The United Nations University
FISHERIES TRAINING PROGRAMME
P.O. Box 1390, Skulagata 4
120 Reykjavik, Iceland
Final Project 2007

PRE- AND POST-HARVEST HANDLING AND PROCESSING PROCEDURES FOR THE PRODUCTION OF SAFE AND HIGH QUALITY FRESH FISHERIES PRODUCTS IN BANGLADESH

Hasan Ahmmed
Department of Fisheries
11th Floor, Matsya Bhaban, Dhaka-1000
Bangladesh.
hasan_ahmmed2006@yahoo.com

Supervisors
Prof. Hjorleifur Einarsson (hei@unak.is)
Arnheidur Eythorsdottir (arnh@unak.is)
University of Akureyri

ABSTRACT

Fisheries play a significant role in Bangladesh providing 63% of the animal protein supply and 10% direct or indirect employment for 150 million people, and are the second highest export earning source of the country. The fish processing sector has not achieved expected export returns with respect to the growth rate of aquaculture and overall fish production. Lack of technical production knowledge on high quality and safe products prevents proper utilisation of the available carp and catfish from aquaculture.

To improve fish processing in Bangladesh, the limitations of current practices were studied in comparison to processing practices in Iceland. Long, complicated fish supply chains, shortage of technical skills, and weak safety and quality management systems were identified as the major obstacles in the Bangladesh fish processing industry. Based on information gained in Iceland, a comprehensive handling, processing and quality management system has been suggested for Bangladesh and a set of recommendations made to implement this practice.

Key words: handling, processing, quality, safety, carp, catfish

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

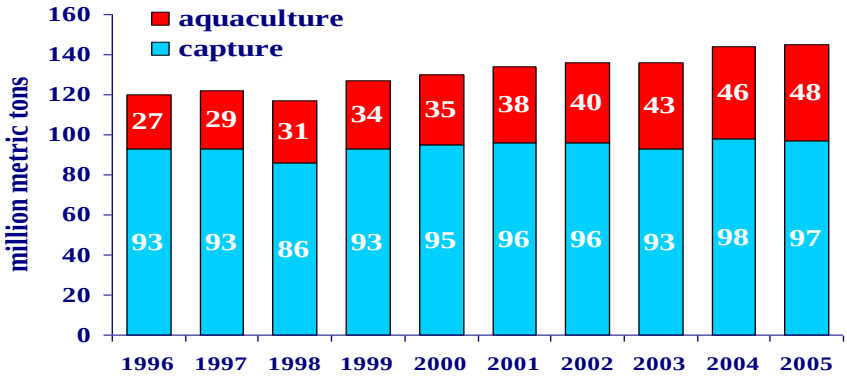
1 INTRODUCTION

1.1 Global fisheries overview

Fisheries play an important role in many countries contributing to livelihood, food security and trade as well broad aspects of national economies. In developing countries, fisheries resources management and aquaculture are considered to be the most effective tools for poverty eradication through employment and income generation, increased nutrition and livelihood improvement. During the last three decades, involvement of fisheries in the global food production for domestic use has increased considerably. This progress has been achieved through the development of aquaculture. Beside this development, some issues have been raised regarding the global distribution, utilisation and trade of the fisheries resources as well as quality, safety and future sustainability.

1.1.1 World fisheries production trends

World fish production increased from 40 million tonnes in the early 1960s to nearly 142 million tonnes (t) in recent years (FAO 2006a). During the last decade, this increase is mostly from growing aquaculture production amounting to 48 million t along with the stable catch of capture fisheries, about 94 million t (Figure 1). World aquaculture production increased from 27 million t in 1995 to 48 million t in 2005, of which 43.2 million t were produced in Asia, 2.1 million t in Europe, 2.1 million t in North and South America and the remaining parts in Africa and Oceania. The expansion of aquaculture is mainly due to an increase in carp and shellfish culture practices in developing countries during the last 20 years. The algae production has also increased considerably to about 15 million t where brown algae is 7.8 million t, red algae 4.8 million t and other aquatic plants 3 million t (FAO 2006b).



. Source: FAO FishStat

Figure 1: Global fisheries production (1996-2005) capture and aquaculture, fish and other animals.

During the last 10 years, a considerable increase has been observed regarding aquaculture production and exports in some South Asian countries such as China, India, Thailand, Philippines, Vietnam and Indonesia. Among the aquaculture producing countries, China contributes a major share of the world aquaculture production in both finfish and shellfishes. In 2004, the aquaculture production of

China was 33.7 million t where carps were 14.4 million t, which were about 70% and 65% of the world aquaculture and carp production respectively (FAO 2006b). Following China, other top ranking aquaculture producing countries are India (2.8), Philippines (1.9), Vietnam (1.5), Indonesia (1.3), Thailand (1.1), Bangladesh (0.9) and Japan (0.8).

1.1.2 Utilisation of fisheries production

Out of 148 million t world total production, about 105 million t of fish went for human consumption in 2005. Figure 2 shows the utilisation trends of the fisheries production since 1983 and from 1993-2005. Fish has a significant capacity for processing to produce diversified value added products and almost two third of the catch were used for further processing and marketing in 1998 (FAO 2000). During 1960 to 2000, between 20 and 30% of the total world fish production had been used for manufacturing animal feed (FAO 2000). At that period, a large portion, approximately 30%, of fish used for human consumption was frozen fish, 14% was canned, 12% cured and the remaining 45% were sold fresh. A significant growth of fresh fish consumption was observed during the 1990s (FAO 2002) and the trend has continued with an increasing utilisation rate of fresh fish for human consumption since 1994.

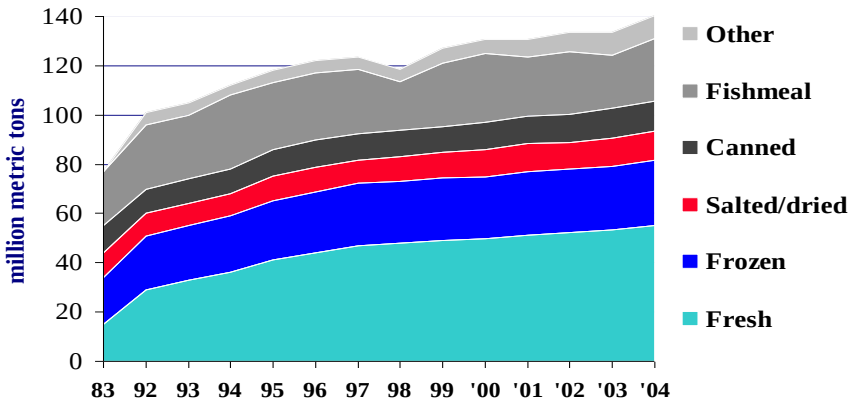


Figure 2: Utilisation of world fisheries supply in 1983 and 1992-2004 (FAO 2006c).

1.1.3 World fish trade and export-import

Fishery products are among the most internationally traded food categories in the sense that they have been widely crossing boarders (Moller 2007). In 2004, the export quantity of fisheries commodities was 53 million t and the value was close to US $ 72 billion (FAO 2006c). A major share of the fish production and exports belongs to developing countries as contributing 30.1 million t of fish exports out of 110.3 million t total production in 2004, which was about 22.7 and 30.1 million t respectively for developed countries (FAO 2006c). Developing countries' production was mostly from aquaculture. On the other hand, developed countries dominated over the developing countries regarding marine catch where they exported 19.2 million tonnes out of their total catch of 33.2 million t (FAO 2006c).

1.1.4 Changing demands of consumers, quality and food safety issues

During the last decade, the quantity of fishery products entering into international trade has increased by over 5 million t but decreased as a percentage of total world production from 42% in 1996 to 38% in 2004 (FAO 2006c). During these years, this increment rate has dropped in terms of value of the aquaculture products due to the fluctuations of prices in competitive world export -import markets (FAO 2000).

Along with the growing global demand for high quality and safe seafood, competition has also increased among the fish producing countries for global market access by increasing supply of cost effective fish products (Moller 2007). Maximum possible utilisation of the available fisheries resources through adaptation of modern processing technology to produce cost effective, high quality and safe fish products is the key factor to sustaining the competitive global market. Moreover, safety rules and regulations imposed by the consumer countries continue to become more straight cut and add challenges for the fish exporting countries. So, fisheries businesses are becoming more concerned with quality, food safety and environmental considerations. That is why more research is required to identify these issues. Assessing and finding probable ways to resolve the issues for future sustainability of the fish processing sector is now a priority for fish producing nations.

1.2 Icelandic fisheries

The fisheries industries in Iceland play an important role contributing about 5% to the Gross Domestic Production (GDP) and more than 50% of export earnings of the country (Moller 2007). Iceland has a renowned history of fisheries resource management and exploration over the last two centuries. Especially, during the last 50 years the country's fisheries management and utilisation of fisheries resources for sustainable economic development has made Iceland an example for other countries. The fisheries resource management, good coordination among the fisheries stakeholders and government, use of modern technologies and skilled human resources are the key factors behind Iceland's success story. Particularly, the utilisation of the resources by the fisheries industries adopting of good handling and processing technologies for production of high quality and safe fish products, has earned them trust on the international seafood market. The successful experience regarding processing industries in Iceland may offer good opportunities for other countries to improve the existing status of fish industries stimulating management for sustainable economic development.

1.3 Bangladesh fisheries overview

1.3.1 Bangladesh: general situation

Bangladesh is a densely populated agro-economy based country in Southeast Asia, with a population of 150 million and an area of 147,000 km^2 (BBS 2005). The average per capita accessible land resources are limited for agricultural production. In the past half a century, environmental degradation of land and aquatic habitats along with frequent natural disasters have affected the national economy. Fisheries are now considered as the most effective sector for employment generation and poverty eradication in Bangladesh. Fisheries contribute employment for about 10% of the

population, 63% of the total animal protein consumption and are the second highest export earning sector of the country (DoF 2006). During the last two decades, significant growth rates in fisheries production have been achieved by expansion of closed water aquaculture through the intervention of production technologies and adoption of community based fisheries management for conservation and sustainable exploration of open water fisheries resources. More than 15 million people are directly or indirectly dependent on the fisheries sector for their livelihood. Therefore, government and development partners have given priority attention to promote this sector.

1.3.2 Bangladesh fisheries resources

Fresh water resources:
Bangladesh is blessed with vast accessible fresh water, brackish water and marine aquatic resources with well-diversified fish fauna along with favourable environmental and climatic conditions for fisheries production (Table 1). Inland fresh water fisheries resources include a number of rivers, estuaries, beels, haors, lakes, reservoirs and seasonal flood-plains covering over 4.0 million ha. Besides, about 8.0 million ha of inundated rice fields around the country where 3.0 million ha remain under water for 4-6 month having unique ecological suitability for fish and shrimp aquaculture with concurrent or rotational cropping (DoF 2007). These open, semi-closed or seasonal fresh water resources provide suitable natural habitats for numerous wild fish and shellfish species. Aquaculture is now practised in more than 310,000 ha freshwater ponds and 283,000 ha coastal shrimp farm areas (DoF 2006). Aquaculture production has increased about 8 times during the last two decades. Large areas suitable for aquaculture still remain underutilised and have a good potential of increasing aquaculture production further in a cost effective way. Open fresh water resources also have potential for increasing fisheries production, employment generation, export promotion and maintaining biodiversity.

Marine water resources:
Bangladesh has large marine resources including coastal plains, islands, tidal flats, estuaries and inshore and offshore waters extending to the Bay of Bengal beyond 714 km and an Exclusive Economic Zone (EEZ) of 164,000 km^2 which is largely unexploited (DoF 2007). The coastal zone houses several natural and mangrove forest ecosystems (like the world famous Sundarbans mangrove) supporting rich aquatic biodiversity. There are more than 490 finfish species and 24 species of shrimps, 4 species of lobsters, several species of cephalopods, marine mammals and other wildlife. Among them, more than 100 species are commercially important. Finfishes include more than 70 pelagic species most of them still remain underexploited due to lack of resource information, skilled manpower, modern fishing vessels and gears, modern technology for resource management and utilisation policy (DoF 2007).

Table 1: Annual total catch and area productivity by fisheries resources of Bangladesh (DoF 2006).

	Resources of fisheries	Water area (ha)	Total catch (metric tonnes)	Percent production (%)	Catch/area kg/ha
A.	Fresh water inland fisheries				
i	Capture fisheries:				
	River and estuaries	1,031,563	137,859	5.9	134
	Sundarbans (Coastal forest)*	*	16,423	0.7	
	Beels (Large reservoirs)	114,161	76,365	3.3	669
	Kaptai lake	68,800	7548	0.3	110
	Flood land (Seasonal water area)	2,832,792	718,491	30.9	254
	Capture fisheries total =	**4,047,316**	**956, 686**	**41.1**	
ii.	Closed water culture fisheries				
	Pond and ditches	305,025	759,628	32.6	2490
	Baor	5,488	4498	0.2	820
	Shrimp farms	217,877	127,923	5.5	587
	Culture fisheries total =	**528,390**	**892,049**	**38.3**	
	Freshwater inland fisheries total =	**4,575,706**	**1,848,735**	**79.4%**	
B.	Marine fisheries (Trawl)				
	Industrial fisheries (Trawl)		34,084	1.5	
	Artisanal fisheries		445,726	19.1	
	Marine catch total =		**479,810**	**20.6%**	
	Country total production =		**2,328,545**	**100%**	

(*Sundarban area is included in river and estuaries, but catch assessed separately)

Marine fisheries presently contribute only 480,000 t of fish and shrimps which is less than a quarter of the annual production. The lion share of the marine catch comes from artisanal fisheries (92.7%) involving over 22,000 non-mechanised and 21,000 mechanised boats mostly fishing within the 50 m depths onshore harvesting demersal fish and shrimp seed. Out of 166-licensed industrial fishing trawlers, about 123 are fully or partly engaged in fishing mainly based on shrimp trawling (42) and white fish trawler (65) along with a few mid water trawlers (10) and only one squid jigger (DoF 2007).

1.3.3 Bangladesh fishery production

Annual fish production in the year 2005-06 was about 2.33 million t where aquaculture production was 0.9 million t (38%), fresh water capture fisheries 0.95 million t (41%) and marine capture fisheries contribution was about 0.48 million t (21%) (DoF 2006). Total production was expected to exceed 2.5 million tonnes in the year 2006-07. During the last 10 years aquaculture production and total fish production has increased considerably (Figure 3). It is due to the involvement of the private sector under technical and management support from the government and active participation of different NGOs and international agencies.

