CIFE

A SHORT INTRODUCTION

The Central Institute of Fisheries Education, Mumbai was established in the year 1961, under the Ministry of Agriculture, Govt. of India. The Administrative control of this Institute was transferred to ICAR in 1979. Subsequently, the scope and mandate have been widened to include education, research and extension. Recognising the pivotal role played by the Institute in Human Resources Development in fisheries, the Institute was accorded the status of Deemed-to-be- University in March, 1989.

There are six major functional divisions at CIFE equipped with state of the art laboratories and various sections/cells to carry out specific work. The Institute has two campuses one at Yari road and another at Seven Bungalows, Mumbai. The new Yari road campus (three floors and basement) houses scientific divisions, chambers of the Director and Joint Director, Academic and Accounts sections, Conference hall, Community hall, Aquarium, Examination and Academic cells, Library building, Staff quarters and Ladies hostel etc. Wet labs, ponds and hatcheries are also developed in Yari road campus. The old campus at Seven Bungalows houses three divisions, laboratories, classrooms, computer cell, committee room, auditorium, workshop and museum. These two campuses are a kilometer apart from each other at Versova. The Institute with its headquarters at Mumbai has four centres at Kolkata (West Bengal), Kakinada (Andhra Pradesh), Powerkheda (Madhya Pradesh) and Rohtak (Haryana) near Delhi. The Institute's field facilities include 20 ha Freshwater Fish Farm at Powerkheda (Madhya Pradesh); 9.0 ha Freshwater Fish Farm at Balabhadrapuram (Andhra Pradesh); 7.5 ha Brackishwater Fish Farm at Kakinada (Andhra Pradesh), 4 ha Freshwater Fish Farm and 10 ha Ground Saline Water Farm at Rohtak for training and research in aquaculture. The Institute has two training-cum-research vessels viz.: M.F.V. Saraswati (36 m OAL) and M.F.V. Narmada (11 m OAL) for training and research in marine fisheries. The total sanctioned strength of the Institute as on 31 March, 2009 is 356 comprising of 2 Research Management, 104 Scientific, 113 Technical, 57 Administrative, 1 Auxialiary and 79 Supporting staff.

The CIFE has been accredited by ICAR for five years from September, 2007 to August, 2012. CIFE offers Master of Fishery Science programmes in nine disciplines viz. Fisheries Resources Management, Aquaculture, Post-harvest Technology, Fish Nutrition and Biochemistry, Fish Pathology and Microbiology, Fish Genetics and Biotechnology, Fish Business Management, Aquatic Environment Management and Fisheries Extension, while the doctoral programmes are offered in the ten disciplines viz. Fisheries Resources Management, Aquaculture, Post-harvest Technology, Fish Genetics, Fish Biotechnology, Fish Nutrition and Biochemistry, Fish Pathology and Microbiology, Fish Business Management, Aquatic Environment Management and Fisheries Extension. A two-year post

graduate (PG) Diploma in Fisheries Science, which the Institute used to conduct since its inception, mainly for inservice personnel of State Fisheries Departments, was discontinued from the academic year 1998. This course was solely responsible for providing the trained manpower for fisheries development in the country till fisheries colleges under State Agriculture Universities (SAUs) came into the picture during the Seventies.

CIFE KOLKATA CENTRE

The center traces its roots to `Inland Fisheries Training Unit (Centre) under CIFRI, Barrackpore. In 1967, the training center was transferred to CIFE, Mumbai and the center was popularly called Barrackpore center.

The course run by the Barrackpore Centre was reorganized from the 1981-82 session when an improved syllabus and a new curriculum were introduced. The Centre started conducting the new course designated as "One Year Post-graduate Certificate Course on Inland Fisheries Management". The Barrackpore Centre was shifted to its own new building complex, established at 32-GN Block, Sector -V, Salt Lake City, Kolkata, in 1997-98, and started functioning under the new name of "CIFE KOLKATA CENTRE".

