method called reverse printing which is commonly used for plastic packaging or products. In this method, printing is done on the outside of the inner layer of plastic film, which is then covered with another layer of plastic. This type of printing is specially important for wet and frozen products.

Packaging regulations for fish products

The packaging of fish products must consider a number of regulatory and legal considerations, most important of which are –

i. assure that legal packaging requirements are met;

ii. protect the products from contamination either from package or from the environment;

iii. assure that all materials, including packaging, meet the appropriate requirement of the concerned government;

iv. assure that all materials, including packaging, meet the appropriate requirement of the buying country;

v. assure that the labeling meets all requirements as to the contents, weights, print, size and other related requirements;

vi. assure the label states the contents when required and /or contains the required verbage, such as “imitation” and similar information;

vii. assure the label carries any required warnings, e.g, drug, poison, etc.;

viii. assure the claims, such as “jumbo size” or “economy size” meet the requirements.

Labeling requirements

Labelling means complying with regulations regarding product manufacture and accordingly, providing necessary information on product for consumer’s satisfaction and protecting rights. Information on labels are important to regulatory agencies, custom officials, traders and consumers. Basic labelling requirement of a product includes common name of raw material, net weight, grade, class, size, count, moisture content or other composition as applicable, name and address of producer, packer and distributor, place of origin, type and amount of ingredients used, date of process,

date of expiry/minimum durability date, etc. ‘Instructions for use’ may also be displayed where appropriate. For the products consumed in the domestic market, the producer must comply with the regulations of the own country. But for the product that is to be exported, the labelling must comply with the labelling regulations of the importing countries, along with basic export requirements.

Facilitation sheet-10

16a

Quality Control of Fish

Activity: 1. What is meant by quality of fish? How can this quality be controlled ?

The facilitator will conduct a brainstorming session with the participants after dividing them into 2 groups. Group A will be assigned to define the quality of the fish and fish products while group B to elaborate how the quality of fresh fish and local fish products be controlled. The group leader will present group findings. Other group members will ask questions. The facilitator will explain the quality control mechanism of fish and fish products consumed in domestic markets.

Group A Quality characteristics of fish/products	Group B Quality control measures

Activity: 2. Assessing the quality of fresh fish.

Group A will be supplied with some prime quality fresh fish and asked to find out the characteristics of those fishes in terms of physical appearance, texture, colour, eye and gill conditions etc. Group B will be supplied with spoilt fishes of different category and asked to find out the changes in the quality of those parameters. The facilitator will explain the quality defects and grading of fish as per given grade points against each quality characteristics.

Group A Quality characteristics of fresh fish	Group B Quality characteristics of spoilt fish

Information sheet-12

16b

Quality Control of Fish

Group exercise: 2
Field demonstration: 1

Introduction

Fish is one of the highly perishable commodities and the public requires continuous reassurance about its quality. Unlike most raw materials, fish is not a single commodity but consists of a large number of species of widely differing appearance, composition and flavour. Because of this variety customers are often unsure if particular species or products made from them are good to eat. Thus from several points of view fish quality has a special importance and there are several reasons for which quality consciousness of the customers is likely to increase. On the other hand, most of the quality control and quality assurance programmes of the competent authorities are aimed at maintaining quality of export oriented products, which constitutes only 1.0% of our total harvest. The quality control of the rest 99.0% fish which are consumed domestically are totally ignored. Because of high perishable nature of fish, people of the country very often do not know what they are eating. It is therefore, deemed important to make the people conscious about the quality of fresh fish and domestic fish products as well as to give them some basic tasks on simple quality assessment tools.

What is quality and quality control?

Simply quality means the saleability of a product. The totality of features and characteristics of a product or service that bears on its ability to satisfy a given need, degree or grade of excellence or grade of goodness is termed as quality (ISO 8402, 1986). According to the modern concept quality of a product greatly depends on the quality of the raw material.

Quality control can be defined as the maintenance of quality at a level which satisfies the customer and the health authorities and which is economical to the producer and seller. Quality control techniques are applied to the complete manufacturing and marketing enterprise to obtain operations as efficient as possible. Effective quality control minimizes customer complaints that lead to loss of business. Effective quality control of a product should address four major generic issues: i. design of product specification; ii. inspection of raw material and final product; iii. process control and iv. training of personnel involved in quality control and quality assurance. Through addressing these four steps quality control in a process or processing plants ensures that the products reach the criteria set out in the product specification.

International quality management standards

ISO is the International Organization for Standardization. It is a world-wide federation of national standard bodies (like BSTI in Bangladesh: Bangladesh Standard and Testing Institute), at present comprising of 127 members, each representing own country including Bangladesh. ISO develops standards for the quality management systems for product manufacturing that are required by the markets. These standards, although voluntary, if adopted by a country, become inevitable for the exporter countries to strictly follow if they want to invade its markets. Standard organizations in most of the countries, however, have adopted these standards. ISO technical committee is responsible for developing and maintaining the ISO 9000 family of standards. The European Community (EC) has adopted the ISO standards as the European norm (EN) 29000

series. American National Standard Institute (ANSI) and American Society for Quality Control (ASQC) have assembled these standards into ANSI/ASQC Q 9000 series.

ISO 9000 elaborates guidelines for the quality management and quality assurance standards- guidelines for selection and use, while ISO 9001, 9002 and 9003 present the models for quality assurance in design/development, production and installation and final inspection and tests respectively. ISO 9004 provides guidelines to consider when designing or revising a quality management system. ISO 9000 is both the shortcut name for the overall series of five documents and the specific name for the first one in the series. Companies are required to register their quality management systems to only ISO 9001, 9002 and 9003.

What is quality assurance?

Quality assurance is a composite programme that consists of quality standards, quality control, quality evaluation, auditing and inspection and it applies to the whole industry. A quality assurance programme aims to ensure that everyone in a processing chain from the catcher to the retailer is working to achieve a high quality end product (Clucas and Ward, 1996).

Quality assurance of products i. e., consumer safety and product quality are major factors that any food processor should consider. The principles, concepts and application of good manufacturing practice (GMP) and hazard analysis and critical control point (HACCP) provide the tools through which this aim could be achieved. Quality assurance serves three major purposes:

i. Maintenance of quality: The primary purpose is to provide a mechanism to the consistent maintenance of quality at a level that satisfies the customer while being economical to the processor. It saves money to the "bottom" and rather than being a luxury, is an absolute necessity in protecting the profitability of a company.

ii. Gathering of information: Quality assurance serves as a mechanism to gather information and date that advise efficiency and effectiveness of each unit operation in the process. The information like- the quality level of incoming raw materials which will impact on processing yields, cost and ultimate profit; the defect levels at each unit operation which will relate to either the amount of non conforming product; the sanitation level of the plant as measured through standard microbiological indicators.

iii. Meeting regulatory requirements: Effective regulatory programmes enable seafood processors to consistently meet the regulatory requirements to which their products are subjected, including both in-country and foreign regulatory bodies (FDA, EU, Canada, etc).