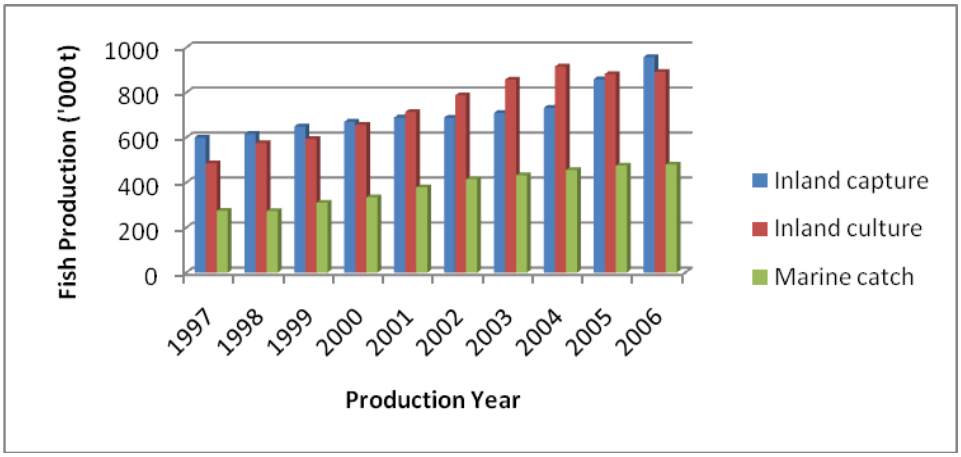


Figure 3: Resource wise fisheries production of Bangladesh from 1997-2006 (DoF 2006).

The inland fisheries production of Bangladesh is mostly dominated by carp and catfish contributing over 870,000 t which is about 47% of the total inland fish production of 1,850,000 t. In pond aquaculture production (760,000 t), carps contribute more than 90%. The contributions of major fish species or groups in the total production are shown in Figures 4 and 5. Recent culture of catfish (*Pungasius*), tilapia and Thai Koi aquaculture has increased. These are fast growing species and there is a strong export market demand for them (Moller 2007, FAO 2006b).

Hilsa contributed the largest catch of 277,000 t in 2005-06 which is 58% of the total marine catch (480,000 t) and 12% of the total fish production. The calculated value of the Hilsa catch is more than US $ 700 million (DoF 2006). Other main marine species include Bombay duck 39,000 t, jewfish 32,500 t, sea catfish 18,000 t, pomfrets 12,000 t, Indian salmon 1000 t, sharks, skates and rays 4500 t and other marine fishes 125,000 t. Along with these finfish catches, the marine shrimp catch was more than 48000 t. The main marine shrimp catch comes from black tiger shrimp (*Peneus monodon*) along with some other species like white shrimp (*Peneus indicus*) and brown shrimp (*Macrobrachium monoceros*).

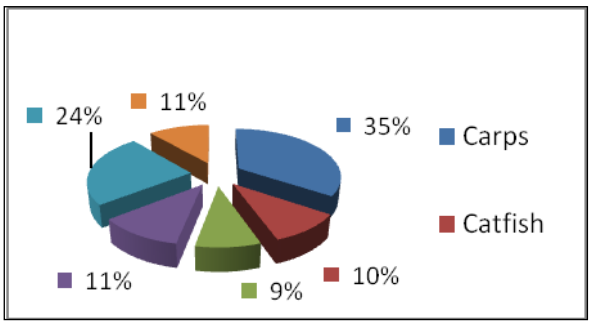


Figure 4: Catch composition of the total fisheries production of Bangladesh (DoF 2006).

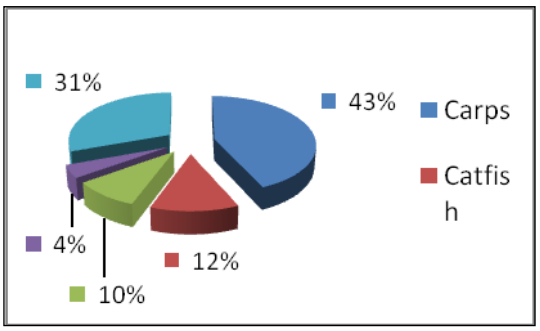


Figure 5: Catch composition of the fresh water fisheries production of Bangladesh (DoF 2006).

1.3.4 Export trends of fishery products

During the last 15 years the export quantity and values earned from fisheries increased considerably (Figure 6) which was 26,000 tonnes (value US $ 140 million) in 1992-93 and increased to 69,000 tonnes (value US $ 500 million) in 2005-06 (DoF 2006).

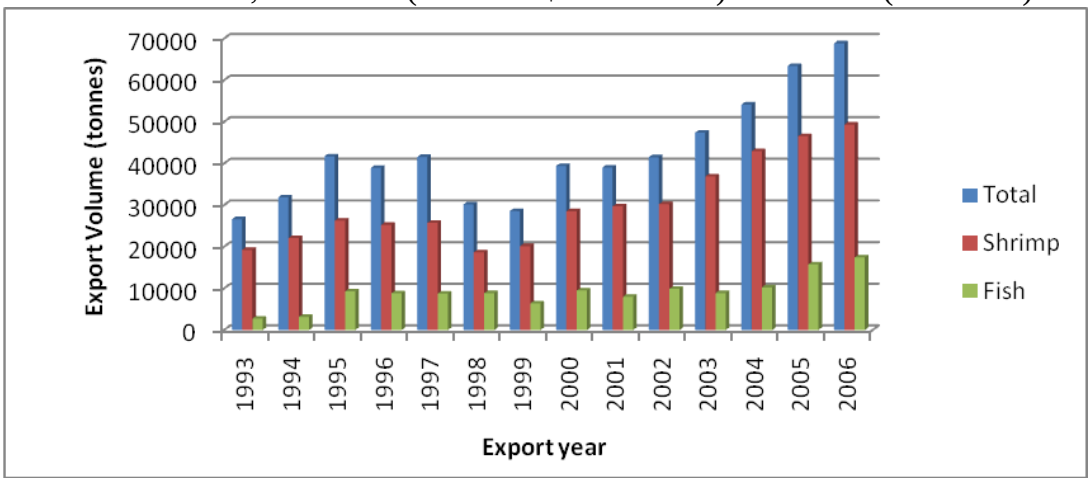


Figure 6: Shrimp and fish export trends of Bangladesh from 1993 to 2006 (DoF 2006).

In 1995-96, the total shrimp and finfish production was 1.26 million t where the export volume was 39000 t with a value of US $ 223 million. The export volume and value increased but the percent contribution of fisheries to national export earnings came down to 4.56% while it was 9.38% in 1995-96.

Excluding shrimp, the export of fish and fisheries products increased from 13,700 t in 1995 to 17,500 t in 2006 with a value increase from US $ 48 million to US $ 55 million respectively. In comparison to shrimp, the quantity and export value earnings from fish are very low. Although fish production increased more than double to 2.33 million t, the export quantity of fish is less than 1% of the total fish production. This is mostly due to the lack of diversification in export products along with quality and safety requirements to comply with the changing demands of consumers.

1.3.5 Fisheries export commodity

The main export fisheries product from Bangladesh is shrimp (Figure 6). In 2005-06, about 49,000 t of shrimp were exported, which was 70% of the total exported quantity. Regarding export value shrimp contributed 89% (US $ 450 million) of the total export earnings (DoF 2007). Only 17,500 t chilled and frozen fish and 2500 t other fishery products were exported this year. The shrimp exported was mostly frozen in block. Recently, a few processing plants have introduced processing of fish fillets, sticks and other fish products. The other export fish and fisheries products are mainly whole gutted head on and headless frozen and chilled fishes, IQF and frozen blocks of different fish species (60%), crabs, eels, tortoises, turtles (16%), salted and dehydrated fish (9%), dry fish (2%) along with limited quantity of live fishes (catfishes), shark fin and fish maws etc. The exported fishes are mainly fresh water species like Indian major carp and Chinese carp, catfish, tilapia, small wild fishes along with a few marine fish species like Hilsa, pomfrets, jewfish, Indian salmon, catfish, ribbonfish etc.

1.3.6 Processing industry sector in Bangladesh

Before independence of the BD in 1971, there were nine fish processing plants with a production capacity of only 58 t per day. All of these plants were engaged in exporting fresh water headless shell-on prawns and frog legs to Europe and the USA. The fish processing industry sector gained momentum during the period of 1972-1984, when 40 processing plants were installed by the private sector mostly under government initiation and bank loan support to promote the sector with a vision to export shrimps and frog legs to Europe and the USA. During the 1970s, newly constructed factories were designed for shrimp and frog leg processing. The industry had a setback in the mid 1980s, when frog leg processing and export were banned, most of the factories went bankrupt (DoF 2007). From 1985-1998, 72 more processing plants were established by the private sector for processing and exporting shrimp and fish products.

According to a government report (DoF 2007), 131 shrimp and fish processing industries are now running part time utilising less than 35% of their total capacity of processing 1000 t per day (based on 200 working days, single shift). Prior to establishing of fish processing industry, a biological survey of the potential fish resources should have been done which could have been used as a primary basis for the feasibility study of these plants. Unfortunately, that was ignored before and gradually the capacity utilisation decreased due to unplanned growth of the industry leading to a shortage of raw materials. This situation is partly due to lack of expertise regarding modern fish handling and processing technology. A shortage of educated skilled personnel at different levels is the limiting factors for the processing industry in Bangladesh.

1.3.7 Existing problems of processing industry

Export processing industries in Bangladesh are mostly based on traditional knowledge on handling and processing of fresh and frozen shrimps (head on/off) collected from farmed or catch sources. The processing factories personnel do not have good technical knowledge how to handle and process carps or catfish from fresh water and

marine resources. Their workers lack skills and technical expertise and machinery and technology is not advanced enough to produce good quality fish fillets or other diversified fish products for export in the competitive international market. Therefore, they could not able to utilise the available carp or catfish raw materials for producing quality export products. As fish handling and processing activities are quite limited in the industry, the workers could not increase their skills, efficiency and experience. On the other hand, the dependence of all processing plants on shrimp results in a shortage of raw materials and finally limits the utilisation of the processing factories. This situation also enhances competition for raw materials and to some extent the processing plant owners collect shrimp ignoring quality aspects and finally fail to get the expected price in the competitive market. Even such quality compromises may create future image problem in the strictly regulated export market for Bangladesh.

About 50% of the leading processing industries have good technical, management capabilities and regulatory compliance to the export market but they are now not running well due to lack of raw materials (Pichler 2007). Out of 131 shrimp/fish processing plants 67 are maintaining International Food Standard (IFS) graded (>90% QM Score) and have EU licenses for the export of shrimp and fish (DoF 2007). To sustain the small and large factories, their economically feasible utilisation must be ensured. There are no other alternatives but for them to develop technological and management efficiency for handling and processing available carps, catfish and other fishes as raw materials to utilise the existing processing facilities. The supply of these fish to the factories can be easily increased in Bangladesh, which might not be equally possible for shrimps in a cost effective way.

1.3.8 Marketing of fish and shrimps

In the domestic market, most of the rural consumers have limited income levels and lower purchasing capacity that makes them unable to pay a good price for the fish. About two thirds of the population live in rural areas and a major part of them consumes their required fish either from own/leased household ponds or from natural open water resources. Market prices of fresh harvested or iced preserved fish is comparatively higher (50-200%) in urban markets. But involvement of middlemen at several steps in the long marketing chain deprive the producers from having a good price. Due to inadequate cool storage facilities and the unavailability of good quality ice in the growing area, farmers or fishermen tend to sell their fish as early as possible to middlemen before spoilage. Other than shrimp farming regions, there are limited facilities for farmers to directly sell their fish/shrimps in a scheduled market place without interference of middleman. Medium and large scale farmers arrange their own transport to sell their fish or shrimps to the processing factory or market at nearer towns or the large cities. Similarly, some intermediary collecting agents collect fishes from fishermen after fishing in open water or sea at recognised landing stations and they successively handle, grading, cooling, preserve, transport and sale of the fish to the next market or processing plant.

In pond aquaculture harvesting usually begins in October and continues up to March. During the same period, open water fishes are also mostly harvested and supplied to the same market. Due to inadequate storage facilities and a large supply of aquaculture fishes in the harvesting season, the price goes down and farmers do not get their expected profit.

Large aquaculture farms are now suffering from marketing of their fast growing carp and catfish production. They could not utilise their farm production capacity. During the last ten years, along with the carp, semi-intensive and intensive farming of Thai catfish Pangus largely increased due to its higher production performance within limited time and space. Because of increasing production costs and gradual price decreases in the domestic market, the profit margin is being reduced and they are losing interest. On the other hand, production of shrimps for the export market has limited scope to grow fast due to several biological and environmental limiting factors. It is easier to utilise the carp and catfish aquaculture potentiality and increase production many times. If these raw materials could be handled and processed properly to produce diversified high quality and safe fisheries products, the processing industry could run well and utilise the efficiency of processing plants.

Under the prevailing situation discussed above, it is clear that the existing drawbacks of the processing and export industries in Bangladesh are not due to a shortage of fish but rather more to the technical and management efficiency required for utilising these valuable resources. Adopting good experience of shrimp industries achieved during the last ten years, initiatives should be taken to improve the technical and management issues concerned in fish processing. If they can successfully utilise the carp and catfish raw materials for production of high quality and safe fish products like other countries, the existing drawbacks of the industry could be overcome enabling fisheries to contribute more to export earnings, employment and the national economy as a whole.

The most important limiting factor is the lack of technical knowledge about fish handling and processing of fishes along with quality management requirements.

1.4 Justification

The information presented above shows that there are great opportunities to increase the production volume and export of fresh fishery products from Bangladesh to demanding markets given that the industry acquires the necessary skills to process safe fish of high quality.

In Iceland there is substantial knowledge regarding the processing and exporting fresh fish that surpasses international, national and other formal quality and safety requirements.

A successful transfer of technical, quality and safety knowledge from Iceland to Bangladesh would greatly increase the possibilities of further successful development of the Bangladesh fishery processing sector.

1.5 Goal and objectives

The goal of this project is to provide the fresh fish sector in Bangladesh with a comprehensive description of the most important technical and management requirements for the production of safe and high quality fishery products.

The objective is to write guidelines on best practises applicable in Bangladesh based on observations and information from Icelandic sources and literature. The guidelines could be useful as benchmark information for future planning and further improvement of the processing and export industry in Bangladesh.

2 MATERIALS AND METHODS

2.1 Information collection

To find out about the handling, processing, safety and quality management systems practised in Iceland and other developed countries, relevant literature was gathered from the Marine Research Institute (MRI) library. Information was also collected from different scientific journals, books and electronic sources. The referred information obtained from the theoretical class notes and presentations by different persons during general and special courses were also considered as key sources to search specific information on relevant fields. To know the common food safety regulations and assess safety and quality requirements for handling, processing and export of fresh and frozen fishery products, food safety regulations were reviewed from reports, journals and electronic sources.

During the general and specialised course organised by the UNU-FTP, a number of fish processing industry, cleaning and hygiene inputs supply shops; packaging, transports and business organisations, private QM and lab service provider organisations, research and education institutions relevant to the fish processing industry were visited. An overall study and brief visit report was also prepared on the largest fish processing and export business company of Iceland, SAMHERJI Hf. In fact, these study visits encouraged the selection of this project to learn about the procedures for fish handling, processing and quality management systems practiced in Iceland and utilise this experience for the improvement of the fish processing sector in Bangladesh.