The Calcutta Metropolitan Development Agency (CMDA now KMDA), to allotted a plot of 3.5 acres to CIFE/ICAR in early 1980 in Sector -V of Salt Lake City, Kolkata for the construction of new building complex of the CIFE Centre. The first phase programme comprised the construction of 12 staff quarters - 4 each of type I, type II and type III, 72-bed student hostel with dinning hall and common room etc., main building of the Centre (ground floor and 1st floor), water supply tank of 25,000 liter capacity, 11 KV electrical sub-station, landscaping, lay-ing of parks and construction of necessary infrastructure facilities etc. The new building complex was inaugurated by Professor (Dr.) R. S. Paroda, the then Director General of ICAR & Secretary, DARE, Govt., of India, New Delhi, on 20th June, 1997.

The Centre conducts refresher training courses for the benefit of extension workers of states on the development of inland fisheries. Need-based capsule courses are also organized on different aspects of fisheries and aquaculture. The implementation of short-term courses on inland fish farming and ornamental fish culture for the benefit of women belonging to the fishing communities and other backward classes is the note worthy extension service offered by the Kolkata Centre. A good number of short-term programmes (STPs) were conducted during the Silver Jubilee Year of ICAR, under "The Lab to Land" programme. Many foreign students particularly drawn from Laos, Tanzania and Cuba, were given "Attached Trainings" on various subjects of inland fisheries from 1982 to 1985. Presently short-term training programmes are conducted regularly at Kolkata Centre on: Fin fish and shellfish hatchery operations and management, Recent advancements of giant freshwater prawn, Ornamental fish breeding and culture, Eco-friendly aqua feed and feed strategies for sustainable aquaculture, Fish processing and marketing, Value added fishery products,

Monitoring of water and pond sediments parameters for sustainable aquaculture. From 2001 to 2011, 1381 numbers of trainees were trained in STPs on different aspects of fisheries and aquaculture.

The center provides advisory services free of cost to the fish farmers and students of various states, who frequently visit the Kolkata Centre. Scientists of the center were frequently invited to deliver lectures by the State Governments, KVK's, NGO's and some other Organizations connected with the development of inland fisheries.

INTRODUCTION

At earlier time, the domestic consumer was not used to anything other than fresh fish and the export trade had just begun a humble beginning with moderate shrimp exports. Later this consumed processing of fish into diverse products with the establishment of freezing plant machinery during 1965-66, tunnel drier during 1975 and fish canning plant in 1978. During the period from 1966 to 2010, the project of fish processing processed 8794 tonnes of fish & shellfish in its various plants. The implication of the popularization of Processed Fish Products in early sixties and seventies can be conceived only with an understanding that the fish eating public which confined to the narrow coastal belt would accept nothing other than fresh fish, while sea fish is totally unfamiliar to the populace in the hinder lands. The urban dwellers would like to have it but it is not simply available in places other than the coastal towns and cities. New product development and value addition was achieved through sustained Research and Development efforts of the division. Consultancy continued to be provided in processing of fin fish to the industry. As a promotional measure, specific fin fish processing operations such as filleting, production of steaks, development of Individual Quick Frying fin fish products and fin fish drying used to be undertaken by the Project for the exporters.

Post-harvest technology is a multidisciplinary science. It refers to various treatments and unit operations carried out on harvested crops for the purpose of preservation or enhancement of quality by eliminating avoidable losses. The important areas of post-harvest technology is the familiarization with major crops, harvesting indices, harvesting technological tools and their maintenance, post-harvest technology-concept and scope, unit operations of crop processing, post-harvest equipment and machinery-operations and maintenance, storage of farm produce and concept of fish-processing center.

In developing countries, where tropical weather and poorly developed infrastructure contribute to the problem, losses are sometimes staggering proportions. Losses occur in all operations from harvesting through handling, storage, processing and marketing. They are according to the influence of factors such as the perishability of the commodity; ambient temperature and relative humidity which determine the natural courses of decay; fungal and bacterial decay; damage by pests-insects, rodents and birds; the length of time between harvesting and consumption; and practices of post-harvest handling, storage and processing.

Most often, post-harvest losses are symptom rather than the problem. Knowledge of their cause is, therefore, essential deciding measures to prevent them. Such measures may have to be taken by the small farmer, the private trader, a cooperative, the marketing board or other operator, handlers and transporters, wholesale and retail markets, etc.

Post-Harvest Technology is concerned with although situations where fish is used as a food commodity, from the point of captured to the point of consumption. It embraces handling, transportation, processing and preservation (chilling, freezing, smoking, salting, drying etc.), distribution, marketing product innovation and development, nutritional considerations, standards and specifications, quality control (Collell, 1979) Fish is a rapidly perishable commodity. There it needs to be handled carefully immediately after capture. The technology that is used to keep the quality of the fish after capture is now referred as post harvest technology. It has many branches.