Methods of assessing quality of fresh fish and locally consumed fish products

Over the years, many different methods of quality assessment have been developed and investigated in an attempt to determine the most suitable index for use in quality control testing but no single method is found appropriate or suitable completely. Usually two or more methods are applied to measure the quality of fish or fishery products. The methods that are used to assess the nutritional and food quality of fish and fishery products can be conventionally divided into 3 major categories as outlined in chapter 5, *viz*. i. sensory or organoleptic methods; ii. mechanical, instrumental and laboratory methods; iii. microbiological methods. Out of these methods, organoleptic or sensory methods are best suited for assessing the quality of fresh fish in local conditions.

Organoleptic or sensory methods

Sensory methods are used to assess the degree of freshness based on organoleptic characteristics such as odour, colour, general appearance, eyes, slime and consistency of flesh. These characteristics are judged by panel members and the changes in

quality of fish are assessed every day during ice storage. In such sensory methods, subjective judgements are made by individuals. Numerical scoring or ranking systems have been developed to evaluate the judgement or the results.

Sensory methods have advantages that it can be adapted by the human being easily and quality can be assessed by testing odour to visual inspection for defects. Instrumental or laboratory based objective methods are lengthy and time consuming. Consumers can not wait for more than a day to buy fresh fish or other fishery products, although the results seem to be more accurate. It is often true that up to certain level the human senses are more efficient in some complex tasks than the instruments. However, an important disadvantage is that the responses of human being to a particular defect may vary from person to person and also from situation to situation.

Following points are taken into consideration for assessing quality of fish by sensory methods-

i. Quality factors open to sensory methods

Following senses are used in sensory evaluations:

a. Sight and touch: In most of the cases the detections of deterioration and defects are accomplished very efficiently and rapidly by sight. In assessing the quality of some glazy, shinny and good looking products like premium quality fish or smoked fish the practiced eyes have so far proved to be better than any instruments. The colour matching can also be done effectively by eye or sight. However, detection can be varied with the degree of illumination on the fish.

In assessing the textural attributes (firmness, softness, mushiness, rubberiness, woodiness, mealiness, succulence, dryness) the sense of touch in fingers or mouth are both used as occasion demands. Some instruments are available for the degree of firmness but for the most part there is no substitute for sensory methods in the assessment of fish texture.

b. Odour and Flavour: Every fish and fish products has characteristic odour and flavour those can be used to assess their quality. Human nose is a powerful tool in assessing quality and in some cases there is no substitute up to the present time. Anyone can distinguish between the smell of fresh and spoilt fish without any hesitation.

ii. Types of sensory assessment

Depending upon how they are used, two types of assessment can be distinguished.

a. Objective: The judgement is done without any personal feelings and favourites and has no freedom of the person of his own. For eg. comments like- this fish is fresh/ salty/ stale/ sour/ tough/ has too many bones, etc.

b. Subjective: In this case, the person has freedom of his own wills and favourites. It may vary according to the judges. For eg. comments like – I think this fish is excellent/ OK/ inedible/ unacceptable, etc.

iii. Scales, ranks, grades

In ranking tests, the judges arrange a series of two or more samples in ascending or descending order of intensity of a specific characteristic. The samples may be ranked for degree of acceptability, for general quality or for a specific attribute of colour, texture or flavour intensity. Where a number of defects or deteriorations occur together in the same products, it is common practice to sum the scores or points allocated to the individual attributes to give an overall demerit score or grade. Grading can be done by numerical scoring system or descriptive hedonic system.

a. Numerical scoring system: Freshness of fish or degree of spoilage may be assessed in raw fish from -

- the general appearance, including that of the eyes, surface, slime and the texture of the flesh; and
- the odour of the gills, broken neck and belly cavity.

Points may also be awarded for the odour, texture and flavour of different fish products and quality can be assessed.

With some modifications, of the freshness grading scheme used by European Economic Community for the determination of quality of fresh fish by numerical scoring system is described in Table 16.1 and 16.2.

Table: 16.1. Determination of defect points for freshness test of fish

Characteristics	Defects	Defect points	Grade
Odour of broken neck	a) Natural odour	1	Acceptable
	b) Faint or sour odour	5	Rejected
Odour of gills	a) Natural odour	1	Excellent
	b) Faint sour odour	2	Acceptable
	c) Slight moderate sour odour	3	Acceptable
	d) moderate to strong sour odour	5	Rejected
Colour of gills	a) Slight pinkish red	1	Excellent
	b) Pinkish red to brownish	2	Acceptable
	c) Brown or grey	3	Acceptable
	d) Bleached colour, thick yellow slime	5	Rejected
General appearance	a) Full bloom, bright, shining, iridescent	1	Excellent
	b) Slight dullness and loss of bloom	2	Acceptable
	c) Definite dullness and loss of bloom	3	Acceptable
	d) Reddish lateral line, dull, no bloom	5	Rejected
Slime	a) Usually clear, transparent and uniformly spread	1	Excellent
	b) Becoming turbid, opaque and milky	2	Acceptable
	c) Thick sticky, yellowish or green colour	5	Rejected
Eye	a) Bulging with protruding lens, transparent eye cap	1	Excellent
	b) Slight cloudy of lens and sunken	2	Acceptable
	c) Dull, sunken, cloudy	3	Acceptable
	d) Sunken eyes covered with yellow slime	5	Rejected
Consistency of flesh	a) Firm and elastic	1	Excellent
	b) Moderately soft and some loss of elasticity	2	Acceptable
	c) Some softening	3	Acceptable
	d) Limp and floppy	5	Rejected

Table: 16.2. Grading of fish with grade points

Grade	Points	Comments
A	< 2	Excellent/ Acceptable
B	2 to < 4	Good / Acceptable
C	4 to 5	Bad / Rejected

iv. Judges

A judge is anyone called upon to carry out sensory assessments. Judges must be experienced or trained to assess the quality objectively. Assessment by a single judge should be avoided. Judges should be trained on systematic inspection, scoring and grading scheme. To assess the same product, judges should act independently and average of their scores on attributes should be taken.

Quality Control Programme in Processing Plants

The training programme and this training book are designed to address the traditional process or products and their quality control. Therefore, information on quality control of export-oriented plant-based products is excluded here. However, the quality control measures applied for the plant based fish products are equally important for the traditional process and products also. To create awareness among the GO extension officials, therefore, some elementary information on quality assurance of plant based export-oriented products are provided.

1. Good manufacturing practice (GMP)

GMP refers to all the measures implemented to ensure product quality, safety and fitness for human consumption: from raw material quality and fish plant construction to personnel hygiene and hygienic operating practices. All processors need to process fish and fish products, either for export or domestic consumption, under the GMPs.