To prepare a statement of required activities for best practices in the handling and processing of fresh/frozen fish, recommended theoretical procedures and practical applications in the processing industry were reviewed. The previously published information booklets, manuals and reports on handling, processing and quality management systems of Bangladesh were also reviewed to know the existing practice and prepare suggestions for improvements to comply with the safety requirements. The information regarding handling and processing technologies of fresh and frozen fish and quality management systems followed in Iceland and BD fisheries industries were taken into special consideration.

2.2 Visiting the Icelandic fish processing industry

To study the overall technical and management steps involved in the handling, processing and quality management systems from harvesting to final products, a full two days practical orientation study was conducted at one of the largest and reputed fish processing companies of Iceland, the BRIM HF, at Akureyri. The quality manager of the plant first gave a detailed briefing on the activities of the company, their products, market, raw materials, handling and processing steps, quality and safety management plan, the company's own rules, procedures and documentations regarding the quality assurance programme, staff policy, manuals and guidelines for all the relevant activities followed. Then each of the handling and processing technical steps along with relevant safety and quality management steps were practically observed in successive two full operations from raw materials to final product for in-depth study and documentation of the processes. After this practical orientation and based on the information received from the QM manager, this systematic documentation was prepared in two successive week consultations with the manger and experts in Akureyri University.

2.3 Documentation of suggested practice for Bangladesh

A description was prepared on every technical and management step followed in the handling and processing of fresh and frozen fishery products from supply to export considering the defaults, limitations and recommendations. These were compared with traditional methods of processing and quality systems followed in Bangladesh. Based on this information, technical and management practices have been suggested for improved handling, processing and quality management to produce safe and high quality fresh fishery products utilising carp and catfish of Bangladesh.

3 RESULTS

3.1 Food safety regulations

3.1.1 Food safety regulation of Bangladesh (FIQC Ordinance, 1983, amend. 1997)

The food safety and quality control regulations of Bangladesh are mostly based on EU and USFDA regulations as they are the major consumers of exported products. In the early 1980s, recognising both the potential for exports of fish and fisheries products and the problems concerning safety and quality of the products, FAO came forward to develop product standards, regulations, and fish inspection schemes for Bangladesh. In 1983, the Bangladesh government created a Fish and Fish Products Ordinance (Inspection and Quality Control Ordinance 1983) and in 1985 upgraded the inspection laboratory and its personnel. This ordinance was created under the prevailing situation of the processing sector to comply with the safety regulations following from that period, which required upgrading. FAO initiated another project in 1996 to assist in the preparation of a fish safety and quality control programme for the shrimp and fish processing plants in Bangladesh based on the Hazard Analysis and Critical Control Point (HACCP) approach. The programme provided training in HACCP procedures to both the public and private sectors (Cato and Subasinge 2003).

In July 1997, when adopting the upgrading process, the EU banned imports of fishery products from Bangladesh as a result of EU inspections of Bangladesh's processing plants. Inspections found serious deficiencies in the infrastructure and hygiene in processing establishments and insufficient guarantees of quality control by the government's quality inspection services. In fact, that was a wake-up call for the fish processing and export sector of Bangladesh. On behalf of quick recovery initiatives taken by the government and a spontaneous response from the private sector, an appreciable development was achieved regarding the renovation of the processing plants as required by EU standards and strengthening of Fish Inspection and Quality Control (FIQC) services under the Department of Fisheries. To strengthen the legislative support, the FIQC Ordinance 1983 was also revised and amended in 1997. In that period, both the public and private sectors invested more than US $ 18 million to upgrade the quality and safety assurance system. The ban impact on both the industry and the economy of Bangladesh was substantial. The ban was withdrawn after five months upon satisfactory progress in the safety and quality assurance system.

The existing Bangladesh FIQC Ordinance required some new additions and revisions with respect to the changing EU and USFDA regulations and these are underway. The existing regulations mostly force the responsibilities to the post-harvest suppliers and processors to ensure food safety and quality. According to changing rules, an integrated Quality Assurance System assured from pre-harvest production management steps to export level (farm to fork) defining responsibilities for each concerned stakeholder in the value chain introducing a traceability system and risk assessment. To fulfil the requirements of changing food safety regulations and consumer demand concerning quality issues, it is essential to strengthen the national inspection and quality management system of Bangladesh.

3.1.2 General aspects of food regulations

Ioannis *et al.* (2005) reviewed the EU regulations and directives on food related issues and provided an update of the main safety regulations applicable for animal food production and food business operation. There was a new basis for all food legislation in Europe. Regulation EC 178/2002, known as the "General Food Law", sets out a range of general principles and obligations that food businesses must adhere to. In addition to this, from 1 January 2006 all the general food hygiene regulations were replaced by new European regulations which apply to all food businesses. There were a suite of several regulations including Regulation (EC) 852/2004, which laid down the general hygiene requirements for all food business operators and Regulation (EC) 853/2004 which laid down additional specific requirements for food businesses dealing with foods of animal origin, including live bivalve mollusks and fishery products. Regulation (EC) 854/2004 had included the official controls for foods of animal origin. The new regulations replaced and simplified the previous hygiene rules which were scattered across 17 directives**.**

Overall, the changes from previous rules are minimal. They covered all stages of the food chain including primary production (i.e. farming, fishing and aquaculture) in line with the EU's "farm to fork" approach to food safety and imposed the same hygiene requirements on food imported from outside of the EU. The main change under the new regulations was the introduction of a Hazard Analysis and Critical Control Points

(HACCP) system for all food business operators (except primary producers) to identify any step in their activities that is critical to existing food safety and ensure that adequate safety procedures were identified, implemented, maintained and reviewed. The package also introduced periodic audits, new controls on imports and the development of national and community guides to Good Practice for Hygiene (GHPs). The obligation for the food business operators to comply with the requirements means that they need to refer to the regulations for full details on compliance.

3.1.3 General Food Law

The principles of the General Food Law are:

Safety: Food businesses must ensure that food satisfies the requirements of all applicable food laws and unsafe food must not be placed on the market.

Honesty: Food businesses must not advertise, present or label food in a way that misleads consumers.

Responsibility: Food business operators (FBOs) are responsible for the safety of the food that they produce, transport, store or sell.

Transparency: FBOs shall immediately inform the Food Safety Authority or official agency if they have reason to believe that their food is not safe.

Traceability: Food businesses must keep records of their suppliers and businesses that they supply (except to the final consumer) in order to assure traceability and be able to rapidly make this information available.

Withdrawal and recall: Food businesses must initiate withdrawal and recall of unsafe food and inform consumers of the reasons for the recall. Food businesses must notify the Competent Authority or official agency of such withdrawals and recalls.

3.1.4 Food business operator's obligations

Food business operators should have to ensure that all stages of production, processing and distribution of food under their control satisfy food hygiene regulations effective from 1 January 2006. Obligations to consider include food businesses operators being wholly responsible for food safety, ensuring food safety throughout the food chain and maintaining the cold chain where foods cannot be safely stored at ambient temperatures.

Cooperation of food business operators: FBOs must cooperate with the official agencies, the Competent Authority and other food businesses on actions taken to reduce or remove risks to consumers. An official agency is an agency that carries out enforcement of food safety law on behalf of the Competent Authority.

3.1.5 What is a food business?

For the purposes of Regulation EC 852/2004 and Regulation EC 853/2004, food businesses and FBOs are defined as follows: "Food business means any undertaking, whether for profit or not and whether public or private, carrying out any stage of production, processing and/or distribution of food". This includes all primary producers, importers, wholesalers, transporters, exporters, retailers, caterers, manufacturers, market stalls, mobile vans, and any other business importing, exporting, handling, storing, transporting, preparing and selling food. "Food business operator (FBO) means the natural or legal persons responsible for ensuring that the requirements of food law are met within the food business under their control."

3.1.6 Registration and approval

Regulation EC 852/2004 requires all food businesses and all primary producers involved in fishing and aquaculture to be registered with the Competent Authority. Premises approved under the previous legislation should need to be approved under the new legislation. Some must be approved by the relevant official agency before food production commences (this depends on the business type). Food businesses handling food of animal origin must, with some exceptions, be approved by the official agencies. This requires an on-site visit and assessment. Even if the business is already approved or licensed, it will need to be re-assessed. Once registered, FBOs must notify the official agency of significant changes to their business, e.g. change of proprietor, the type of food being handled, the amount of food being produced and substantial building alterations. Wholesale markets handling fishery products are also subject to the requirements of Regulation EC 853/2004.

3.1.7 General requirements

At each stage of food production, processing, distribution and retail, FBOs must ensure that raw materials and foodstuffs under their control, e.g. supply, handling and processing, meet the process hygiene criteria. All foodstuffs placed on the market and under reasonably foreseeable conditions of distribution, storage and use meet the food safety criteria. FBOs should ensure compliance with these criteria through the implementation of a food safety management system based on the principles of HACCP and other good hygiene practices. Testing against the criteria should be undertaken when validating or verifying the correct functioning of these systems. In addition, FBOs should determine shelf life by a strict testing programme to ensure that the criteria are met over the entire intended shelf-life of the product. To meet these quality and safety requirements, the following generic applicable good practices have been made suggestive/obligatory for all FBOs:

- Good Aquaculture Practices (GAP)
- Good Manufacturing Practice (GMP)
- Good Hygiene Practice (GHP)
- Sanitation Standard Operating Procedure (SSOP)

3.1.8 Hygiene requirements

Annex II of Regulation EC 852/2004 describes the requirements that must be met by FBOs. In order to produce food safely, the FBO must ensure that where and how the food is produced is hygienic. The FBO must make sure that the premises are kept clean and are properly equipped. Foods must be safely and hygienically handled. Staff must observe good personal hygiene practices. Staff must be properly supervised, instructed and trained in food hygiene matters so that they can handle food correctly. The regulations describe in general, the requirements that the FBO needs to meet.

Most hygiene requirements under these new regulations are similar or identical to the hygiene requirements under the current legislation.

3.1.9 Food safety management system (HACCP)

HACCP requirements are set out in Article 5 of Regulation EC 852/2004. All food businesses must have a documented food safety management system appropriate to its size and nature and this must be based upon the principles of HACCP. Operators have to identify and regularly review the critical points in their processes and ensure that controls are applied at these points. Management personnel responsible for HACCP must receive HACCP training. The primary principle is that FBOs must ensure safe food. It will be necessary for the FBOs to show their environment, health and hygiene that there is an organised and effective food safety management system in place to ensure the food produced or sold is safe. This system must be based on the principles of HACCP.

HACCP system will include the following elements:

- Identifying risks to food safety that might be present or occur within the food business
- Having controls in place that will deal with these risks
- Having a clear procedure if something does go wrong, which is followed by all staff
- Keeping these arrangements up to date
- Maintaining records of the procedures and checks carried out.

These requirements can be achieved in a number of ways that best suits the business. This will range from a formal HACCP system, following a recognised standard or an industry code of practice, or for some operators, simply applying the pre-requisite hygiene requirements.

3.1.10 Training

Adequate training facilities for all levels of staff, workers should be provided by the FBOs to ensure their qualitative upgrading and good management practices in the business. Training must be consistent, relevant, continuous, up to date and understandable. Managers cannot supervise trained employees if they have not received a higher level of training themselves. To learn they must want to be taught. Post-course, managers show how they help their employees turn the theory taught on the courses into practice, and provide evidence of up to date training. Demonstration of competency is more important than holding a certificate.

3.1.11 Traceability

FBOs must be able to identify from whom and to whom a product has been supplied and have systems and procedures in place that allow for this information to be made available to the Food Safety Authority or official agency upon their request. The requirement relies on the "one step back - one step forward" approach. This means that FBOs shall have a system in place enabling them to identify the immediate supplier(s) and immediate customer(s) of their products. There needs to be a "supplier-product" link established (which products supplied from which suppliers) and a "customer-product" link established (which products supplied to which customers). FBOs do not have to keep details of which of their products are supplied to final consumers, e.g. selling to customers in retail outlets, takeaways and restaurants. The information must be recorded in all cases (considered as essential to complying with the regulation) and be made available on demand is: name and address of supplier and name of products which were supplied to the FBO by that supplier, name and address of customer and name of products that were delivered by the FBO to that customer, date of transaction/delivery. Internal traceability within a food business is not a legal requirement.

3.1.12 Notifications

A FBO that initiates a product withdrawal or recall is required to notify either the Competent Authority or an official agency of the withdrawal or recall. The requirement to notify applies at all stages of the food chain, e.g. retailers, wholesalers, importers and manufacturers. Those who initiate action to withdraw or recall food must meet this obligation.

3.2 Fish and fish processing in Bangladesh

3.2.1 Important fish species

Fresh water fish:
The fresh water fisheries in Bangladesh mostly depend on numerous indigenous fish and shrimp species. During the last four decades, some important carp, catfish, perch and other large and small fish species have been introduced in the aquaculture production system (Rahman 1989). Research is ongoing on the reproduction, genetic improvement and culture technologies of all these species.

As mentioned earlier, carp and catfish are the most common fish groups in Bangladesh contributing the lion share of the fresh water fish production both in aquaculture and open water capture fisheries (DoF 2006). Only two shrimp species, the brackish water black tiger shrimp (*P. monodon*) and fresh water giant prawn (*M. rogenbergii*) are now exported mostly collected from farm production sources (DoF 2007).

The marine catch:
Bangladesh has diverse marine resources with more than 100 commercially important fish species. The vast majority of species exploited are demersal fishes. The major marine fish species or groups harvested are Hilsa, pomfret, catfish, jawfish, ribbonfish, Bombay duck, Aila, Indian salmon and sharks. Among the pelagic fishes,

Hilsa alone contributes a major quantity of the mechanised boat commercial catches, other pelagic fish catches are much less in quantity (DoF 2007). The most important marine shellfishes are shrimp species such as tiger shrimp, white shrimp and brown shrimp along with lobsters, crabs, molluscs and cephalopods.

3.2.2 Feeding habit and growth of carp and catfish

Depending on the depth of the water and nature of food stratum available in the pond, different carp fish species have individual food and feeding habits in the fresh water ecosystem. Some are herbivore (grass carp, silver carp), surface feeders (Catla, bighead carp) column feeders (Roi, Sarputi) and some others are omnivore or bottom feeders (Carpio, Mrigal, Calbasu). Carps are usually fast growing and well adapted to shallow ponds (1-2 m) to medium deep (3-10 m) open water ecosystems. Small carps and catfish can attain a size grade of 100-500 gm and breeding maturity within a year in a suitable pond environment or natural habitat. Large carps and some catfish (*Pangusius*) attain breeding maturity and weigh about 3-5 kg in 2-3 years in semi-intensive pond aquaculture systems or in open water habitats depending on the culture practice and suitability of environmental factors. Catfish and carps have a good muscle structure with white fibre and less of red/dark muscle under the skin and in the tail region. From the processing point of view, both carps and catfish have good market acceptability due to the high edible portion and nutritional value, good taste and texture.