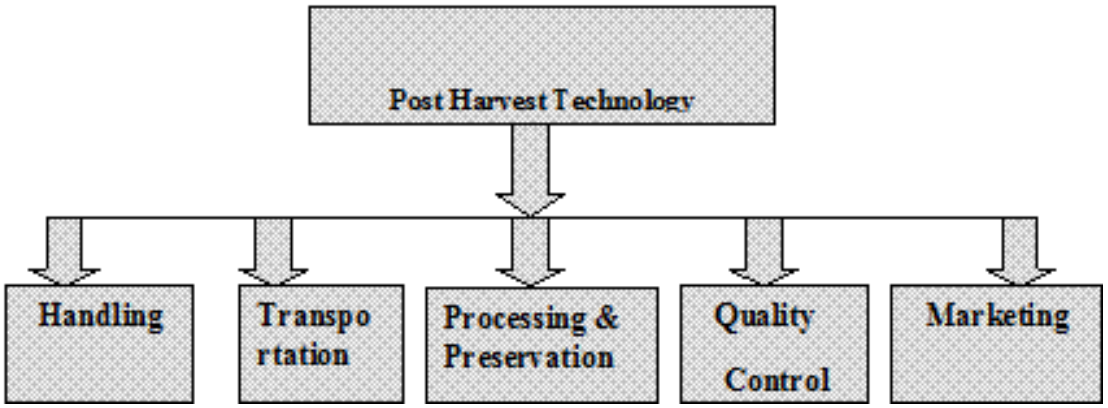


Figure 1: Branches in Post Harvest Technology

IMPORTANCE OF POST HARVEST FISHERIES

Fish preservation is a very important aspect of the fisheries. Normally the fish farms or other fish capturing sites are located far off from the market place and there is chance of fish decomposition and the uncertainties of their sale in market. When the fishes are caught in numbers, greater than the amount of consumption, their preservation becomes a necessity for their future use. Preservation and processing therefore become a very important part of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of flavor, taste, odor, nutritive value and the digestibility of their flesh.

Post harvest fisheries are new hope in our country. Even it is not fully introduced in our country. But this subject is being performed in various areas of our fisheries sector and develops our country in the following ways:

a. Supply of protein

Fresh and processed fish is important source of protein supply. Application of post-harvest technology resist the spoilage of fish muscle. When a fish is in fresh state, it contains a considerable amount of microbes on skin, gill and in intestine. Proper processing with the application of post harvest fisheries technology provides us almost microbes' free fish. It will maintain the good quality of fish and fisheries products. So, more fish and fisheries products will reach to the consumers which able to meet the protein demand.

b. Earning foreign exchange

Total fisheries production of India is about 15-16 lack ton/year (approx.). From this production only 40-50% is exported to foreign countries (recent year). About 30-40% loss occurs during the post harvest. This loss can be minimized by using the knowledge of post harvest technology. Good quality of fish and fish by-products is ensured by post harvest technology which can be exported and earn a lot of foreign exchange. It is said that India earns a lot of foreign exchange by processed fisheries products.

c. Supply of better quality of fish product

The fisheries resource in India is enormous. By applying better technology supply of better quality of fish product will be available to the local and foreign markets. Proper processing

and preservation of fish maintains good quality of fish including its protein quality avoids rancidity of lipid or fat and also maintains other nutritional status.

d. Conversion of fish species into nutritional (biochemical and pharmaceutical) products

Post-harvest technology gives us the knowledge of conversion of fish species into products for nutritional and industrial uses. Some biochemical and pharmaceutical products of economic importance from fish and fish wastage is only possible by applying the knowledge of post-harvest technology. Protein, vitamins and minerals can be extracted from fishes. For example Cod fish has a wide use in industries which is used to produce cod liver oil. It meets the requirement of vitamin-A.

e. Production of Ornamental and Perfumed products

Ornamental and perfumed products are prepared from some fish and fisheries products. Without proper processing and preservation, it is not possible because it produces bad odor.