2. HACCP

HACCP (hazard analysis and critical control point) is a technique for reviewing and analysing a specific manufacturing operation's compliance with the GMPs, with the objective of identifying control procedures and implementing preventive measures required to ensure consumer safety and to prevent economic fraud. It is a system of self-regulatory quality control

which, if properly implemented, can be used by both manufacturers and regulatory agencies to provide assurance about the safety of the product.

It is thus obvious that, HACCP stands for a food safety assurance methodology, which is mainly the responsibility of food processors. Due to increasing consumer concern over food safety, this responsibility has now been extended up to primary producers of raw food materials. It is a scientifically based programme for safe food management system in food industry. This system identifies specific hazards and measures for their control in order to ensure the safety of food to the consumer.

A number of quality control points exist in the processing of the product. However, critical control points (CCP) are those points in a food production process where failure to carry out control measures will introduce unacceptable risks to the consumers. In complying with HACCP regulations, these CCPs need to be identified and a system of monitoring and recording data at these control points to be set up. It is necessary to have records so that the process may be audited for product safety assurance.

HACCP type regulations in different countries

HACCP was originally designed by the Pillsbury Company in U.S.A. in the early 1960's as a means of providing assurance about safety of food used in United States space programme. Since then this concept has taken a global perspective. The joint meeting of FAO/WHO Codex Alimentarius Commission in 1993 adopted HACCP and formulated the "Guidelines for the Application of the HACCP System". This is subsequently added as Annex to the Codex- "General Principles of Food Hygiene". The European Union through its Directives 91/493/EEC (1991) and 93/4/EEC (1993) has adopted this system (EU regulations) as mandatory for all fish processors exporting fish and fishery products to Europe. The USA-HACCP Regulation for Seafood Processing became effective on 18th December, 1997. Canada has implemented HACCP as their own Quality Management Programme (QMP) for seafood industry in

1992. Many Asian countries like Bangladesh, Thailand and India started implementing HACCP in seafood industry as it is mandatory for export to U.S.A. and Europe. The concept of HACCP has assumed a lead role as a system for measuring equivalence of food processing industries between exporting and importing nations in view of the World Trade Organisation (WTO) agreement on Application of Sanitary and Phyto-sanitary Measures (SPS).

HACCP Program

HACCP is essentially a pre-requisite programme involving a number of steps or procedures that control the operational conditions of food industries. Some of the well-defined pre-requisite programmes include:

1. Premises - Outside property, building, hygienic condition, working space and facilities, water quality, toilets, etc.
2. Equipment - Design of equipment, safetyness, performance, maintenance, etc.
3. Hygiene - Sanitation programme for whole establishment, pests and\rodent controls, hygiene of staff and equipment used.
4. Safety recalls - Product identification programmes, coding, product recall system.
5. Labelling - Should comply with the market or importer.

The HACCP system consists of "*plans*" in a written document that describes and defines the procedure followed by a manufacturer assuring safety of the product as well as process. The whole concept of application of HACCP is described in a nutshell below.

A. General tasks to implement HACCP in a processing plant

1. Assemble the HACCP team
2. Describe the product
3. Identify the intended use
4. Construct a flow-diagram of production system/process.
5. On-site verifications of flow-diagram

B. Generic principles of implementation of HACCP

HACCP is based on a set of principles which must be adhered to uniformity between agencies, the industry and the nations. The principles are as follows:

1. Conduct of hazard analysis:

Conduct an analysis of all hazards that are likely to occur based on the processing operation of a particular product. Identify all risks likely to occur related to those hazards in the processing.

2. Determination of critical control points (CCP) in the process:

Identify the CCPs, the failure of which could render the product, unsafe for consumption, in the processing.

3. Establishment of critical limits:

Establish critical limits to the parameters of the process associated with control measures at each identified CCP, i.e. boundaries that are used to judge whether an operation is producing safe products.

4. Monitoring each CCP:

Establish a system in the factory to monitor the implementation and observance of CCP.

5. Establishment of corrective actions:

Ensure corrective action taken while monitoring of a particular CCP is safe and efficient.

6. Establishment of verification procedures:

Establish a verification procedure to confirm that HACCP plan is working efficiently and smoothly and conduct review whenever a change is done on the processing.

7. Establishment of record keeping and documentation procedures:

This is perhaps the most important and difficult action plan of HACCP implementation for industries. Necessary documentation in a prescribed pro-forma should be made concerning all procedures and records appropriate to these principles and their application to

satisfy regulators, importers etc. that the plant is operating in accordance with HACCP principles.

The theme of HACCP is to prevent problems before they occur. It is a system of preventive controls by clearly defined practices for every specific product and process under which plant staffs prevent hazard. It has good procedures to monitor and audit practices. HACCP is also a cost-effective assurance of food safety where most of the responsibility is placed to the operating staffs.

The concept of HACCP is very useful to maintain quality of processed seafood ensuring total food safety to the consumer. The successful implementation of HACCP in a seafood processing plant depends on the total involvement of all the staffs. What is more needed is the positive thinking on the part of the owner of the establishment. Very often this is seen as a missing link.

3. Traceability System in Exportable Foods

What is traceability?

Recent EU and US consumers demand greater information of foods and ingredients on which their purchasing choices to be based, not only for food safety, but also for moral, ethical and environmental reasons. Consumer's demand provokes the regulatory agencies to formulate new rules. Under the new EU and FDA rules, food businesses must be able to identify the sources from whom they have obtained a food ingredient or food product and the next door to whom they have supplied a food ingredient or food product – what is referred in a simple term as 'information of one step forward and one step back'. This outlines the concept of traceability of foods and food ingredients.

According to ISO/CD 22519 *(Traceability in feed and food chain – General principles and guidance for system design and development),* the traceability of ingredients or food products is the ability to trace the history, application or location of those things which is under consideration. According to *Codex Alimentarius*

Commision of the FAO, the traceability is the ability to follow the movement of food through specified stage(s) of production, processing and distribution.

More precise and clearly understood definition of traceability comes from the EU Commission Regulation *(EC No. 178/2002).* According to the EC, traceability is the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.

Why is it important for Bangladesh?

Bangladesh is a major exporter of frozen shrimp and fish in the EC, USA and Japanese markets. Implementation of traceability in exportable frozen foods in Bangladesh has become mandatory because-

i. EU Commission Regulation (EC) No. 178/2002, has enforced traceability since January 1, 2005- that explains (i) that it is to record information of exportable food products/food ingredients from one step back and to one step forward; (ii) that it does not have an extra-territorial effect outside the EU; (iii) that it covers all stages of production, processing and distribution in the EU, from the importer up to the retail level; (iv) that this business's contractual agreements could be beyond "one step back-one step forward" principle; and

ii. US Bio-Terrorism Act, has enforced since April 2004 that covers a mandatory traceability system through creation and maintenance of records- immediate previous sources and the immediate subsequent recipients of foods.