Catfish have wide tolerance limits to temperature, oxygen, water pollution or other environmental conditions. They can be cultured in intensive farming and can achieve high production rates within limited time and space. Catfish have very few or no intra-muscular bones which are suitable for fillets and other processing products. Catfish in Bangladesh is mostly marketed in live conditions (both wild and cultured fish).

3.2.3 Chemical composition of carp and catfish

Chakraborty *et al.* (2003) studied the proximal composition of the edible and inedible portion of 64 fresh water fish species which are commercially important. Carp species are lean or semi-lean fish having a high percentage of edible flesh characterised by high protein and low muscle fat content (Chakraborty *et al.* 2003, Ali *et al*., 2005 and Ali *et al.* 2006). The chemical composition of the edible portion of important Bangladesh fish species is shown in Table 2. For all these species the ratio of edible and inedible portions was found to be from 1:0.43 to 1:0.72.

3.2.4 Fish supply chain in Bangladesh

The handling and processing chain of fish in Bangladesh differs from the shrimp production and supply chain. In the case of fish, fish processing and export is limited and not regular. The supply chain of fish to the processing plant is different based on sources of production or catch. However, in all cases, fishermen, middlemen and fish depot operators (fish collecting centres) play an important role in handling, preservation and transport of fish to the consumers or processing plants.

Table 2: Chemical composition of some important fresh water carps and catfish of Bangladesh (Chakraborty *et al.* 2003)

Species name	Moisture (%)	Crude protein (%)	Lipid (%)	Ash (%)
Rui	72.33	19.85	6.07	1.75
Catla	74.95	19.43	3.69	1.93
Mrigal	77.37	17.23	2.98	2.21
Grass carp	74.75	17.86	4.20	2.00
Silver carp	77.53	17.61	3.00	1.92
Common carp	74.62	17.95	4.10	2.44
Mirror carp	70.10	19.10	8.30	2.32
Thai Pangus	68.82	17.51	11.58	1.96

The processing plant agents (exporters) contact the producers (aquaculture farms, fish depots in markets, fishing trawlers, boats or landing sites) to collect the required fish raw materials either pre-contract or on a direct auction basis. Raw material collection is irregular by the processing plants based on the buyer's contract; there is no specific regular supply chain between the producers and exporters like for shrimps. Figure 7 shows the observed fish logistic chain from different sources of fish to the processing industry.

Culturally, people in Bangladesh prefer to buy whole live or fresh fish. The price of all fresh harvested fish is relatively high in the domestic market. Particularly catfish demands a high price especially in live condition, but the price will go down to half or less after death, so the major quantity is marketed as live fish. Therefore, fish producers always intend to market the fish in live or very fresh conditions on the local market without any handling, cooling or preservation procedure. After selling, the remaining fish (mainly carp) has to be kept for further storage or transport to other markets. Usually a wholesaler or depot owner takes over responsibility at that point for icing, packing and short storage of the unsold fishes taking a certain commission for each kg of fish.

The supply chain for fresh water fish from the production source to consumer or processing plant is largely as follows:

A major part of the farmed fish is produced by small, marginal household pond owners and small-scale semi-intensive fish farm owners (< 1.0 ha). They mainly harvest their fish by hiring a fishermen team on a share basis (usually 1: 0.25 to 1:0.40 ratios) and sell their own share to the harvesting team, or pre-contracted collecting agents or depots in the area in search of a better price. The harvesting batches are usually small, between 20 kg and 100 kg per one-day harvest and most of it is marketed locally.

Mid level aquaculture farmers (> 1.0 ha to < 5.0 ha) have their own netting arrangements for regular harvesting and selling of fish. They regularly supply small consignments (< 100 kg to 500 kg) to pre-contracted local depots or transport it to depots in neighbouring towns using hired or public transport. Sometimes they arrange for icing in case of long (12-24 hours) transportation to distant markets.

Some large scale farmers or large reservoir owners have regular marketing linkages with processing plants and supply the fish directly to factories according to a contract, in addition to a regular fish supply to different local and distant city markets. Most of

these farms have their own transport (or hired) to carry the fish in live or fresh conditions within an hour to a maximum of six hours from harvesting to the local markets. Their harvesting amounts range from 500 kg to 5000 kg fish per harvesting day. For long distance transportation, they use good plastic containers with water change (for live fish) or flaked ice/block ice to maintain fish freshness and quality.

In case of open water capture fisheries, the harvesting takes at least six hours and up to daylong or overnight periods using varieties of fishing gears like gill nets, seine nets, push nets, traps, angling and wounding gears. In most cases (except organised seine netting), the fish faces considerable physical stress due to gear and fishing methods. Most of the fish die shortly after catch, but fish landing in collecting centres (depots) and marketing takes place much later where icing or no special handling procedure is being followed. The earliest catch falls into rigor condition far before landing, which is usually at early morning or late evening. If a two day fishing trip is planned, they sometimes take iceboxes with flaked ice to preserve the fish for a short time. When the depot owner receives the fish, he washes, grades and packs the fish with the required ice and handles the transport to local market retailers or processing plants.

The marine artisanal small fishermen groups catch fish in day long trips with small traditional boats or mechanised boats and come back to the seaside landing station to handover the whole fish mostly without any handling steps or icing. Sometimes they use large ice boxes with flaked ice for long fishing trips. Most of the fishing trawlers go for short fishing trips and come back within 2-5 days or even within the same day. They have small storage beans or carry large iceboxes with required flake ice. After catch, they wash and grade the fish on the basis of species, size and weight and ice un-gutted whole fish in containers to store until landing at the nearer station or harbour. After landing, the processing agent checks the quality and grades again by required specifications. The fish is rewashed with fresh water and re-iced in a new container for further transport. There are also some industrial trawlers with freezing facilities operated to catch bottom or pelagic marine fish in the deep sea for month long fishing. The fish is then gutted onboard and frozen whole.

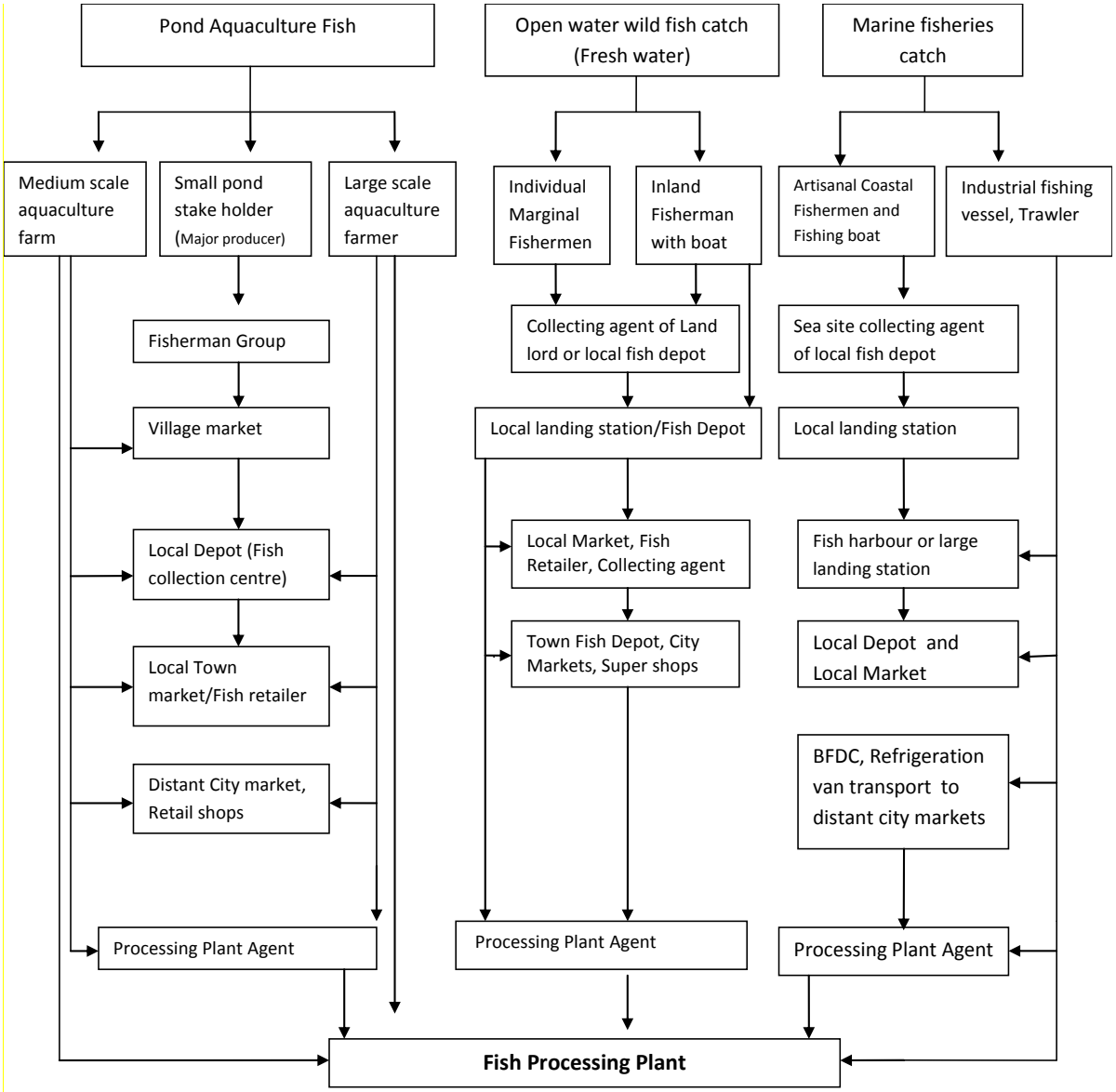


Figure 7: Fish supply chain from producer level to processing plant or consumers in Bangladesh.

3.2.5 Current fish processing practice in Bangladesh

Categories of fisheries export products from Bangladesh:

The fish and fisheries products exported from Bangladesh are not very diversified in comparison to other developed fish exporting countries like Iceland. Handling and processing technology and products are not diversified as with the consumer demand. Fish export products are mainly whole, gutted, head-on or headless frozen fish (large fishes), frozen blocks of wild small fishes, live fish (mainly catfish) and recently a few industries have started filleting fish to some extent. Excluding live fishes, the

seafood processing in Bangladesh can be classified into the following main categories:

Frozen fish processing: Large fish is whole frozen (IQF), headless and gutted (belly-clean) or processed as slices, fillets or steaks in IQF and block frozen. Small fish is whole block frozen. Large IQF fish or blocks are wrapped with polyethylene sheets or put in polyethylene bags and then packed into a master carton wrapped with Hessian cloth. The main markets of the frozen fish products are the EU countries, USA, Japan, China, Canada and Thailand.

Chilled fish processing: Chilled fish is mostly sold as whole gutted headless fish, also some in fillets, sticks or mince block form. Packaging is generally 5-20 kg fish packed with 20% flaked ice or 1% (200 g) dry ice in Styrofoam boxes in sizes according to the customer's specifications. The main markets are the Middle East countries especially Bahrain, also China, Japan, Thailand, Korea and Vietnam.

Dry fish and salted fishery products: Dry fish, moisture content less than 10% exported to the UK, USA, Spain, Portugal and the Middle East.

The major quantity (49,000 tonnes, 72%) of the exported products belongs to the category frozen fresh water and marine water shrimps. In 2005-06, only 3700 t of chilled fresh whole Hilsa fish was exported (5%), which is expected to increase to 5000 t in the current year. Other frozen fish species exported are mostly fresh water and a few marine fishes in small quantity all together amounting to 14,000 t (20%). Other than frozen and chilled fish, dry and salted fish, live crabs, eels, turtles, shark fins, fish maws etc. are also exported in limited quantity of only 2500 tonnes (3%). The demand for processed chilled fresh fish is increasing, but the processing industry could not avail the opportunity due to limitations in their processing knowledge and facilities. Excluding live fishes, brief information on exported products, processing techniques followed, packing and export markets for the processed seafood are listed in Appendix 1.

3.3 Quality control and food safety

Regarding safety and quality management issues in Bangladesh, it is mostly oriented to shrimps from post-harvest handling to product processing steps following control measures based on HACCP principles. The existing Fish and Fish Products Ordinance (Fish Inspection and Quality Control Act, 1983 and revised amended in 1997) needs to have some corrections and additions to comply with the existing legal requirements of food safety regulations as well to improve the quality and safety management system for fish and shrimps.

3.3.1 Hazard factors involved in production steps

Hazard factors involved in farmed fish:
Two decades ago aquaculture was limited within improved traditional practices of pond aquaculture or large reservoirs mostly based on natural productivity and minimum external input utilisations. There were minimal possibilities of environmental degradation of soil-water quality and subsequent residual effects of any pollutant leading to hazardous contamination of fish or shrimps. The major quantity

of fish and shrimps exported from Bangladesh previously harvested from wild sources which turned towards aquaculture farmed products developed in some limited areas of the country in the last decade. Along with the intensification of the farming practices to increase unit production yields, the external input utilisation has been tremendously increased which, in fact, increases the probability of environmental hazards in farmed produced fish and shrimps.

In the international seafood market, Bangladesh's products have a good reputation as naturally grown organic products with a good taste, nutritional value and less environmental contamination risks. In the course of time due to increasing inputs (fish feeds, inorganic and organic fertilizers, poultry drops, slaughter waste, cow dung, growth promoters, antibiotics, chemicals and fish toxins etc.) the risk of contaminations has increased and requires more attention. During the past years four or five rejection cases of exported farmed shrimp consignments to EU countries having nitrofuran and other hazardous chemical contaminations exceeding safety limits draws the attention of all concerned to think about the environmental risks as an added new safety issue for the Bangladesh processing sector. The investigation regarding the sources of such other chemical contamination is also going on. The suspected chemical contaminations which may cause hazards in the future are nitrofuran, chloramphenicol, malachite green, methylene blue, other hazardous antibiotics and heavy metals (arsenic, Pb, Hg, Cu etc); pesticides, organophosphate compounds. Some of these were found in limited quantity below hazard limits in some specific shrimp farming areas coming through different routes and have been taken into consideration to be prevented.

In Bangladesh, possibilities of pre-harvest biological hazards in fish are usually minimal. Particularly microbial contaminations from small rural aquaculture pond water sources have a minimum chance to contaminate fish. Almost all the farms and small pond water sources are underground tube-well water or rain-fed water. Culturally sewage wastage use in aquaculture ponds to produce fish and marketing or consumption of sewage water fish is mostly avoided. Any sewage contamination in household ponds is socially not very acceptable. Rural small pond owners maintain water clean and possible hygiene for uses in household purposes rather than for aquaculture. But recently excessive uses of organic manure (cow dung, poultry drops, slaughter waste etc) and low quality fish feed in some semi-intensive or intensive commercial farms may raise the future possibilities as a source of biological contamination. The government has strict rules to control the use of waste water for aquaculture and prevent marketing of health hazard fishes, but its implementation is still limited. To regularly monitor the safety parameters of fish and the environment, monthly samples of water quality and fishes collected from different resources were examined by the Fish Inspection and Quality Control Division of DoF, Bangladesh.