f. Reduction of post-harvest losses

Application of post-harvest technology helps to reduce the loss of production after harvesting. Fresh and processed fish already are making important contribution to the world's protein supply. The part of post-harvest technology has a great diversity in fisheries sector. By studying on various information about post-harvest technology in India it is found that there are very few researches on post-harvest technology in India and the research have done mainly on handling but lack of other side. So, India faces enormous losses every year. Many developed countries are varying aggressive in post-harvest technology. They have modern technology and equipment. Only introducing the modern technology and equipment in post-harvest technology can reduce post-harvest losses.

g. Improve or changes of life style

By helping in additional income post-harvest technology can change our common life style. Post-harvest technology is also important by the following ways:

- It helps in the production and use of fisheries by product.
- It helps to know about the techniques used for maintaining the quality of fish (processing and preservation)

h. Job opportunity

Many people can be employed in the fish processing industries and fish collector agencies. Thus post harvest technology provides job opportunity. If new industry is established the opportunity will be greater. So, it can be said that application of fish post harvest technology in our country plays an important role in solving the unemployment problem in Bangladesh. Job opportunities may be of two types:

- Wage Employment
- Self-Employment

SCOPE OF POST HARVEST FISHERIES TECHNOLOGY

The scope of the Post-Harvest Technology covers all aspects of post-harvest research pertaining to fish and fisheries products, from post-harvest up to processing. There is considerable room for improvement in the way fish is handled, processed, distributed and marketed for the domestic market. The distribution of benefits may be improved by focusing on traditional producers and processors. Since the scope to expand inshore catches in the long-term is limited, the opportunities that exist for small-scale fisher folk communities in post-harvest value-added production must be tapped. The potential for this in India is considerable.

As we know from the definition of post-harvest technology, it includes the following areas or scopes that give the special visualization or study to check the qualitative and quantitative losses of fisheries resources.

Fish is one of the most perishable commodities. Considerable wastage occurs after capture. Small-scale fishermen face problems in handling, transporting and marketing fresh fish under difficult conditions and at high ambient temperatures. The absence of adequate facilities both on fishing craft and a shore prevents the distribution of good quality fish. As a result, microbial spoilage and contamination by pathogenic bacteria occurs. This can have important implications for the export trade, especially as more stringent international quality parameters are applied worldwide. Large quantities of fish are also discarded by shrimp vessels because the financial returns do not make it worthwhile to bring the by-catch back to shore. Large quantities of pelagic fish, in particular, are caught at certain times of the year and cannot be processed. Improvements are possible, but technology alone cannot succeed, without a thorough understanding of the social and economic factors and strong support from the Government in tackling the problems of poor infrastructure that affect small-scale fishing communities.

Market trends are now towards convenience foods that can be rapidly prepared. Value addition in fisheries comes through improved handling, processing and storage, and the use of better packaging materials for fish products. The range of convenience fish products includes spreads, dips and salad ingredients as well as main dishes. Preparations involve shrimp and a wide variety of other fish species.

Fishing craft in small-scale fisheries are generally small. They fish the area of the sea close to the shore. The gear they use often determines the fishing methods used. As the craft are small, there is very limited space onboard, which makes proper handling and preservation of the catch difficult. Fishing communities confront severe problems in handling, distributing and marketing fish.

The lack of suitable infrastructure including transport and ice-making plants increases the problems of rapid spoilage. Landing sites are often remote, and it is not economic to provide the infrastructure needed to preserve fresh fish either onboard or immediately on landing. Even when landing sites and road sexist, it is often not economic to transport the catch. Because of these factors, a large part of the catch is processed by traditional methods of salting, sun-drying and smoking.

The best way to preserve fish is by icing it and keeping it cool. However, this is not always technically and economically feasible. The limited use of ice in small-scale fisheries may be due to its high cost or a lack of knowledge about the benefits of using ice. The easiest way is to use a low-cost, sturdy, well-insulated box made of local materials. Boxes should be portable and easy to handle and be designed to meet the rigors of a marine environment and the fishing craft.

Salted, sun-dried and smoked fish are less perishable than wet fish and can keep for several weeks. However, unless the processing is done very carefully, physical losses can occur which reduce quality and quantity and lower value to the fish processor.

Women play a vital role in post-harvest activities, particularly in the small-scale sector where they work in shore-based activities such as handling, processing and marketing of catch. Women have traditionally been involved in fresh and dried fish marketing, which can be seen as an extension of the production process, and provide a crucial link between the supplier and the customer in the rural areas. However, they often face difficulties in procuring, distributing and marketing wet fish and fish products. Any initiatives in the small-scale post harvest sector must take into account the role played by these women.