Therefore, it is clear that Bangladesh should take all preparations for establishing a credible traceability system so that food stuffs can be traced right from the farm to the buyer. Traceability report must be well documented, otherwise the EU or US will not accept the traceability report and will not accept any shrimp or fish from

Bangladesh. Bangladesh shrimp industry may be jeopardised if a credible traceability system is not expeditiously in place.

Benefit of traceability

Traceability ensures

- targeted and accurate withdrawals or recalls of suspected items;
- appropriate information for consumers and food business operators;
- easy risk assessment by control authorities and avoidance of unnecessary wider disruption of trade.

Traceability information could be of immense beneficial by minimizing losses during a product recall to only the affected products. Record keeping systems help processors to minimize the production and distribution of unsafe or poor quality products. The better the system, the faster the resolution of food safety or quality problems.

Generally, the following benefits can be drawn from a traceability system of food products:

- Consumer protection
- Prevention of criminal actions
- Consumer assurance
- Creation and maintenance of credence attributes
- Food chain uniformity & improved logistics
- Productivity improvement and costs reduction

Scope of traceability

- Traceability system is completely science-based;
- It is applied in principle with no more trade restrictive than necessary and not to be used as a trade barrier;
- Traceability is cost effective;
- It is very much practical to apply.

Conceptual framework development of traceability

In order to develop a traceability system for a specific food production, following points should be considered:

1. Define lot size;
2. Identify information what to have;
3. Identify information what to be transferred;
4. Select tools that to be used;
5. Define information that to be kept or preserved.

Table: 16.3. Example of traceability in a shrimp farm

Item	Farm
1) Lot size	Farm – Pond crop
2) Info to have	Farm info: name, location
	Feed info: name, batch
	CoC practice info
3) Info to be transferred	Farm info, final residue analysis, CoC certificate
4) Tool to use	Certificate and movement document (MD)
5) Info to be kept	Feeding record, f-info, CoC practice info

What is a Movement Document (MD)?

The Department of Fisheries in Thailand has developed a movement document, a structured document that moves with the products from the origin to the destination.

- MD is a tool to accomplish traceability;
- The rule in the MD is legalized for cultured marine and freshwater shrimp as of July 1, 2002 in Thailand;
- The rules are extended to cover all cultured species including ornamental fish;
- The MD is carried from hatcheries, through farms to the processing plants.

Movement document has been found very useful:

(i). For certifying shrimp exported to the US; certified if of Thailand origin or imported;

(ii). For exported shrimp to US or EU to trace back to origin when drug residue is detected;

(iii). For exported live aquatic animals to trace back to origin when disease is detected.

It is, therefore, recognized that both public health and safety of consumers are the driving force for the traceability of a product. Traceability approach, i.e. “farm-to-table” approach is proved to be an effective tool to address wider food safety. To implement this new quality assurance programme, Bangladesh should come forward to overcome the challenges in a proactive way. For smooth implementation of this new approach, however, collaborations between the government and fishery industry are required.

4. Risk Assessment

The European Community Regulation No. 178/2002 (Article 3-Other definitions) has given clear definitions of risk assessment and other terms related to food quality assurance. The term 'risk' is a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard, while 'risk analysis' refers to a process consisting of three interconnected components: risk assessment, risk management and risk communication. Risk assessment, based on scientific process, generally assesses the risks quantitatively to answer the questions like how big is the risk and what factors control the risk, etc. Risk communication, based on social and psychological process, answers the question like- how can we talk about the risk with affected individuals. On the other hand, risk management, based on political process, find the ways of what can be done about the risk.

'Risk assessment' consists of four steps: hazard identification; hazard characterisation; exposure assessment; and risk characterisation.

'Risk management' means the process, distinct from risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors, and, if need be, selecting appropriate prevention and control options.

'Risk communication' means the interactive exchange of information and opinions throughout the risk analysis process as regards hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, feed and food businesses, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.

There are three areas of risk assessments in food, viz., microbiological, chemical and biotechnological.

Both microbiological and chemical areas are the most critical risk assessments in food. These risk assessments, obviously science-based, are driven by the Government to assess the severity of illness and the probability of its occurrence as a consequence of the exposure to certain pathogen, food combination, drugs or chemicals. In other words, the process consists of determining the likelihood and severity of an adverse health effect in a population exposed to a certain pathogen/food combination and drug/chemicals. The main purpose of such risk assessment is to facilitate and support decision making by the risk managers. This may be achieved by providing estimates of risk of illness by consumption of certain food/pathogen combination and estimates of risk reduction through certain control measures.

Glossary of terms used in quality control

Code

A quantity of a specific product type and form produced and handled under uniform conditions, within a limited time period normally identified by means of a day, shift or batch code.

Contamination

Direct and indirect transmission of objectionable matters to the products.

Control point

A point in time or a physical location at which there is an opportunity to evaluate compliance with specific requirements and, if necessary, to correct any defects, deviations or deficiencies that may be found related to quality, fair trade of products and regulations in force.

Critical control point

A critical point at which failure of preventive measures will expose a customer to unacceptable risks related to safety and unwholesomeness.

Culling

Removal of defective units from a lot of raw material, products or other materials.

Decomposed

With respect to seafood, means that it has offensive and objectionable odour, colour, texture and substance associated with spoilage.

Defect

An imperfection or inadequacy in raw materials, other input materials or products.

Deficiency

An imperfection or inadequacy in physical facilities, equipment, implements or environment.

Deviation

An imperfection or inadequacy in a process or procedure.

Foreign material

The presence of readily detectable (without magnification) material which has not been derived from fish/shrimp but does not

pose a threat to human health (such as insect pieces, water, sand, tapioca, etc).

Good manufacturing practice

A set of principles and hygienic practice for the manufacturing and handling of food such that they assure safe controlled sanitary conditions.

Inspection

A measurement or evaluation, examination, comparison, survey, analysis, test or activity or a series there of, based on an evaluation or measurement system, which leads to a decision being rendered.

Labelling

Complying with regulations related to product manufacture and providing necessary information on product for consumer's satisfaction and protecting rights, includes common name of raw material, net weight, grade, class, size, count, moisture content or other composition as applicable, name and address of producer, packer and distributor, type and amount of ingredients used, date of process, date of expiry, etc.

Lot

With respect to products, it is a collection of one or more codes of same product type and form. With respect to raw materials or in-process materials, it is a quantity of one particular species, or family of seafood species caught and handled under uniform conditions, usually within a limited time period.

Packaging material

Any containers such as cans, bottles, cartons, boxes and cases, or wrapping and covering materials such as foil, film and paper.

Poisonous or harmful substances

Bacteria of public health significance, natural toxins, all regulated pesticides, mercury, other metals, non-permitted additives, non-permitted antibiotics and other contaminants like fuel, oil, etc.

Potable water

Freshwater fit for human consumption. Standards of potability should not be lower than those contained in the latest edition of the "International Standards for Drinking Water", World Health Organization.