The presence of pathogenic microorganisms of public health significance is also identified in some previous cases at exportable shrimps and fishes in Bangladesh. Contamination mostly occurs in post-harvest handling stages rather than in pre-harvest production sources. The rate of contamination incidence is comparatively lower and intensity of contamination still very often exceeds the safety limits. The incidence of major outbreak of fish borne pathogenic illness causing massive death is very often. The pathogenic bacteria sometimes identified in shrimps and fishes are: *E. coli, Staphylococcus aureaus, Salmonella, Shigella, Vibrio cholera, Vibrio*

parahaemolyticus, V. vulnificus, Listeria monocytogenes, Camphylobacter, Bacillus cereus, Clostridium botulinum, Cl. perfringens etc. Habitually people prefer to buy and consume live or fresh fish and long time cooking procedures with use of enough spices is another safeguard which is culturally adopted. Food borne pathogenic illness occurs mainly due to lack of hygienic conditions during the process.

3.3.2 Limitations of existing post-harvest handling and processing practices

Research information is very limited about the technical steps in handling processing of carp and catfish. No specific technical guidelines or training manuals are available regarding harvesting gear and methods, time-temperature effects, prescribed time and methods for stunning, slaughtering, bleeding and gutting of carp and catfish, use of quality ice following correct procedure, use of good containers, package materials, shelf life of fish and preservation procedures. Even the plant agents or depot owners have very limited knowledge about the selection of specific raw materials for definite use. They apply their common knowledge regarding fish freshness tested by visual observations and are not aware of the after effects of rough handling of fish on the final products.

3.4 Fish handling and processing practice in Iceland

A selected Icelandic fish processing plant was visited to observe the handling, processing and quality management chain of fresh and frozen fish. After a scheduled study visit to that representative fish processing industry, BRIM Hf, information was collected, interpreted and documented. Analysis of activities at every step of the handling and processing chain was done to explain the compliance or incompliance to standard procedures, causative factors and positive or negative effects of each activity on the quality management system.

Harvesting and handling procedures usually followed in the renowned Icelandic fish processing industry BRIM Hf. are as follows:

Most of the larger Icelandic seafood processing factories collect their fresh fish raw materials (cod, haddock, saithe, redfish) from their own modern fishing trawlers (bottom trawl) and frozen fish raw materials from large fishing vessels. The trawlers usually go for fishing in the sea at selected grounds and come back within 2-5 days. The large freezing vessels stay at sea for a much longer time (even more than a month) and come back with the desired amount of frozen raw materials.

3.4.1 Production planning for processing of fish and fisheries products

The fish processing companies have diversified marketing channels on the international seafood market either by direct customer contacts or through different renowned multinational marketing companies (e.g. Icelandic Group). After receiving customers purchase orders with product specifications they compare them with their existing product codes or go for negotiations with the customer on an acceptable new specification before the contract is agreed. The management team contacts the fishing fleet and processing team to confirm the availability of raw materials and other resources on the desired product feasibility. If the order leads to a contract, a schedule

of production, safe storage and shipment to the customers is put in place. According to this schedule, the product is manufactured complying with the total quality system.

3.4.2 Onboard handling of marine catch

Stunning, bleeding and gutting on board:
When a trawler leaves for a fishing trip, it carries specialised tube ice (long durable) in tubs from the factory onshore. Slurry ice is produced onboard the trawler, using seawater as required during the trip. The fish is bled and gutted onboard just after catching, applying the deep throat-cutting method followed by gutting the fish by a belly cut at the same time. The gut content is removed; the fish is washed well and left for proper bleeding in a large tub with running/changing seawater for 20-30 minutes at the normal sea water temperature, 7-8°C.

Icing/Cooling:
After that sometimes the fish is put in ice water for 30 minutes to 2 hours to reduce its temperature gradually down to 0°C before boxing it with slurry ice in tubs. A sudden drop of temperature for cooling of fish from sea water temperature (or farm fish temperature, 7-15°C or more) to direct slurry ice (0°C) may cause quality deterioration of muscle. Standard sized plastic tubs with 460 kg capacity are used but loaded with maximum 300 kg fish and usually 20-30 kg to maximum 50 kg of slurry ice depending on storage time. The fish is properly arranged in the tubs to minimise pressure damage. Fish and slurry ice is loaded in the tubs in layers. Each of the tubs is labelled with the required information to identify the sources, catching date and other relevant information. When the trawler arrives at the factory after a few days, fish temperature is expected to be steady at 0°C. In case of ice melted before landing, they cover it with re-icing, if necessary. No salt, chemical preservatives or disinfectants are used in the ice or water and the company regularly checks the quality of ice and water in the processing plant.

3.4.3 Processing techniques

Receiving of fresh raw materials in ice:
The fish tubs are unloaded from the trawler directly into an intake (receiving) cool storage room close to the fish landing harbour. The temperature of the intake room is centrally maintained at 2°C. A member of the receiving staff is responsible for the inside arrangements of the raw material and receives the relevant report from the vessel's crew. He checks the number of tubs, labelling of tubs, size grading of the fish and other required information according to this report. The received fish tubs are arranged in different separate categories coded with specific labels as their supposed use for different products. They check the temperature of the fish at intake time and if required, immediately place the fish into slurry ice to maintain the temperature at 0°C. Usually they use fresh water slurry ice and put the fish in for 2-3 hours before or until processing. They also use brine ice water (1.5% salt conc.) to chill the raw materials when used for processing light and high salted products. Fish is then placed from 2-3 hours to overnight (12 hrs) in brine ice water to drop down the temperature to -2°C.

Frozen raw materials from freezing vessels:
Receiving of frozen fish raw materials from the freezing vessel is to some extent different from fresh chilled fish. The quantity in each landing of a freezing vessel is

also much greater than from a fresh fish trawler, as they come back after long periods of fishing. The frozen gutted head on fish is stored in the vessel's freezing hold, arranged on relatively large pallets with approximately 900 kg fish per pallet. Each pallet is frozen in block and covered with polythene. The pallets are labelled with specific information and stored in the freezing storage of the factory at -27°C. When needed for processing, they select the specific pallet, enquiring the labelling information and taking the fish into the intake cool storage room for thawing following prescribed methods. Packing materials are removed and the pallet left for 12 hours or overnight. Individual fishes are then separated and thawed in continuous flowing water at +12°C. When thawing is complete, the quality is checked and grading is done in the intake room before processing. Thawed fish is kept in slurry ice to maintain the temperature at or close to 0°C until entering the processing line. The generic processing flow-chart of the Icelandic fish processing industry is shown in Figure 8.

Grading of fish raw materials:
The company generally has focused on a certain size range which best serves their production customers and proper grading has to be in place for maximum yield. Among different weight size grades, 1.9-3.6 kg is the most expected grade to process good conformation of quality fresh and frozen products.

Heading, filleting and skinning:
Heading of the fish is automatic in a heading machine and the heads are collected. The headless body goes to a size grading to the filleting machines. This size grading is very important as the filleting machines are adjusted for specific fish size for maximum yield and efficiency. After heading, the collected heads are manually separated into different parts as valuable by-products for export. The remaining parts of the head are mostly used to produce dry products for the Nigerian market. Filleting is the most important part of the processing line, where raw materials are converted to semi–final products. The filleting is automatic (machine operated) and the fillets go directly into automatic skinning where the fillet's skin is removed carefully to maintain the texture, size and uniformity of the products. The backbones or other excluding parts are collected in collectors under the filleting machine.

Cooling, trimming and portioning:
Skinless fillets are mechanically passed through a cooling chamber for 8 minutes where they pass through circulated cool water of 0°C. The main objectives of this cooling are to reduce the temperature of fillets that has risen in the previous steps and maintain it close to 0°C. After cooling, the fillets automatically pass through a computer controlled scanning system where they are classified and directed to separate trimming lines. On the trimming line, skilled trimming workers check every fillet manually on a candling table placed 6 inches above the light source with standard illumination from min. 500 lux to max. 1500 lux to identify unwanted objects. In this step, pin-bones are removed; all visible parasites, leftover pieces of gill, bones, blood spots, bruises, skin spots or black membranes are removed which may have been overlooked during mechanical checks before trimming. All ragged edges are removed and tail ends are also trimmed.

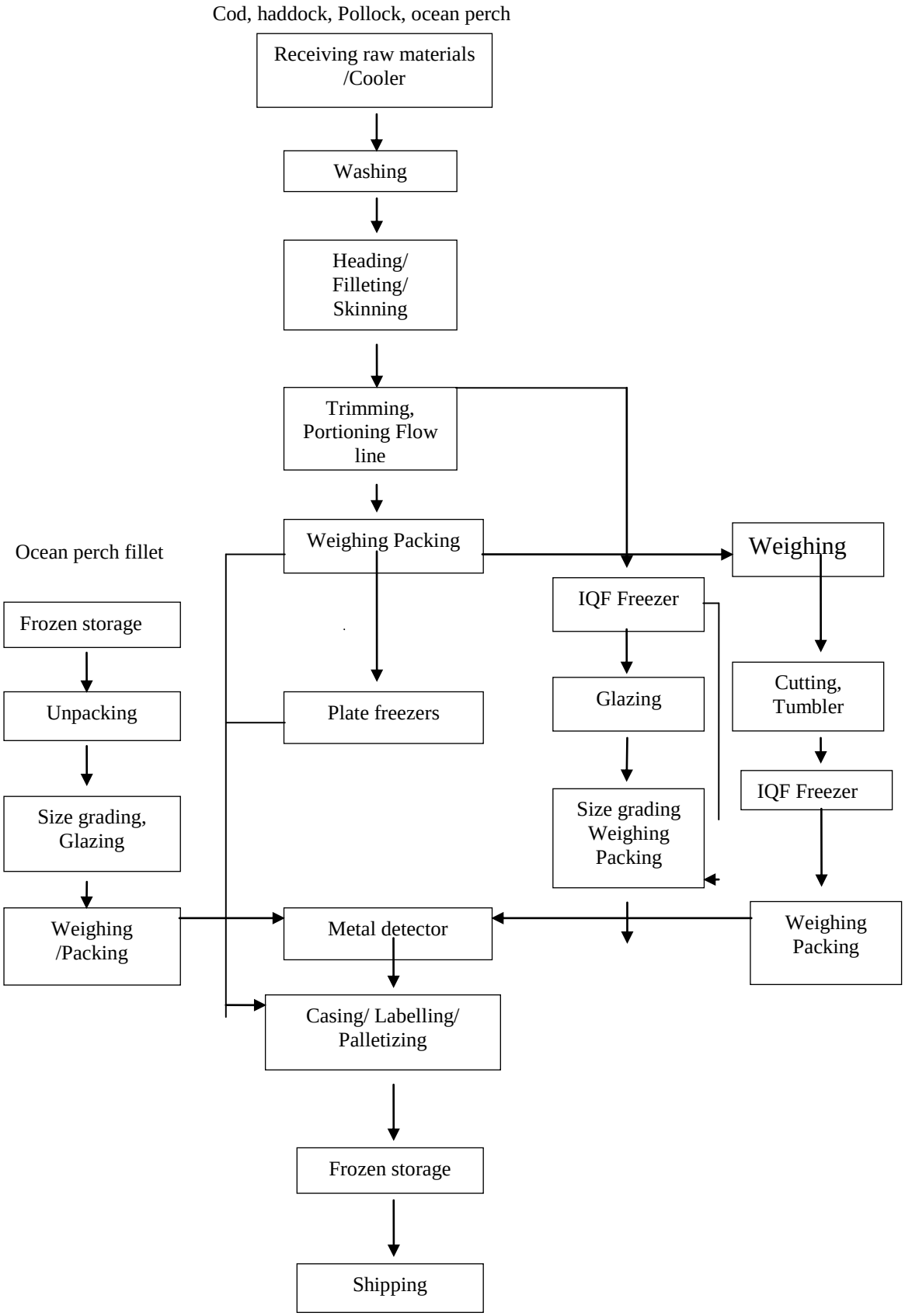


Figure 8: Processing flow-charts for production of fresh and frozen products from Icelandic fish species (cod, haddock, Pollock, ocean perch).

As this step is considered the most important quality checkpoint, a quality control inspector takes random samples (2% of total) from the line and checks the trimming quality parameters (worm, bone, texture, structure and size). The acceptance limit of bone and worm is maximum two per kg final products. A computer weighing and monitoring system is connected to each work station on the trimming line and each worker receives on-line information on own work performances (number and kg of fillets trimmed, number and type of trimming defects) on an individual LCD monitor. This data system allows the quality and processing management to monitor the processing line continuously, as it collects information on hour-to-hour processing yield, individual workers efficiency and total success of the operation. On average, each trimmer is able to trim 70-75 kg fillet per hour where expert ones can do more than 100 kg per hour. After trimming, the fillets are cut into portions, sometimes manually, but mostly by automatic portioning machines (Marel, Iceland). The automatic system then scans the fillets according to a pre-programmed cutting pattern and consequently portions it. According to specifications and quality criteria, a part of the production is directed on to block product lines.

Final products:
In case of any waiting time steps before finalising products, they are put into ice flakes to maintain the temperature at 0°- 4°C.

The main product categories in Icelandic fish processing factories (e.g. BRIM Hf) are as follows:

- Fresh chilled products
- Portions: mostly loins are taken directly for packaging and labelling and quality checking. Fresh portions or fillets (near 0°C) are packed in insulated boxes (Styrofoam) covered with polythene and dry ice (solid CO_2 at ca. -70°C), for immediate export shipment by air freight.
- Light salted products: portions go for brining at 4% salt-water solution overnight at 0°C. Final products are either fresh or frozen.
- Frozen portions (IQF): portions or fillets enter an in-fed conveyor belt to the IQF freezer. The final core temperature must reach at least (-24°C). IQF freezing is followed by glazing (if required), by spraying with potable water. Products are graded, weighed, packed and finally moved to the cold store at a minimum temperature of (-18°C) to expectedly at -26°C.
- Frozen blocks (fillet blocks, piece blocks and mince blocks): the products are packed directly into 7.5 kg or 20 kg labelled cartons, which are then placed in block frames or freezing pans into contact plate freezers. Freezing time is usually two and half to three hours or until the core temperature has reached (-18°C) at minimum to -24°C. Products are transferred to the cold store and the pans and frames are washed properly after each use.

Weighing, packing, storing and transport:
The company uses different types of packaging according to the product specifications. These include plastic, plastic trays or envelopes according to specifications. Individual packs may vary from 40 g to 20 kg in a single retail pack to a 500 kg bulk carton. Weighing is done both automatically and manually separately for fresh and frozen products at the end of the packaging operations. The weighing machine records data for all the products that pass through and reports any faults. After weighing and packaging, all frozen items are passed through an automatic metal

detector to identify any metal foreign bodies or particles inside the package. However, this metal detection is not efficiently applicable for fresh chilled products, as moisture snow on the outside of these packages can confuse the detector scanner and lead to a false alarm. Master cases are labelled, loaded onto pallets, which are strapped with plastic and labelled. Palletised products are taken directly from the cold store into freezer containers at -18°C for sea freighting. A contracted transport company ensures safe transport of the fresh products from factory to airport.