OBJECTIVES OF POST HARVEST TECHNOLOGY

- To reduce post-harvest losses of fish and fisheries products.
- To improve the quality of fishes and seafood products.
- To introduce new flexible pouch packing technology.
- To implement substantially delayed after approval.
- To reduce the cost of food packaging, processing and preservation.
- To have a good concept on areas like fish handling, preservation and processing, with focus also on safety problems that are specific of seafood.
- To develop skilled personnel for undertaking/ organizing/ supervising/ assisting in post-harvest technology activities.
- To acquaint the students with gainfully remunerative occupations in the field of post-harvest technology.
- To develop proficiency in the efficient use of post-harvest technology for the benefit of producers.
- To train manpower to meet the needs of producers, suppliers and consumers of post-harvest equipment.
- To train young entrepreneurs for self-employment by way of developing processing Centers at village levels.
- To impart knowledge on the safe and judicious use of post-harvest equipment with the aim of processing of farm produce at producer's level.
- To provide fish-processing consultancy services.

Fish Preservation – Biochemistry

Fish being one of the most perishable among the foodstuffs, processing aims at controlling, if not totally arresting, and the process of spoilage and make the fish available in a variety of forms acceptable to the consumers. The biochemical changes taking place in the fish post-mortem is very complex. Several changes take place in the fish muscle constituents leading to changes in texture and flavor producing odoriferous compounds indicative of spoilage. The degree of spoilage is dependent on several factors, some of which are intrinsic, that is the sum of attributes inherent in the fish muscles. Besides, there are several factors having direct bearing on spoilage. A through understanding of these factors and their role in the mechanisms of spoilage of fish is essential to maintain spoilage under the control and to develop a processed product with maximum acceptability to the consumer.

Proximate composition of fish flesh

By proximate composition is meant that the composition of the major constituents. In fish the major constituents are water, protein, lipids and ash. In addition to these fish also contains minor constituents like non protein nitrogen compounds, vitamins and carbohydrates. The principal components are given bellow:

Water – The main constituent of fish flesh is water, which usually accounts for about 80 per cent of the weight of a fresh white fish fillet. Whereas the average water content of the flesh of fatty fish is about 70 per cent, individual specimens of certain species may at times be found with water content anywhere between the extremes of 30 and 90 per cent.

Protein – The amount of protein in fish muscle is usually somewhere between 15 and 20 per cent, but values lower than 15 per cent or as high as 28 per cent are occasionally met with in some species.

Fat – The lipid in the fish muscles show wide variation from as low as 0.2% to as high as 65% in some species. Fat in the form of triglycerides is the most concentrated energy source of the fish. The fish often classified as the leas, semi-fatty and fatty depending on the lipid contents in the muscles. How ever the contents of fats depend upon the season, sex, maturity of the fishes, and breeding of the fishes too. Taking all species into account, the fat content of fish can vary very much more widely than the water, protein or mineral content. Whilst the ratio of the highest to the lowest value of protein or water content encountered is

not more than three to one, the ratio between highest and lowest fat values is more than 300 to one.

Carbohydrates – The amount of carbohydrate in white fish muscle is generally too small to be of any significance in the diet; hence no values are given in the tables. In white fish the amount is usually less than 1 per cent, but in the dark muscle of some fatty species it may occasionally be up to 2 per cent. Some molluscs, however, contain up to 5 per cent of the carbohydrate glycogen.

Minerals and Vitamins – These include a range of substances widely different in character that must be present in the diet, even if only in minute quantities, not only to promote good health but also to maintain life itself. Although fish is very unlikely to be the only source of an essential mineral in the diet, fish does provide a well balanced supply of minerals in a readily usable form. The table of mineral constituents of fish muscle gives values averaged from a large number of species and is intended to serve only as a rough guide. It would be impracticable in this short note, and of limited value, to give a detailed analysis for individual species.

Composition tables for fish often include a value for total ash. Since ash consists largely of a number of different minerals, and the total rarely exceeds 1-2 per cent of the edible portion, this figure has also been omitted, except from the table of fish products.