Reconditioning

A process which eliminates bacteria of public health significance by heat treatment.

Re-working

The removal of defects from the material in a lot (e.g. through conditioning, trimming).

Sanitary area

Area of plant where particular attention must be paid to sanitation and to the prevention of cross contamination.

Sanitising

The application of hygienically satisfactory chemical agents and/ or physical methods and processes to clean surfaces with the intention of reducing the total bacterial load of a product contact surface to a safe or low level.

Tainted

Fish/shrimp that is rancid or has an abnormal odour and flavour.

Unwholesome

Fish/shrimp that has in or upon it, bacteria of public health significance or substances toxic to aesthetically offensive to man.

Waste

Those parts of fish/shrimp which remain after the meat removal is completed.

17

Evaluation of the Course

Effectiveness of theToT

Using the new training approach, 8 full-course ToTs were conducted by the author and feedback from the participants were collected. Out of the eight ToTs, 5 were on fish processing and quality control and 3 were on coastal resource conservation and management. After the TOTs, evaluations were made through a prescribed evaluation sheet attached in *Annex-III*. In order to understand the *modus operande* of evaluation process in expressing the effectiveness of the ToTs, the results of some evaluations are summarized below.

Here, the evaluation results of 4 ToTs on fish processing are presented. In these four ToTs, a total of 67 trainees were attended. Qualifications of the trainees were: B. Sc. Fisheries (Honours) and M. Sc. Fisheries -20, M. Sc. in Zoology-11, M. Sc. Marine Science-5 and Graduate in general science subjects-31. Thirty nine of them were Upazila level officers (SUFO, UFO and AFO) of the Department of Fisheries, 11 were Quality Control Inspectors of the DoF and 13 were NGO extension workers. Except the NGO workers, most of the DoF officials had basic knowledge on *Fish Processing* since they studied the subject in the graduate courses. The average level of progress they had made on fish processing through the ToT, as indicated in the evaluation sheet (*Annex-III)*, has been given in Table 17.1.

Table: 17.1. Improvement of knowledge on fish processing after the training

Basic degree of trainees	Working Agency	Number	Level of knowledge * before ToT	Level of knowledge * after ToT	Knowledge Improved (%)
B. Sc.Fisheries (Honours)	GO	20	30-40	80-95	50-55
M.Sc. Zoology	GO	11	15-35	80-90	45-65
M.Sc. Marine Science	GO	5	25-35	85-90	45-60
M. Sc. Stat. Botany, Mathe.etc.	GO/NGO	19	15-20	70-85	50-55
B.Sc. B.A., etc.	GO/NGO	8	15-20	75-85	60-65

* on a scale of 0 ~ 100 with 100 being the highest.

Table: 17.2. Effectiveness of new ToT technique as perceived by the participants

Basic degree of participants	Working Agency	Number	Effectiveness (%)
B. Sc. Fisheries (Honours)	GO	20	75-95
M.Sc. Zoology	GO	11	70-75
M.Sc.Marine Science	GO	5	85-95
M. Sc. Stat. Botany, Mathe.etc.	GO/NGO	19	85-95
B.Sc. B.A., etc.	GO/NGO	8	90-100

Most of the participants rated the present ToT technique on fish processing as effective as more than 70%, while many of them (55% of the participants) rated it as highly effective as 90-95% (Table 17.2). While asked why it was effective above 50%, some of the answers were:

i. delivery methods made the training environment learner-friendly so that the participants were able to participate spontaneously, fully and wholeheartedly;

ii. subject matters were made clear to every participant;

iii. practical demonstrations, group exercises, group reviews, question-answer sessions, etc. as teaching tools were found very effective;

iv. competitive environment was created among the participants for learning and performing better;

v. attitudes of learners changed towards cooperating each other. Sharing knowledge and experience helped to learn more;

vi. presentation of the topics was lively;

vii. greater opportunity of self-learning existed;

viii. group review process through question-answer was unique that made the learning more participatory;

ix. more man-hours in practical session and field work than in-house discussion and group activity;

x. self-facilitated course, not interfered by the trainer or facilitator;

xi. scope for independent thinking to justify one's opinion prevailed all along the course;

xii. not monotonous;

xiii. correct things and many things learned through question-answer.

The trainees were further asked to write down two strong and two weak points of the training. The strong points perceived by different trainees were:

i. training was mostly based on practical and field works;

ii. good facilitation;

iii. adequate training materials and hand outs available;

iv. informative but easy, learner-friendly and field-based training guide;

v. full time use of audiovisuals- LCD power point presentations;

vi. immediate field testing of knowledge learned during discussion session;

vii. liberty of trainees all along the course;

viii. greater involvement of trainees than facilitator;

ix. direct interaction with the target beneficiary;

x. spontaneous participation ensured through group exercise and group review;

xi. unique evaluation technique.

Weak points perceived by the trainees

i. non-residential training;

ii. time constraints;

iii. lack of sufficient leisure/amusement in between the sessions;

iv. liberty gave extra chance to some smart participants to be involved more frequently that hindered other's participation in review, discussion and question-answer sessions;

v. training conducted/facilitated by one facilitator- thus became monotonous;

vi. training transformed into a mode of training workshop.

Improvement of the course

More or less similar results were found during the evaluations of other ToTs (on resource conservation, CCRF, quality control, etc) conducted by the author using the same techniques. In many cases, a major weak point that the participants raised was: – it was a non-residential training. If physical facilities and budget allow, then there is no question that it can be organized as a residential training. Training schedule (Table 3.1) also supports it to be a residential one. Due to budget constraints, the organizers were unable to make all of those training fully residential for the extension workers. However, arrangements were made to lodge the participants at the vicinity and adequate vehicle facilities were provided.

During the evaluations, some of the participants opined for more leisure/amusement in between the sessions. Leisure is important to increase interest and attract full attention on discussed issues. During the later courses, however, different ice-breaking tools, in-place aerobics/physical exercise, etc. were practiced to reduce monotony. These practices noticeably improved the situation, as reflected in the evaluation sheet of the later courses. It was realized that leisure issue should be considered very sympathetically during the designing of the course so that sufficient time is allocated for mini-leisure in between the sessions.

Topics/chapters should be selected in the ToT schedule based on the immediate requirement of the trainees. The course should not be over-loaded with many topics at a time. Rather the whole content of a subject can be divided into two or more training sessions. Duration of a single course should not exceed 6 days, but 5 days would be the best. For a refresher course, it should be for 3 days with reasonably adequate number of topics. This will also benefit the primary beneficiaries to be involved and interact more.

Flexibility is the key to make any participatory process effective. This is also true for a participatory training. The trainer(s) should play a perfect facilitator's role so that everybody can participate equally throughout the course.

To make a full-course training fruitful and attractive, it can be facilitated by more than one facilitator but the number should not exceed two.