3.4.4 Quality monitoring and control

Every Icelandic fish processing industry has its own quality management policy. They accordingly developed relevant manuals and guidelines to implement the safety and quality assurance programme at every step from raw materials to end-product level. BRIM has its own quality management policy and a QM manual and handbook, where they have clearly defined all the quality and safety assurance issues in compliance with the customer's demands as well as existing food safety regulations (Appendix 2). Special quality inspectors take care of the continuous quality checks. Some of the important quality checkpoints cover:

- Temperature: measurements are done at all steps. The fish temperature should not exceed 4°C throughout the processing. Core temperature of frozen products should be minimal -18°C.
- Bones, parasites and trimming defects: measurements are done at the trimming lines and results continuously handed to the relevant workers on the line. The acceptance limits of bone and worm is a maximum of two pieces per kg final product, where the maximum size of one piece is also defined.
- Size and weight: measurements done on IQF products. Size and weight has to comply with each product's specification.
- Metals: all packages are run through automatic metal detection equipment. Calibration of the detector is performed in defined intervals.
- Cleaning: the company have well defined cleaning rules and a relevant manual for regular cleaning operational procedures to ensure maximum possible safety within the industry. They continue cleaning activities during the processing operation as and where necessary followed by final cleaning at the end of the day. They involve trained special cleaning teams for the purpose using safe cleaning agents and instruments following the regulations.
- Personal hygiene: the company has a strict worker's health and hygiene policy and guidelines following regular monitoring procedures, documentation and auditing of hygiene systems. They have a good staff policy in support of provisions for sick leave with pay, regular health check ups and self regulatory hygiene practices.

3.4.5 Traceability

The company maintains systematic documentation of all information relevant to the sources of raw materials, processing and quality management steps. They provide all necessary information on the product labels as required by the customer's specifications and food safety regulations.

4 SUGGESTED PRACTICE FOR BANGLADESH

4.1 Production planning for handling and processing of fresh fish

To process and market cost effective, safe, high quality products fulfilling the demands of consumers as well as complying with legal requirements, the processing industry should follow a suitable production plan depending on its own resources. Before going for any processing operation, some important factors should be carefully considered, such as analysing the customers' demands for types and specifications of fish products, quality and safety requirements, price and market sustainability. Adequate resource information about the desired fish products like stock information, availability of fish species, size, and age are preferable. For marine catch, the fishing ground, area, season, spawning, migration or other biological information, fishing vessel, gear, weather etc. is relevant. Careful analysis is necessary of the cost-effectiveness of fishing operations for the particular species and market accessibility of by-products from the fish raw materials.

4.2 Generic handling steps of fresh fish

The following handling, processing and quality management procedures for carp and catfish species have been suggested based on the available research information about the effects of different handling procedures on important cold water and some tropical warm water fish species. The different environmental factors and ecology of habitats, biology of important fish species, food and feeding habits, wild fish from natural habitats, aquaculture production systems and input utilisations, have been taken into careful consideration.

4.2.1 Harvesting

Harvesting is the first step/activity in capture fisheries and last step in production management procedures for farmed fishes. It has several significant direct and indirect effects on the quality and safety of fish and fisheries products. Numerous harvesting methods are in use for effective catching of different fish species from different natural or captive environments. All the fish harvesting methods have common objectives to catch selected fish species of desired size and age utilising minimum efforts and ensuring maximum quality of the catch.

<u>Harvesting of fresh water farmed fish (carp and catfish):</u>
In tropical regions, it is best to harvest carp and catfish late at night or early in the morning for handling and transport to avoid the effects of increasing temperature after sunrise. In case of intensive/semi intensive farming systems, where ponds/lakes have higher bottom deposition due to regular intensive feeding, it is suggested to stop feeding fish 12-24 hours before harvesting. Starvation of fishes before stunning and bleeding will support good flesh quality of fish after death. Seine netting is a good harvesting method to collect desired fishes causing minimum handling stress. By seine netting, most of the desired sized fish can be caught using different mesh sizes. The advantages of such harvesting are that primary grading of selected sizes of fish can be done in the pond avoiding further handling stress.

<u>Harvesting of fresh water wild fishes in Bangladesh:</u>

Wild fishes caught from natural habitats like rivers, haor, beel, flood plains, or large lakes usually does not require such starvation or acclimatisation. However, for long periods of fishing, it is better to encircle the fish in a large net bag allowing easy movement, avoiding physical stress to allow for stomach emptying. Gill net and wounding gear should be avoided for harvesting fish to be processed. These types of gear are currently very commonly used in Bangladesh fisheries, but cause serious physical stress before death and quick deterioration of fish quality occurs. It is preferable to bleed and gut the fish in a live condition just after catching.

4.2.2 Handling of aquaculture farmed fishes

Fish should be kept at for least 6-12 hours acclimatisation in a large water tank with flowing well water of lower temperature (16-20°C) than pond water (25-30°C). This practice will allow the fish to empty its stomach and reduce the temperature difference between their habitat (pond/large reservoir) and cooling (icing) temperature after death. Gross variation between these temperatures may enhance early rigor and subsequent spoilage activity (Huss 1995). All harvested fish should be stunned, bled and gutted following prescribed methods before starvation effects and after acclimatisation. It has been shown that if the fish is starved or stressed so that the glycogen reserves in the tissues are depleted, rigor mortis starts immediately or shortly after death. The method used for stunning and killing the fish also influences the onset of rigor. Therefore, the feeding status before harvesting the particular fish species, the fishing gear, procedure and killing method directly influences the degree of stress and subsequent glycogen level in the fish tissues (Huss 1995).

Stunning, slaughtering and bleeding of fish:

According to the available research information, mechanical stunning (by blow to the head, brain skipping, and hypothermia) might be suitable for the warm water large size commercial catfish (Pangus, Boal, Air) and large carp in Bangladesh. For small sized, freshwater catfish, temperature shock with icing (hypothermia) might be effective for stunning. Usually farmed catfish and carp can be slaughtered by deep throat cut and belly cut for swift killing after stunning. For larger size open water catfish (Boal, Air, Rita, Baghair, Pungus) slaughtering can be done by throat-cut or brain skipping methods considering their size and purpose. Small sized carps and catfish can be quickly and effectively killed only by deep throat cutting. Effectiveness of different killing methods for carp and catfish need to be studied. It is advisable to grab the fish by its tail to haul it on board and carry out all subsequent handling on the foam pad. Depending on species, the following cutting procedures might be suggested for effective bleeding of large carps and catfish of Bangladesh:

- Deep throat cut: cutting the blood vessels between the heart and gills. It is important to be careful not to cut up the heart. Slice through the V-shaped nape of flesh between the gill covers and the body of the fish and sever the major artery that is just below the skin surface.
- Gill cut: cutting the gill using a sharp knife to slice through the blood vessels that supply blood to the gills. It is better to lift the gill cover and cut through the gill arch and then put the knife through the gill membrane and cut up towards the spine to sever the blood vessels at the top of the gills. Shallow blood vessels should be cut that run near the lateral line. Depending on the size of the carp or catfish to be bled, it can be suggested to make a shallow cut with a sharp knife below the pectoral fin, cutting through the raised ridge of

the skin. It should be known when it has to be done right the blood flows out of the cut. Repeat on the other side.

- Gutting: gutting means the removal of all the internal organs inside the body cavity (viscera/intestine, liver, kidney, heart, lung, air bladder, blood vesicles etc.) following a prescribed cutting method to keep the fish in fresh and extend the shelf life.

It is suggested to gut the fish as early as possible after harvest to avoid autolysis and prevent microbial and enzymatic spoilage enhanced by the gut content. Cut the belly from the anal opening forward, open the belly cavity and remove the guts. To completely remove them, slice the entrails as close as possible to the gill area. Be careful not to slice through the belly wall and into the meat. This technique will allow the chilling medium, either slush or ice, to closely contact the muscle both inside and out. Be sure to firmly pack ice into the belly cavity during iced storage.

4.2.3 Icing or cooling of fishes

Then transfer the fish to another tank with ice water (0°C) to reduce the temperature slowly. After 30 minutes to one hour or when the fish temperature slows down near to 4°C, immediately place the fish into tubs/containers with the required slurry or crushed block ice to reduce the temperature finally to 0°C and transport it to the processing plant as soon as possible. Large sized carps and catfish harvested from open water resources might be iced onboard just after bleeding and gutting following the above procedure. In this case, the required amount of quality ice in insulated boxes has to be carried from shore, predicting the catch and landing time. For onboard marine catch large fish species, bled and gutted fish should be washed in running seawater or immersed in seawater in a large tank for a required time and subsequent icing should follow after gradual reduction of temperature using ice-water immersion as above.

Icing or cooling is the most important step for small fresh water fish species (10 g to 500 g individual weight) which are harvested slowly by fishermen taking a long time landing and, in practice, gutting is not possible. To maintain the desired quality of small fish, icing in live conditions might be suggested following proper washing just after catch. If facilities are available, they could be allowed to swim for some period in a net cage for discharge of gut contents before icing to avoid more contamination.

The quality and quantity of ice is an important consideration for effective cooling. In the case of shrimps 1:1 (fish:ice) ratio with flaked or pieces of crushed block ice is suggested for cooling with an expected storage time from 6-12 hours at the usual temperature (20-30°C) in Bangladesh (Karim 2000). Fish requires more ice than shrimps because the surface contact of large fish species and the latent heat of fish bodies is different from shrimps. The quantity of available flaked or crushed ice may be suggested as at least 1:1 to 1:1.5 fish:ice ratio considering the type of ice and container used, temperature, storage, transport time and other factors. Training of people involved and availability of quality ice in a cost effective way should be ensured by the government and private sector concerned.

4.2.4 Container of fish

Traditionally, fishermen use bamboo baskets or cane containers, which cause some handling damage, discolouration of fish along with a risk of hazards concerning the entrance of bamboo or cane materials into the fish tissue. Moreover, these types of containers are not insulated and have a greater chance of microbial contamination or other hazards during handling. The fish should be handled and transported in suitable containers such as plastic baskets or tubs with required specifications.

4.3 Generic processing steps of fresh fish

4.3.1 Receiving of fish raw materials

Fresh iced fish raw materials:
After the arrival of the farmed fish consignment, fishing trawler or freezing vessel with iced cooled fresh fish, all the head-on gutted fishes are unloaded along with fish tubs in intake (receiving) cool storage rooms after the fish transported from farms or landing harbours. The temperature of the intake room should be centrally maintained at 2-4°C. The raw material consignment should be received along with relevant reports from the fishing farm/fleet. The number of tubs, labelling of tubs, fishes with specific weight and size grades and all other required information should be checked for compliance with the report from the fish farm/boat. The received fish tubs are then placed at different separate categories coded with specific labels as used for different products.

The temperature of the fish has to be checked at intake time and if required, immediately placed in slurry ice to maintain the temperature at 0°C. Usually it is better to use fresh water slurry ice and immerse the fish for 2-3 hours before or until processing. Fishes could also be immersed in brine ice water (1.5% salt conc.) to chill the raw materials when used for processing salted products. Fishes are placed from 2-3 hours to overnight (12 hours) in slurry ice or brine ice water to bring down the temperature to -2°C.

4.3.2 Information regarding raw materials

The fish raw material consignments sent to the processing factories must provide a report with information from the fishing vessels or aquaculture farms. Information on the label of each fish tub should include the tub number, name of fishing trawler/farm, date of fishing, fish catching time and temperature, species, size grade, quantity of fish etc. In addition to fish tub labelling, the supplier must provide more detailed traceability information to the factory before or on arrival of the fish.

4.3.3 Quality checking of fish raw materials before processing

Before entering the processing chain, the fish should have to go through quality checking following prescribed quality assessment methods. Just after receiving the fresh fish consignment, it is first necessary to look through the visual quality of fresh fish stored with slurry ice in the fish tubs and subsequently use sensory evaluation methods (QIM, EU scheme) to check the freshness of the fish. Samples of fish in the tub are visually checked one after another by the quality inspector and sample studies

applied for detailed sensory evaluation of the fresh fish. Microbiological analysis has to be conducted frequently as per demand of the buyers. Some buyers have the demand for both sensory and microbiological quality assessment for each of the products as per contracted specifications.

Quality checkpoints:
For routine visual quality checking, the following common issues could be taken into consideration at the receiving site before processing:

- Quality of container or tubs, quantity of fish in each tub, whether it exceeds capacity or not, how many overloaded tubs?
- Is the arrangement of fish and ice in the tubs satisfactory or not, does it cause damage?
- A report should be received on the fish to ice ratio for individual tubs, storage period (day/hour), time and temperature of fish before cooling and at receiving in the factory
- The amount of remaining ice in the tubs is satisfactory and fish temperature was 0°C.
- If no or little ice is left in tubs but fish temperature is near to 0°C (below 4°C), considering other physical factors, it might be acceptable. However, the total number of such doubtful tubs should not exceed 25-30% of the total consignment.
- The melting ice water should not have been transmitted from one tub to another and not contaminated.
- Bleeding and gutting has been done following proper methods (checking the cutting method of deep throat cuts, belly opening smoothly from anus to throat or not), no clotting blood inside the belly flap muscle observed.
- Fish has been washed properly with clean water, all blood, viscera, kidney muscle, slime, any unwanted organs have been removed completely.
- No bad smell from the fish body, colour, appearance, skin, eye brightness, muscle texture (firm, flexible or not in good texture) and other organoleptic properties are acceptable.
- No foreign bodies, insect, pests, visible biological agents that may cause food safety hazards are found.
- In case of farmed fishes, all relevant information regarding pre-harvest production management steps (traceability information) are provided along with fish.

4.3.4 Grading of fish raw materials

Fish materials received in the factory should be graded into different size and weight categories for processing of different products as per contracted specification of buyers. A primary grading can be done on-farm or onboard when fish is placed on ice tubs or freezing bean. After bleeding, gutting and washing, head-on fishes have to be graded onboard/on-farm into 3-4 weights and stored in different tubs/pallets with labels. After receiving the chilled fresh fish or thawed frozen fish, they can be graded manually with expert hands or placed on a grader machine.

4.3.5 Processing of fresh fish

Fish processing technology has not yet been modernised enough in Bangladesh to produce quality and safe value added fish products to compete on the global market. The processing activities are not well integrated and remain traditionally as secondary activities of the processing plants apart from shrimp processing. Utilising the experience of upgrading shrimp processing industries in Bangladesh in the last ten years, adaptation of fish processing technology is also possible by increasing the facilities and expertise in this field. For such a technical development process, theoretical research, information and practical experience of Icelandic processing industries is hoped to be successfully adopted in Bangladesh. For processing of export quality, safe fresh and frozen fish products from Bangladesh fish species (carp and catfish), the following flow chart (Figure 9) of processing activities is suggested adopting some reasonable adjustments from the Icelandic activity flow chart (Figure 8) as discussed in Chapter 3.3.