Vitamins can be divided into two groups, those that are soluble in fat, such as vitamins A, D, E and K, and those that are soluble in water, such as vitamins B and C. All the vitamins necessary for good health in humans and domestic animals are present to some extent in fish, but the amounts vary widely from species to species, and throughout the year. The vitamin content of individual fish of the same species, and even of different parts of the same fish, can also vary considerably. Often the parts of a fish not normally eaten, such as the liver and the gut, contain much greater quantities of oil-soluble vitamins than the flesh; the livers of cod and halibut for example contain almost all of the vitamins A and D present in those species. In contrast, the same two vitamins in eels, for example, are present mainly in the flesh.

Water-soluble vitamins in fish, although present in the skin, the liver and gut, are more uniformly distributed, and the flesh usually contains more than half the total amount present in the fish. The roe, when present, is also a good source of these vitamins. In general the

vitamin content of white fish muscle is similar to that of lean meat and, with the exception of vitamin C, can usually make a significant contribution to the total vitamin intake of man and domestic animals. The mineral and vitamin content of fish is not markedly affected by careful processing or by preservation, provided storage is not very prolonged.

Extractives – These substances are so called because they can easily be extracted from fish flesh by water or water-based solutions. Unlike the proteins, substances in this group have comparatively small molecules; the most important extractives in fish include sugars, free amino acids, that are free in the sense that they are not bound in the protein structure, and nitrogenous bases, which are substances chemically related to ammonia. While many of these extractives contribute generally to the flavor of fish, some of them, known as volatiles, contribute directly to the flavors and odors characteristic of particular species; as the name suggests, volatiles are given off from the fish as vapors. Most of the extractives are present at very low concentrations but, because of their marked flavor or odor, are nonetheless important to the consumer. Detailed analyses of these substances have not been given because of the large variation existing both between and within species. An additional complication is the way in which the concentrations of these compounds change during storage and spoilage. When fish is stored after capture, the amount of some of the extractives present will change with time; thus measurement of the amount can often indicate the storage time and hence indirectly the quality. Extractive compounds whose concentration in fish varies directly with time of storage have long been studied since they may provide indicators of the quality of fish.

Factors affecting the composition of fish flesh

The composition of a particular species often appears to vary from one fishing ground to another, and from season to season, but the basic causes of change in composition are usually variation in the amount and quality of food that the fish eats and the amount of movement it makes.

Rigor Mortis and Fish Spoilage

What is Rigor Mortis?

Rigor mortis is one of the recognizable signs of death (Latin mors, mortis) that is caused by a chemical change in the muscles after death, causing the limbs of the "Cadaver" to become stiff (Latin rigor) and difficult to move or manipulate. A cadaver or corpse is a dead body.

Introduction

General composition of fish is given below though there are wide variations from species to species and from fish to fish;

Water:	65-80%
Protein:	12 - 22%
Lipids:	0.5 - 16%
Minerals:	0.1 - 3%

Fishes are perishable commodities. After the catch when fish dies the biochemical changes responsible for anabolism stop and as inevitable consequence only catabolism processes keep functioning. The digestive enzymes still being active, instead of acting on food eaten begin to digest fish tissue components itself. Due to this, fish tissue components e.g. lipids, carbohydrates and proteins breaks down (autolysis). In addition to this, the native bacteria present in the fish multiply rapidly and secrets various enzymes causing rapid breakdown of fish tissues. Lipid oxidation causes rancidity of fish flesh which produces foul smell. Autolysis also causes fading of fish pigments, development of off flavor and browning. The rapid colonization and multiplication of bacteria and several other autolytic changes eventually complete the total breakdown of fish muscle.

Changes in fish flesh biochemistry during post mortem

The demise of a fish begins a series of irreversible changes which lead to spoilage and loss of quality.

The natural process: Slime secretion-r-Rigor martis-r-Desolution of rigor-r Autolysis can be slowed down if correct handling and storage procedures are followed. On the death of the

fish, processes of physical and chemical change caused by enzymes and micro-organisms begin to occur. The complete decay of the fish is the final result of those changes.

Post-mortem changes which take place in fish tissue occur in the following phases: - slime secretion on the surface of fish

- rigor mortis
- autolysis as enzymatic decomposition of tissues
- microbiological spoilage

The duration of each phase can change or phases can overlap. This depends on storage conditions, especially the temperature which greatly influences these processes.