This type of self-facilitated, participatory and highly interactive training often gives a taste of training workshop. It is obvious, when maximum participation is ensured through more group exercise, group presentation and participatory review. This workshop mode helps to understand and realize things more effectively.

At the end, it can be concluded that the participant's choice is final to improve a training course.

References

Adams, M.R., Cook, R.D. and Pongpen, R. 1985. Fermented fish products of Southeast Asia. Tropical Science, 25 (1): 61-73.

Ahmed, M. 1978. Radiation disinfestation studies on sun-dried fish. Proc. IPFC, 18 (3): 310-321.

Amano, K. 1962. The influence of fermentation on the nutritive value of fish with special reference to fermented fish products of Southeast Asia. In *FAO International Symposium on Fish Nutrition*. E. Heen and R. Krauzer (eds.). Fishing News (Books) Ltd., London.

Aref, M., Timbely, A. and Daget, J. 1965. Fish and fish processing in the Republic of Mali. 3. On the destruction of dried fish by the Dermestid insects. Alexandria J. Agric Res., 12(2):95-108.

Bala, B.K. 1997. Experimental investigation of the performance of solar tunnel dryer for drying fish. Final Research Report, Department of Farm Power & Machinery, Bangladesh Agricultural University, Mymensingh.

Bala, B. K. 2000. Adaptive research on solar dryers for drying, mango, pineapple and fish. Annual Research Report, Department of Farm Power & Machinery, Bangladesh Agricultural University, Mymensingh.

Bala, B.K. and Hossain, M.D. 1998. Experimental investigation of solar drying of fish using tunnel dryer. WREC, Elsevier Science Ltd: 2049-2052.

Bala, B.K. and Mondol, M.R.A. 2001. Experimental investigation of solar drying of fish using tunnel dryer. Drying Technology, 19(2):1-10.

Clucas, I.J. 2003. Mission report - *Technical backstopping on low cost fish processing, quality control and food safety aspects*. GoB/UNDP/FAO Project: BGD/97/017. Food and Agriculture Organization, Dhaka. 31 pp.

Clucas, I. J. and Ward, A. R. 1996. Post-harvest Fisheries Development: A Guide to Handling, Preservation, Processing and Quality. Chatham Maritime. Kent ME4 4TB, United Kingdom.

Doe, P.E. 1977. A polythene tent drier for improved sun-drying of fish. Food Technol. Aust., 29(11):437-441.

Doe, P.E. 2002. Fundamentals of fish drying. *In: Text book of Fish Processing Technology*, K. Gopakumar (ed.). Indian Council of Agricultural Research, New Delhi, 491 p.

FAO, 1981. The Prevention of Losses in Cured Fish. FAO Fisheries Technical Paper No. 219. Food and Agriculture Organization of the United Nations, Rome. 87 p.

FDA, 1996. Fish and Fisheries Products Hazards and Controls Guide: First Edition. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Food Safety and Applied Nutrition, Office of Seafood, USA.

Gopakumar, K. 1997. Tropical Fishery Products. Science Publishers, Inc., U. S. A.

Gopakumar, K. 2002_a. Post-mortem changes in fish and quality assessment. *In: Textbook of Fish Processing Technology*. K. Gopakumar (ed). Indian Council of Agricultural Research, New Delhi. 491 p.

Gopakumar, K. 2002_b. Technology of fish freezing. *In: Textbook of Fish Processing Technology*. K. Gopakumar (ed). Indian Council of Agricultural Research, New Delhi. 491 p.

Horner, W.F.A. 1992. Preservation of fish by curing (drying, salting and smoking. *In: Fish Processing Technology*, G.M. Hull (ed.). Blackie Academic and Professional, New York. p. 31-88.

Howe, R.W. 1965. A summery of estimates of optimal and minimal condition for population increase of some stored product insects. J. Stored Prod. Res., 1(2):177-184.

Jones, N.R. 1962. Browning reactions in dried fish products. *In: Recent Advances in Food Science*. (Vol. 2), J. Hawthron and J. M. Leitch (eds.). Butterworths, London. p. 74-80.

Khan, M.A.A. and Khan, Y.S.A. 1992. Study of dry fish (marine) with special reference to insect infestation, use of health hazard insecticides and control effect of pririmiphos-methyl. Msc. Thesis. Institute of Marine Science, University of Chittagong, Bangladesh.

Khan, Y.S.A., Zabber, S. M.A. and Saifullah, A.S. M. 2002. Use of insecticides in dried fish and its effects on human body. Committee for Social and Environmental Development – COSED. 24 p.

Love, R. M. 1992. Biochemical dynamics and the quality of fresh and frozen fish. *In: Fish Processing Technology*, G.M. Hull (ed.). Blackie Academic and Professional, New York. p. 31-88.

Nair, P. G. V. 2002. Biochemical composition of fish. *In: Textbook of Fish Processing Technology*, K. Gopakumar (ed). Indian Council of Agricultural Research, New Delhi, 491 p.

Niwa, E. 1992. Chemistry of surimi gelation. *In: Surimi Technology*, T.C. Lanier and C.M. Lee (eds.). Marcel Dekker, Inc. New York.

Nowsad, AKM. A. 2003. Development and introduction of low-cost solar fish dryer in coastal fishing villages. Paper presented in the workshop on "Sustainable Solar Fish Dryers for Poverty Reduction" organized by DFID in Cox's Bazar, June 17-18, 2003.

Nowsad, AKM, A. 2005a. Low-cost Processing of Fish in Coastal Bangladesh. BGD/97/017 Field Doc: 05/2005. Food and Agriculture Organization of the United Nations. Dhaka. 73 p.

Nowsad, AKM. A. 2005b. `xNKvj msi¶Y I AwaK gbvdvi Rb¨ gv‡Qi mgvRwfwËK e¨envi- ¯Z: cwiPwjZ cYv½ AskMnYgjK GKwU bZb wk¶Y c×wZ. BGD/97/017 Field Doc: 04/2005. Food and Agriculture Organization of the United Nations, Dhaka. 88 p.

Paul, L.F. 1962. A life-history study of the hide beetle *Dermestes vulpinus*. Indian J. Entomol., 24(3):167-179.

Proctor, D.L. 1977. The control of insect infestation of fish during processing and storage in the tropics. *Proc. Conf. on Handling, Processing and Marking of Tropical Fish*, London. July 1976.

Saito, T., Arai, K. And Matsuyoshi, M. 1959. A new method of estimating freshness of fish. Bull. Jap. Soc. Sci. Fish., 24 : 749-750.

Sakaguchi, M. 1994. Objective and subjective method for measuring freshness of fish. Department of Fisheries, Faculty of Agriculture. Kyoto University, Japan.

Sarker, W. and Khan, Y.S.A. 1997. Study on marine dry fish of Chittagong and health hazard to human. M.Sc. Thesis, Institute of Marine Science, University of Chittagong, Bangladesh.