For short distances, raw materials can be collected directly from the farm sources to the factory gate as whole live fish (catfish like *Pangus*) or whole fish in fresh conditions (carp) with or without icing as early as possible after harvest. It is better to handle the fish (slaughtering, bleeding, gutting and icing) inside the factory maintaining the desired freshness for production of safe and high quality products. If fish raw materials are collected from distant places and need to be handled outside the factory, the collecting agent should ensure proper handling in coordination with the supplier depo or landing stations to ensure raw material quality.

Fish should be washed and cleaned properly before handling in the factory. Instead of mechanical methods; grading, heading, filleting and skinning can be done manually. Trimming and portioning and weighing can also be done manually by trained workers. The separation and collection of processing co-products (head, throat, eye, skin, liver, fish maw, back bone, minces) should be done at relevant steps during the processing to ensure proper utilisation. After completion of these steps by manual or mechanical methods, chilled fresh fish products or IFQ and block frozen products could be produced following the systematic processing flow chart as described in chapter 3.4.3 (Icelandic processing technique). The packaging, palletising and storage procedure can be followed as described in the previous chapter with some modifications or adjustments depending on the machineries and facilities available. The products should be labelled with the required information following the safety regulations. All traceability information regarding the products should also be collected, documented and preserved in the factory to supply the buyers and inspectors as and where necessary.

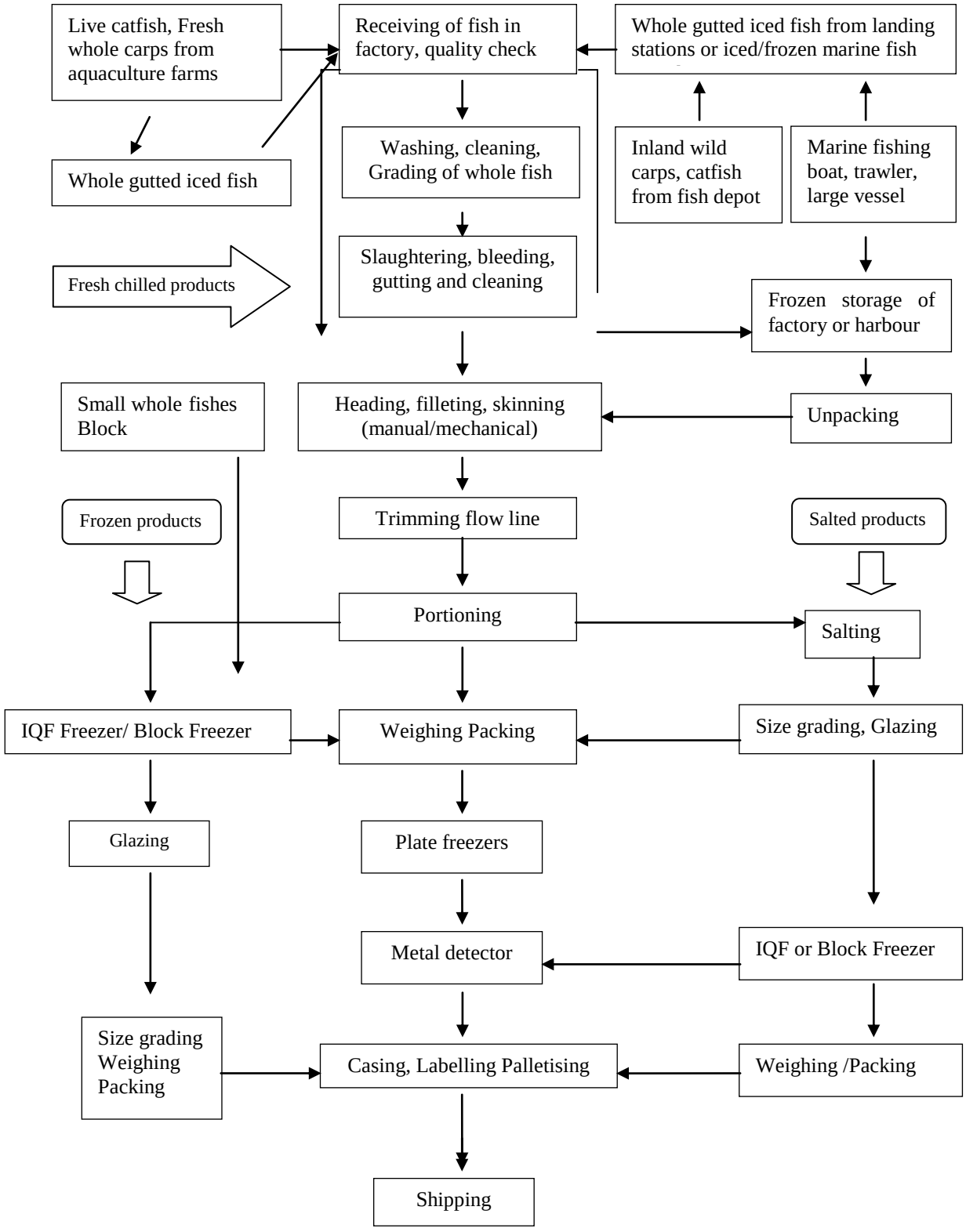


Figure 9: Processing flow-charts for production of fresh and frozen products from Bangladesh fish species (carp and catfish).

4.3.6 Safety and quality control

During the processing steps, quality and safety management issues should be very carefully maintained (especially during manual works) to comply with the product specification and market requirements. In Bangladesh, involvement of workers might be more due to manual operation. Here factory and personal hygiene factors should be taken into prior considerations to avoid contamination from the processing steps up to packaging and safe storage of the products. To control the possible hazards during the handling and processing flow-line, HACCP principles should be strictly followed at every step.

To ensure the control measures, quality and safety check points could be divided into certain sections (areas) of operations inside the processing factory and check the effective control for each section before going to the next subsequent steps. The most important sections are: receiving, grading, washing, and cleaning section; bleeding, gutting and washing (where applicable) section; intake and cooling section; heading, filleting and skinning section; trimming, portioning, weighing and packaging section; chilling and/or freezing section and safe storage section for the final products. Manual operation is time consuming, so keeping a low temperature until storage is important. The time-temperature regime could be strictly followed during raw material intake (fresh or iced), processing line and in storage. In Icelandic processing systems, temperature checks are done every hour before filleting (i.e. after grading and heading), during filleting, after pre-cutting machine, during trimming line and before chilling or IQF freezing. The aim of such frequent monitoring is to maintain the temperature between 0°C and 4°C during the processing line adding ice or using a cooling system where necessary to keep the desired level.

5 DISCUSSION RECOMMENDATIONS AND CONCLUSION

5.1 General discussions

The aim and objectives of the project were to study the on-going practice of Icelandic processing industries and identify the prospects and limitations of the Bangladesh fish processing system. Based on this information, I finally suggest a best possible handling, processing and quality management system for cultured carp and catfish to produce safe and high quality fresh export products. The fish processing industry of Bangladesh is shrimp based and facing serious setbacks due to lack of knowledge regarding production of safe and high quality export products utilising available carp and catfish raw materials. During the last two decades, shortage of shrimp has resulted in underutilisation of facilities, in general only 35% of the total capacity. This set back of the industry has reduced employment opportunities and expected export earnings from the sector have not been achieved. Production and export of carp and catfish has increased considerably in other Asian countries like China, Vietnam, India and Thailand in the last decade. Bangladesh has not shared this success due to lack of initiatives, technical knowledge and expertise on production of safe and high quality fish products utilising available carp and catfish from aquaculture or wild sources.

Icelandic fisheries processing industries have definite production and marketing plans based on resource information and market demand. The larger fish processing

companies have their own fishing fleets and they directly collect their desired fish raw materials mainly from marine resources as per demand. They preserve the required quality and safety of the raw materials as per specification of the customers and in compliance with the safety regulations. Inside the factory, Icelandic processing flow-chain activities are very organised and well equipped with modern machineries and skilled, experienced workers. They have mostly computer programmed in-built processing operations at different steps and maximum activities performed by modern machineries. Trained skilled workers mainly look after the smooth operation of the machineries and monitor quality and safety parameters during the operations. Regarding safety and quality management issues, processing plants have their own rules, Total Quality Management (TQM) plan and supporting manuals and follow the safety and quality assurance rules according to Good Manufacturing Practice (GMP) and Good Hygiene Practice (GHP).

In Bangladesh, fish processing industries usually do not follow any specific production plan activities are not continuous or well organised, except for processing of shrimps. Moreover, the quality and safety requirements of shrimp are in place but have not yet been practiced in fish processing.

The main limitations in the existing Bangladesh fish processing practices are:

- Long and complicated supply chains leading to handling stress.
- Fish remains un-gutted for a long time - from harvesting to until they have arrived at the landing station, fish depot or the factory.
- Poor availability of cost-effective quality ice and lack of proper icing. Furthermore, icing is not considered as cost-effective to fishermen.
- Improper training; poor technical knowledge and operating skills e.g. regarding spoilage factors, importance of low temperature and gutting of fish.

To avoid the long fish supply chain, it could be suggested to collect fish directly from farm sources or from landing stations and fishing vessels. Initially, a few selected fish suppliers could be contracted, trained for good handling to ensure raw material quality. Catfish can be supplied directly from farm sources to factories in live conditions or carp in fresh conditions. To avoid heavy initial investment for installing modern machineries in the factories, manual operations are suggested.

The good experience regarding safety and quality assurance systems that has gradually been developed for the shrimp industry could be adapted to fish. Especially, registration of the producers and food business operators and hazards control involved would improve the production. Environmental hazard factors need to be defined and emphasised.

A numbers of studies have revealed that quality parameters and shelf life of fish is considerably dependant on whether the gut content reaches the flesh after death (Huss 1995). In general gutted fish is preferable to un-gutted whole fish for preservation. Gutting reduces the chances of microbial contamination by preventing the spreading of undesirable bacteria from intestines to muscles. It removes undesirable digestive enzymes leaching to the body cavity from digestive tracts and slows down enzymatic activity (Huss 1995). It also prevents penetration of parasites from intestine (gut) into the fish flesh. If gutting cannot to be done promptly, fish should be washed and chilled until gutting takes place.

The usual Bangladesh temperature ranges between 10-25°C in winter and 25-35°C in summer and the time-temperature regime is the key limiting factor for spoilage where availability and use of quality ice is limited. Availability of quality and cost effective ice is still one of the major limiting factors for fish producers in Bangladesh (Pichler 2007). In the shrimp processing industry, the situation has improved as icing is required as a pre-condition for getting a good price. If fish processing plant agents are made aware of the importance of the use of ice and a supply of ice is ensured, it is possible to adopt good handling and cooling practices for fish raw materials. The fishermen could be provided with small insulated box with the required amount of slurry or flaked ice to be used for cooling and preservation of the fish during their day-long harvest.

To preserve the desirable colour and texture of white flesh fish, bleeding has been proven to be important in many research findings. Due to improper bleeding of fish, blood spots appear in fish muscle, which deteriorates the product quality. Bleeding is considered as a pre-requisite handling procedure to maintain quality parameters for sashimi grade fish. Bleeding and gutting could be scheduled at a desired time after harvesting at the farm and the fish kept in flowing water or immersed in water for maintaining the time-temperature regime.

The availability and use of good fish containers is another factor to be considered for better handling. Large fish farms already have their own fish tubs for handling and transport, but small farmers are not yet aware of these issues. They should be supplied with the appropriate containers initiated by the government as has been implemented in the shrimp industry.

According to some recent studies, it is suspected that indiscriminate uses of antibiotics on the fish larvae by the hatchery operators, uncontrolled import of fish feed ingredients (fish meal, meat and bone meal) by the fast growing fish feed industry and excessive use of antibiotics in poultry farms may be a route of contamination and environmental hazard. Prior attention is required to prevent these types of contamination (Karim *et al.* 2007).

To adopt such good handling practices from farm/natural sources to the processing factory training materials need to be developed based on the available research information and considering the prevailing environmental and biological factors. This could be done gradually, but could be initiated in selective activities to improve the situation through joint efforts of the government and processing plant owners (Bangladesh Frozen Food Exporters Association, BFFEA) who have already been playing an effective role in the shrimp sector.

In Bangladesh, some of the processing plants have adopted significance infrastructure and technological improvements and at the moment 67 processing plants have an EU approval for export of shrimps and fish products. If small renovation could be adopted regarding machineries and training of workers, it is possible to start processing available carp and catfish. The processing industry should be encouraged to turn their attention to producing high quality and safe fish products instead of only shrimp to utilise their capacity and participate in the competitive export market.

5.2 Recommendations for improvements

5.2.1 Introduce good handling of fish

The current fish supply chain of fish harvesting from different aquaculture and natural resources to the processing factory or to the consumer is quite long involving many middlemen resulting in excessive handling stress and loss of fish freshness and quality. For export purposes, some selected fish suppliers (large or mid level aquaculture farms, open-water fishermen, depot owners and marine fishing trawler crews) could be trained and collect fish raw materials for a better price based on a quality index. Subsequently, other suppliers would be aware and interested to be trained in good handling practices and keeping quality of harvested fish as in the shrimp sector.

For concerned government officials (who will acts as trainers), all concerned stake holders in the supply chain and processing factory personnel (who will receive the fish), development of training manuals should be initiated. Some research initiatives need to be taken for optimising the technical issues relevant to each step of harvesting, handling, preservation and transport subjected to different habitat, time, temperature and other correlated factors applicable to carp, catfish or other important fish species. BFFEA can take it as a part of their shrimp handling and processing task, to transfer the knowledge of good handling about fish as they successfully practice for shrimp.

5.2.2 Improve processing of fresh fish

Other plants also maintain required standards to get renewals or new licenses from the DoF. Previously, processing plants have imported their machineries for shrimp and their workers skills and experience are oriented to mostly to frozen shrimp processing. But most of the upgrading factories have minimum machineries for processing of fish and some of them have already started to process fish in small amounts.