Szabo, A. 1970. Rapport au gouvernment du Mali sur les ameliorations possibles des produits de la peche. Rapport FAO (UNDP/TA), No. 2900, Rome.

Voumic, D. 2002. Poisonous insecticides in dried fish: adverse effects in human body. The Daily Pratham Allo, 18 July.

Walker, D.J. and Greeley, M. 1990. Cured fish in Bangladesh. *Report on a visit to Bangladesh on behalf of ODA Post-harvest Fisheries Project, BOBP*, Madras, India, R. 1659 (R).

Annexure-I

Glossary

ADP	Adenosine di-phosphate
AFO	Assistant Fisheries Officer
AIG	Alternative income generation
AMP	Adenosine mono-phosphate
ANSI	American National Standard Institute
ASQC	American Society for Quality Control
ATP	Adenosine tri-phosphate
A_W	Water activity
BGD	Bangladesh
BSTI	Bangladesh Standard and Testing Institute
CAP	Controlled atmosphere packaging
CCP	Critical control point
CP	Creatine phosphate
CSW	Chilled sea water
DDT	Dichloro-diphenyl-trichloro-tetraethene
ECFC	Empowerment of Coastal Fishing Communities for Livelihood Security
EC	European Community
EEC	European Economic Council
EN	European Norm
ESBN	Estuarine set bag net
FAO	Food and Agriculture Organization
FAO-CCRF	FAO-Code of Conduct for Responsible Fisheries
FDA	Food and Drug Administration
GMP	Good manufacturing practice
GO	Government organization
Gy	*Gray*, an unit to measure irradiation of food
HACCP	Hazard analysis and critical control point
HP	Horse power
H_X	Hypoxanthin
H_XR	Inosine
IMP	Inosine mono-phosphate
ISO	International Organization for Standardization
kGy	*Kilo Gray*
LCD	Liquid crystal display
MAP	Modified atmosphere packaging
MCQ	Multiple choice questions
MD	Movement document
MoFL	Ministry of Fisheries and Livestock
MSBN	Marine set bag net
NGO	Non-government organization
OHP	Overhead projector
P & D	Peeled and deveined
PPM	Parts per million
PRA	Participatory rural/rapid appraisal
PUD	Peeled undeveined
PUFA	Polyunsaturated fatty acid
QC	Quality control
QMP	Quality management programme
RSW	Refrigerated sea water
SH	Specific heat
S/O	Shell on
SPS	Sanitary and Phyto-sanitary
SUFO	Senior Upazila Fisheries Officer
TAP	Thermal arrest period
TBA	Thiobarbituric acid value
TMA	Trimethylamine
TMAO	Trimethylamine oxide
ToT	Training of trainers
TVBN	Total volatile base nitrogen
UFO	Upazila Fisheries Officer
UNDP	United Nations Development Programme
VO	Village organization
WHO	World Health Organization
WTO	World Trade Organization

Annexure-II

Participatory Training of Trainers-*A new approach applied in fish processing*

Pre- and Post Evaluation Questionnaire

Full marks: 100; Time: 30 min.

Name: Position & address:

(Put tick mark on appropriate answers; Equivalent marks will be deducted for both no-answer or wrong-answer)

1. What do you think about the objective of this training?
   a. To give an insight into improved handling and processing for producing quality fish product;
   b. To provide information on reasons of post-harvest loss and different critical control points where to intervene for minimizing loss;
   c. Both the two;
   d. *None of these;*
   e. *Don't know.*

2. Why does a fish spoil relatively early?
   a. Due to the characteristic nature of inherent proteins and lipids;
   b. Because of comparatively higher post-mortem pH;
   c. Due to more contact with micro-organisms;
   d. Due to all of these;
   e. Don't know.

3. Fish undergoes spoilage by-
   a. self breakdown of proteins;
   b. oxidation of lipid;
   c. microbiological contamination;
   d. all of these;
   e. Don't know.

4. Which can accelerate fish spoilage?
   a. Exposure to direct sunlight and high temperature;
   b. Lowering of body temperature;
   c. Destroying enzyme and killing bacteria by high temperature;
   d. Reducing water content in fish body;
   e. Don't know.

5. Which one is not a benefit of good handling?
   a. Increased landed weights;
   b. Premium price;
   c. Increased catch of target species;
   d. Premium quality;
   e. *Don't know.*

6. Which one is not a good handling on the deck?
   a. Sorting fish as early as possible – on species, size and on physical conditions;
   b. Removing damaged, sickly and spoiled fish promptly;
   c. Leaving fish under sun-light;
   d. Bleeding fish as required;
   e. *Don't know.*

7. Good handling of fish depends on--
   a. keeping fish obligatorily cool;
   b. keeping fish airtight during transportation;
   c. processing fish immediately after harvest;
   d. selling out fish as early as possible;
   e. Don't know.

8. We should ice fish, because -
   a. ice melt-water in contact with the fish is a good conductor of heat and facilitate cooling;
   b. as ice melts at 0^oC, it will not freeze the fish but automatically controls the temperature at the ideal chill level;
   c. ice melt-water keeps the surface of fish wet that prevents dehydration and preserves the glossy appearance;
   d. of all the three above;
   e. *Don't know.*

9. Which point is not necessary to consider during icing of fish?
   a. *temperature of air and fish;*
   b. *length of transportation and insulation of the container;*
   c. *volume of fish;*
   d. *total length of fish;*
   e. *Don't know*.

10. Which is the ideal condition for icing of fish?
   a. *Finely crushed, clean ice to speed up cooling while minimizing bruising of fish;*
   b. *Fish are stowed at an even pace to avoid clumping while allowing even distribution of fish and ice;*
   c. *Not too much fish is stowed vertically in a fish hold so that the pressure of fish from above cannot damage the fish kept at the bottom;*
   d. *All the three above;*
   e. *Don't know*.

11. Drying season in coastal belt -
   a. *starts generally in October and ends on March;*
   b. *starts in early August and lasts till the end of June;*
   c. *prevails throughout the year;*
   d. *follows lunar cycle of the month;*
   e. *Don't know*.

12. Elevated racks are ideal for sun-drying, because-
   a. *it is operator-friendly;*
   b. *drying is effective and rapid due to greater exposure of surface area and higher wind action;*
   c. *drying is effective due to lesser access of animal to the product;*
   d. *of all the three above;*
   e. *Don't know*.

13. Which is not an ideal condition for premium quality in traditional dried products?
   a. *Fresh raw material with good handling is used;*
   b. *Good sanitation is maintained;*

   c. *Infestation is reduced by organo-chlorine insecticides;*
   d. *Solar energy is used to shorten the drying period;*
   e. *Don't know*.

14. How could you understand a dried product prepared from spoiled fish?
   a. *The original skin is lost and distorted: rough ununiform skin;*
   b. *The product is bitter in taste with off flavour;*
   c. *Total length is increased after drying;*
   d. *All of the three above;*
   e. *Don't know*.