5.2.3 Food safety and quality assurance programme

Regarding the safety and quality assurance system of Bangladesh fish processing, most efforts have been made in the shrimp industry as a prioritised export commodity. The Fish and Fish Products (Inspection and Quality Control) Act, 1997 has the general regulations for fish products but is mostly focused on post-harvest safety and quality control measures of shrimps based on HACCP principles. In the last decade, the supply chain of shrimps from farm to factory has become better organised, which does not apply in the case of fish. Utilising the good experience from shrimps, quality and safety management in the fish supply and processing chain could also be developed. Some important additional pre-harvest safety measures are required both for fish and shrimps to avoid environmental contamination (chemical and biological) before harvesting the products. Particularly, for aquaculture fish or shrimps, these factors should be taken into prior consideration which might be the major sources of raw materials to the export industry. Recent studies and reports have also highlighted this issue (Pichler 2007) as there have been no cost-effective curative options for environmentally contaminated products rather prevention measures are the only solution. To ensure the safety and quality assurance of fish and shrimp products in Bangladesh, the following actions should be taken as early as possible:

- Qualitative and quantitative strengthening of existing fish inspection and quality control services under the DoF providing required training to the existing FIQC personnel as well as gradual recruitment of new staff in short term and long term career plans.
- Required training manuals, guidelines, check-lists etc. need to be developed on inspections, GAP, GMP, GHP and SSOP for the inspection personnel to upgrade their knowledge about the changing food safety regulations and their implications.
- Increase required logistical support for the FIQC to ensure minimum technical and inspection services to the stakeholders, utilising the existing human resources.
- Strengthen laboratory facilities and expertise to get international accreditation and ensure quality laboratory services to the stakeholders and exporters-importers.
- Some legislative change needs to be adopted to impose the necessary control on input supply systems such as quality and use of imported or local aquaculture inputs, relevant business and environmental management.
- To establish a well defined fish supply chain with all relevant traceability information, aquaculture farms should be gradually be registered and linked to the local government extension services. This is essential for transfer of technology, checking utilisation of safe inputs, documentation of culture practices. It is very difficult to register thousands of farmers but could be initiated with selective large farmers and organising local associations of small pond operators.
- Other stakeholders playing an important role to collect, handle, preserve and transport fish, fish depots in landing stations and markets also need to be enlisted. Then they should be registered according to the skills upgrading through training giving special benefit to attract good handling practices.
- To avoid fish spoilage and microbiological hazards after harvesting of fish requires handling facilities in landing stations, fish depots and a supply of quality ice should be ensured at concerned places.
- Quality control on commercial ice plants and ice used for fish preservation. Ice factories should be selected, registered, and staff trained and equipped with required machineries to adopt them producing quality ice for fish and providing a marketing channel of quality ice under private entrepreneurship.
- More strong linkages and coordination need to be developed with government and international agencies, researchers, private sector entrepreneurs, all stake holders, fish exporters and consumers to exchange views, identify problems and prospects, take decisions and prompt actions.
- An updated Management Information System (MIS) should be developed for collection, exchange and access of recent information to all concerned.

5.3 Conclusion

The theoretical knowledge, practical observation and experience gained in this study helps to conduct a comparative analysis of fish processing practices in two countries. Comprehensive information has been provided about the possible best handling, processing and quality management practices for the production of high quality fresh fish products from carp and catfish in Bangladesh. The environmental conditions, species, temperature and other factors are different in a tropical country like Bangladesh than in Iceland.

However, notwithstanding certain modifications, it is expected that this suggested practice could be implemented in Bangladesh. Effective utilisation of suitable handling and processing methods and quality management systems for different fish species could add new advantages to the product quality of the carp and catfish processing industries of Bangladesh.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude, honour and thanks to my supervisor Prof. Hjorleifur Einarsson and co-supervisor Ms. Arnheidur Eythorsdottir for their patient efforts, scholastic guidance and continuous inspiration to complete this project work and write the report. Without their sincere efforts, it would not have been possible to successfully complete this study in time.

I am expressing my thanks and gratitude to the UNU-FTP and Department of Fisheries, Bangladesh for giving me the opportunity to study in Iceland and improve my knowledge and experience.

My deep sense of gratitude and appreciation to Dr. Tumi Tomasson, Mr. Thor Asgeirsson, Mr. Gudni Eiriksson and Ms. Sigridur Ingvarsdottir for their continuous support, guidance and cooperation during the entire study period in Iceland. I am also grateful to Mr. Hreidar Thor Valtysson and Ms. Lara Gudmundsdottir whose assistance and cooperation made our study more convenient and enjoyable.

My gratitude and honour to all of the teachers, scientists, researchers, resource persons, professionals, business and educational institution personnel who contributed their knowledgeable presentations and shared their experience during our entire study period.

My special thanks to Mr. Elvar Thorarensen, Quality Manager, BRIM hf. Sea Foods, Akureyri, Iceland for his sincere and cordial support to conduct a successful practical study visit in the fish processing industry. I am very thankful to BRIM hf authority for giving me this opportunity.

I am expressing my deep gratitude and appreciation to Mr. Mukammel Hossain, Director General, Department of Fisheries (DoF), Bangladesh and Mr. Imtiaz Ahmed, National Project Director, SFIQC Project, DoF for their continuous support, suggestions and inspiration to select and conduct the study. I am thankful to my teammates Prof. Md. Kamal, Mr. Monjur Kader, Dr. Rafiqul Islam and Mr. Maksudul Haque Bhuiyan, Department of Fisheries for their inspiration and providing me with the required information for the study.

My heartfelt gratitude and thanks are extended to all UNU-Fellows (2007-08), from different nations who make our entire study period enjoyable, enrich our knowledge and experience sharing with each other.

Lastly, all my gratitude to almighty Allah, who blessed me to do something better for the people.

LIST OF REFERENCES

Ali M , F Iqbal, A Salam, S Iram, M Athar (2005). Comparative study of body composition of different fish species from brackish water pond. *Int. J. Environ. Sci. Technol.* Autumn, 2005. Vol. 2, No.3, pp. 229-232

Ali M, F Iqbal , A Salam, F Sial, M Athar (2006). Comparative study of body composition of four fish species in relation to pond depth. *Int. J. Environ. Sci. Technol.*, © Winter, 2006. Vol. 2, No. 4, pp. 359-364.

BBS, 2005. Statistical Year Book of Bangladesh 2005. Bangladesh Beauru of Statistics. Ministry of Planning, Government of the Peoples Republic of Bangladesh. Dhaka.

Cato, J.C. and Subasinge, S. 2003. Food Safety in Food Security and Food Trade, Focus 10.

Chakraborty, S.C., Uddin, M. B. and Islam, M. N. 2003. A study on proximate composition of freshwater fishes of Bangladesh. *Bangladesh J. Fish*. (2003) 26(1-2) : 23-36

DoF (2006). Fishery Statistical Year Book of Bangladesh, 2005-06. Fisheries Resource Survey System (FRSS), Department of Fisheries (DoF), Bangladesh. Dhaka.

DoF (2007). Annual Report, 2005-2006. Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh. Dhaka.

FAO (Food and Agriculture Organization). 2000. The State of Fisheries and Aquaculture. FAO, Rome, Italy.

FAO, 2002. The state of world fisheries and aquaculture, FAO, Rome, Italy.

FAO (2006a). FAO Fishery Statistics. Capture production, volume 98/1. FAO, Rome, Italy. <http://www.fao.org/fishery/statistics/global-production>

FAO (2006b). FAO Fishery Statistics. Aquaculture production, volume 98/2. FAO, Rome, Italy. < http://www.fao.org/fishery/statistics/global-aquaculture-production>

FAO (2006c). FAO Fishery Statistics. Commodities volume 99. FAO, Rome, Italy. <http://www.fao.org/fishery/statistics/global-commodities-production>

Huss, H.H. 1995. Quality and quality changes in fresh fish. FAO Fisheries Technical Paper 348. Food and Agriculture Organization (FAO), Rome, Italy.

Ioannis, S., Arvanitoyannis, S. Choreftaki and P. Tserkezo. An update of EU Legislations (Directives and Regulations) on food related issues (Safety, Hygiene, Packaging, Technology, GMOs, Additives, Radiation, Labelling): Presentation and Comments. *International Journals of Food Science and Technology*, 2005, 40: 1021-1112.

Karim, M., Chowdhury, S.N., Rashed, M.A., Das T.K. and Islam M.R. 2000. *Shrimp Quality Preservation-Farm to Factory*. Dhaka. ATDP/USAID Project, Ministry of Agriculture, Dhaka, Bangladesh. Pp. 1-19.
Karim, M., Rashed, M.A., Das T.K. and Islam M.R. 2007. *EU Non-Tariff Trade Rules for Shrimp and Fish Export*. Dhaka. Bangladesh Shrimp and Fish Foundation. Dhaka, Bangladesh. Pp. 1-37.

Moller, A. (2007). Opportunities and challenges of fisheries globalization. Paper presented to the International workshop on-Sea food processing-local sources, global markets. Organized by Organization for Economic Co-operation and Development (OECD), Paris, 16 April 2007.

Pichler, D.R, 2007. Strengthening the fishery/shrimp inspection capacity and competitiveness of the shrimp sector. Mission Report submitted to the Government of Bangladesh under Bangladesh Quality Support Programme (BQSP), Department of Fisheries, Bangladesh. February, 2007.

Rahman A.K.A. (1989) Freshwater Fishes of Bangladesh. Zoological Society of Bangladesh. Department of Zoology, University of Dhaka, pp. 364

Appendix 1. Main products, their processing, packaging methods and export Market (DoF, FIQC, 2007).

Frozen shrimp and prawn: Seawater/brackish water black tiger shrimp **(***Penaeus monodon),* and fresh water giant prawn, (*Macrobranchuim rosenbergii).* Fresh water headless-shell-on tail on (FWSO); Seawater shell-on tail-on (SWSO); Peeled and Deveined (P&D), Peeled and un-deveined (PUD); Broken Product (BP) of Prawn and shrimps in Block Frozen and Semi-cooked.

Size: Several size categories of shrimps and prawns are used according to the specification of the customers, viz. U/5, 6/8, 8/12, 13/15, 16/20, 21/25, 26/30, 31/35, 36/40, 41/50, 51/60, 61/70, 71/90, 91/110, 111/130, 131/200, 201/300, 301/500 pieces per kg. In addition, several others size based on species and desired specification.

Packaging: 2 kg Blocks are wrapped with polythene sheet and packed in both-side wax coated laminated one flap duplex board non-toxic painter inner carton (EEC Standard), and then 2 kg X 6 = 12 kg net weight plus into corrugated wax coated master carton.

Frozen fresh water and seawater fishes: Freshwater fishes includes: Major carps-Rui, Catla, Mrigal, Cabaus, Silver carp, Common carp, Grass carp, Thai Sarpunti, Bata, Shol, Taki, Cat fishes (Boal, Ayer, Shing, Magur, Tengra, Gulsha), Tilapia, Koi, Kachki, Batashi, Baim, etc.

Marine fishes includes: Chinese Pomfret/ *Stromateus chinensis* (Rup Chanda), Silver Pomfret, Nakroor, Hilsha, Jew fish/ *Johnius argentatus* (Poa), Lattya (*Harpedon nehereus*), Lukkha (*Trichiurus haumela*), Ribbonfish, catfish, Indian salmon, Shad, Mullet, Tuna, Mackeral, Red snapper etc.

Frozen Crabs: Whole, gutted, fillet in IQF form, Blast freezing, Block freezing

Processing: The large fishes are processed in whole, headless and gutted (belly-clean) in the form of IQF state or sliced, fillets, steaks in block frozen state. The small fishes are whole block frozen.

Packaging: Each IQF large fish is wrapped with polythene sheet or put in small polythene bag and 20kgs net weight such fishes packaged with large polythene bag and then into a master cartoon wrapped with Hessian cloth. Block frozen fishes are wrapped with polythene sheet and then put into a master carton wrapped with Hessian cloth. The small fishes are packed in 0.5 kg to 1 or 2 kg blocks or as desired specification by the buyers.

Marketing: Frozen seafood exported to EU countries, USA, Japan, China, Canada, Thailand.

Chilled fish: Fresh water and marine fish species as mentioned above.

Processed mostly as whole gutted headless, also some in fillets, sticks, mince block form

Packaging method: 5-20 kg fish are packed with 20% flaked ice or 1% (200 g) dry ice in Styrofoam box. Size of the packet varies with the customer's specifications.

Marketing: Chilled fish are exported to other than EU countries (Middle-East countries specially Bahrine), and also to China, Japan, Thailand, Korea, Vietnam.

Live fish: i) Eel (*Anguilla bengalensis*), ii) Crab; iii). Live catfishes (Magur, Shing)

Packaging method: 15-20 kg fish packed with 0.50 kg ice in perforated Styrofoam box.

Market: Live fishes and crabs exported to countries: UK, USA, Malayasia, HongKong, Singapore, China, Vietnam, Thailand etc.

Cooked Product: Cooked shrimps; exported to EU, Japan, USA

Dry fish and salted fishery products: Dry fish, Moisture content- less than 10% exported to UK, USA, Spain, and Middle East,

Other fish products: Fish scale, fish fins & skins and fish maws (air-bladder of Shark)

Appendix 2: Total quality management (TQM) Handbook of an Icelandic Fish Processing Industry.

Total quality management (TQM) Handbook of Icelandic Fish Processing Industry generally includes the following contents:

Chapter 1: Summary of the TQM System, structure of the plan (Responsibilities, activities, personnel, job descriptions etc.)

Chapter 2: Flow-charts of the activities

Chapter 3: HAACCP plan, product processing flow-chart and adaptation of HACCP in plant

Chapter 4: Quality check: Quality checks points applying dividing the plant at different

activities area as follows:

Raw materials intake, washing and cooling (receiving point)

Heading, filleting and skinning area

Trimming, semi packing and shipments of fillets to fresh chilling or IQF freezer

Freezing area (IQF/Block freezer/Plate freezer

Packaging area for fresh and frozen products

Storage area for fish and fish products

Storage area for packaging materials

Chapter 5: Working rules for different sections:

General rules of activities, cleaning rules,

Safety rules, Specific safety rules for specific area (intake, grading, washing, cooling, heading, filleting, skinning, trimming, freezing, packaging, storage)

Training rules (training plan, training need assessment, training conduct, practical orientation, skilled assess, matrix, monitoring and evaluation of training)

Chapter 6: Manual for cleaning operation (Separate Manual) including:

Introduction to cleaning, importance, objectives

Cleaning Agents (Chemicals and water)

Personal hygiene

Cleaning and sanitation during the process

Cleaning schedule (daily, weekly, monthly, quarterly)

Inspection and checking of cleaning process;

ATP test (everyday), Daily monitoring by workers/inspectors/QM Managers

Cleaning of machineries (daily, weekly, periodical) by workers, foreman, Engineering team, contracted farm

Data recording of cleaning operation (daily, weekly, monthly, quarterly)

Personal Hygiene of the staffs

Chapter 7: Quality assurance: Quality goal of the Company, description of the final products

Chapter 8: Documentation. Rules and procedure data recording, information documentation

Chapter 9: Checking/Monitoring system of quality assurance programme

Chapter 10: Labelling, information of products, traceability system

Chapter 11: Recall of products

Chapter 12: Complaints and claim

Chapter 13: Documentation and storage of documents

Chapter 14: Rules regarding certificates (certificates regarding products, ice, water, sanitation, employee's health, training, all sorts of certificates inside and outside the company)

Chapter 15: Employee's health (health checking, sick leave, insurance, overall health policy)

Chapter 16: Materials for check: for microbiological study of products, sample study-TPC/TCC/CFU, regular sample study, sanitation and hygiene of factory-ATP and swab test-daily/weekly-(internal) and external testing by contracted laboratories (*Promat, Iceland)

Chapter 17: Checking on the measurement: accuracy of all measurement-machineries, weight, time, temperatures, computer controlling system, all handling, processing and storage equipments.

Chapter 18: Products beyond the standards- out of product consignments, try to adopt reprocessing to comply other products specification.