15. Which is not a constraint of traditional fish drying?
   a. *Contamination;*
   b. *Rancidity;*
   c. *Use of health-hazard pesticides;*
   d. *Marketing;*
   e. *Don't know*.

16. Smoking of shrimp (lailla-icha) is done in coastal villages for –
   a. *bright pink-reddish colour;*
   b. *good taste and flavour;*
   c. *protection against aerial oxidation and bacterial action;*
   d. *all of these;*
   e. *Don't know*.

17. Smoking of fish should be done by dry wood, because -
   a. *green or un-dried wood carries molds that can accumulate in the surface of smoked product and thereby serves as the source of contamination;*
   b. *dry wood is light and moisture-free, and easily available;*
   c. *flavour of green wood can degrade the quality of smoked product;*
   d. *of all of these;*
   e. *Don't know*.

18. Salt preserves fish by –
   a. *reducing water content in the fish body;*
   b. *increasing salt content in the fish body;*

c. disinfecting the bacteria;
d. all of these;
e. Don't know.

19. Proper salting of *Hilsa* is done by –
a. using good quality, sand and mud free solar salt;
b. using appropriate fish to salt ratio of 4:1;
c. allowing exudates to drain out in dry salting;
d. all of these;
e. Don't know.

20. Wet salting of fish is better than dry salting, because –
a. the fish are dipped into saturated brine that ensures rapid water removal and salt up-take;
b. the fish is not in direct contact of air, so lipid oxidation is minimum;
c. ripening or maturing in the product takes place comparatively early;
d. of all the three above;
e. Don't know.

21. Which is not a sign of spoilage in salted *Hilsa* ?
a. A pink or red sheen on the surface of the product, caused by salt-tolerant bacteria;
b. A grayish to blackish appearance on the surface of fish by salt-loving molds;
c. Bright brownish to pinkish texture with glazy appearance developed during ripening;
d. None of them;
e. All of them.

22. *Nga-pi* is an enzymatically fermented paste product made by the *Rakhaings* from -
a. very small shrimp and fish;
b. sea grass and algae;
c. a variety of small snails, bivalves and other mollusks;
d. all of the above;
e. Don't know.

23. Which is not a good manufacturing practice of *Nga-pi* ?
a. ensuring premium quality of raw material shrimp/fish by early salt treatment;
b. use of elevated racks for drying shrimp;
c. use of clean and contamination-free utensils and containers;
d. use of mat on the dyke for drying shrimp/fish;
e. *all of these.*

24. Why should we package fish and fish products ?
a. to protect the products against dirt, chemicals, contamination, insect attack, adulteration, tempering and damage;
b. for easy distribution, preservation and display;
c. to serve as a means of communication and provide information on the products, whether as requirement or to attract consumers;
d. to add value to the products and extend shelf life;
e. all of these.

25. Effective quality control of fish product should address:
a. design of product specification;
b. inspection of raw material and final product;
c. control of process;
d. training of personnel involved in quality control and quality assurance;
e. *all of these.*

Annexure-III

Participatory Training of Trainers-*A new approach applied in fish processing*

Evaluation of the Training Course

Designation:……...…….(not essential)
Educational qualifications:……. …….(essential)

1. How far have you been able to improve your level of knowledge on fish processing through this training? (on a scale of 0~100 with 100 being the highest).

   Level of knowledge before ToT : ……%

   Level of knowledge after ToT : ……%

2. A participatory self-facilitated highly interacting new technique is introduced in this training. How far have you found this technique effective?

   Evaluate in percent ….……%

3. If the efficacy is more than **50%**, then give three reasons for why it is so effective.
   a.
   b.
   c.

4. If the efficacy is less than **50%**, then give three reasons for why it is less effective.
   a.
   b.
   c.

5. Cite **2** strong side of the ToT.
   a.
   b.

6. Cite **2** weak side of the ToT.
   a.
   b.

Annexure-IV

Participatory Training of Trainers-*A new approach applied in fish processing*

Evaluation Score Sheet

Sl. No.	Name of the Participant	Trend of improvement			Remarks
		Marks			
		Pre-evaluation	Post-evaluation	% Development	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Author's Profile

Dr. A K M Nowsad Alam is a professor of Fish Processing, Quality Control & Food Safety in the Department of Fisheries Technology of Bangladesh Agricultural University (BAU), Mymensigh. He earned his B.Sc. Fisheries (Hons.) and M.Sc. in Fisheries from the BAU and MS and PhD in Marine Biotechnology and Biochemistry from Mie University, Japan. Dr. Nowsad was awarded a prestigious JSPS post-doctoral fellowship for 2 years, while he conducted a research on Marine Bio-engineering and Biochemistry. Dr. Nowsad has served the FAO as a Senior Expert of Fish Processing and Resource Management and Development for more than four years, where the main responsibility was the mobilization of coastal fishing communities for livelihood development through improvement of fish processing, quality assurance and participatory management and restoration of coastal and marine resources. He has kept up a superb academic and professional records throughout his professional life. He has more than 50 research publications, of which 30 are in peer reviewed international journals of the USA, UK and Japan. Dr. Nowsad has written 10 books, 5 booklets, several leaflets and huge articles on different aspects of fish processing, community empowerment and resource management, many of them are published by the FAO. He has pioneered a model of highly participatory self-facilitated training of trainers for rural extension- the approaches and methods are published by the FAO in Bangla.

Dr. Nowsad has top level management & coordination skills as he served as the Head of the Department, Manager of Fish Farm, Senior Expert of a community empowerment project, Senior Officer in a nationalized bank, etc. He has collective, conceptual, analytical and management skills with competence in the designing, developing, planning, implementation, monitoring and evaluation of development and research projects, vertical and horizontal communication in project management, human resource development, training and extension of livelihood components, GO-NGO coordination, logical frame-work formulation, implementation of sustainable livelihood approaches, mobilization of communities and their grassroot institutions and empowerment of coastal disadvantaged communities for community participated natural resource management.

Dr. Nowsad has extensively worked at the field with the grass-root level people and earned expertise on both artisanal & commercial small, medium and large scale processing of fish and shellfish of Bangladesh and their constraints and solution options, developed with the beneficiaries, local & international organizations and donor agencies. He has developed several technology packages for the improvement of fish processing and quality control sector of the country, like low-cost solar fish dryer, low-cost ice box for effective handling and transportation of wet fish in rural areas, community ice box for preserving unsold fish and ice-block in fish market, box and ring tunnels for production of pesticide-free dried fish, improved earthen oven for smoking of shrimp, improved process and packaging for salted hilsa and fermented shrimp/fish pastes, value-added tasty mince products from underutilized fish, etc.

Modernizing the delivery technique from a mere "teaching" to "learning together", Dr. Nowsad has introduced many of the participatory tools discussed in this book in his undergraduate and graduate classes, while those have been appreciated by many as more student-friendly and effective.