Slime Secretion

Slime is formed in certain cells of fish skin and the process becomes very active just after fish death. Some of the fish, for example eel, secrete more slime than, for comparison, Salmonidae and perch. Fish which secrete great quantities of slime have poorly developed scales; very often the quantity of slime reaches 2-3% of the fish mass and that in tum creates problems during •processing. The secretion process stops with the onset of rigor mortis. Slime contains large amounts of nitrogenous compounds and these provide good nourishment for micro-organisms originating from the environment. Therefore, the slime spoils quickly: first giving an unpleasant smell to the fish, and second opening the way for further and deeper bacterial penetration into the fish.

Pre-rigor condition

One of the important factors determining the spoilage in freshly caught fish is rigor mortis - the stiffening of the body. Usually this develops within 1 - 7 hrs. after death. As long as the fish is alive, it's circulatory system function even after capture. After death, respiration in organisms ceases to occur, depleting the corpse of oxygen used in the making of ATP. One of the consequences of the stoppage of the circulatory system is cessation of oxygen supply after death. But the oxygenated glycogen rich muscle can remain metabolically active for hours in pre-rigor condition. In the living tissues aerobic breakdown of the glucose is normal reaction that takes place in every molecule of glucose oxidized results in the synthesis of 36 molecules of ATP. However, after death, anaerobic breakdown of glucose

takes place. The synthesis of ATP stops and hydrolysis begins as per the reaction given below:

ATP → (ATPase) → ADP + Pi …… (1)

Rapid decrease in the ATP level and increase concentration of phosphoric acid is observed. Although certain amount of ATP is synthesized by the hydrolysis of creatine phosphate by the enzyme creatine kinase by the following reaction;

CrP + ADP → (Creatine Kinase) → Cr + ATP …… (2)

But the creatine reserves in the tissues are not infinite and soon get exhausted.

The small rate of ATP synthesis by reaction (ii) can no longer compete with the reaction (i) and ATP concentration begins to fall to near zero.

The concentration of lactic acid formed due breakdown of glucose is found to be dependent on the glycogen reserves of the muscle prior to death. The glycogen reserve of the muscle is directly related to the struggle the fish has undergone prior to capture and death. The greater the struggle the fish has experienced the lesser are its glycogen reserves and the onset of rigor mortis becomes rapid. Therefore, Rigor mortis proceeds very quickly in very active fish but rather slowly in inert fish. One consequence of the accumulation of lactic acid in the muscle is the lowering of pH from near neutrality (pH 7.0) to the lactic acid range (pH 6.0).

The decline of pH affects the quality of the fish tissues, in that flesh become firmer and tendency to drip enhances. During the initial stages of disappearance of ATP, some major protein changes take place. At this stage thick and thin filaments of myofibrillar proteins are free to slide past each other. This indicates that muscles are extensible and can contract on stimulation.

Rigor mortis condition

At the final phase of ATP breakdown myosin cross bridges interaction are established firmly between the thick and thin filaments thereby making it non-extensible and hence non-contractile. Finally, the breakdown of ATP becomes complete and the muscle is said to have entered the stage of rigor mortis. Muscle consists of several proteins actively involved in contraction. The two major proteins, actin and myosin, combine in the presence of calcium ions to form actomyosin. ATP then supplies the energy for contraction, and later

also the energy for the removal of the calcium ions via a calcium pump. This breaks the actomyosin complex, leaving the muscle ready for a further contraction.

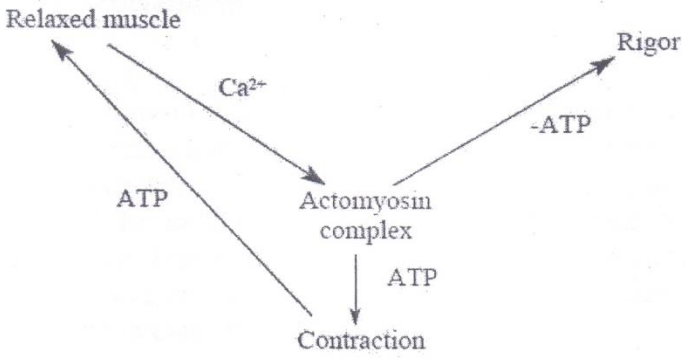


Fig 1. Muscle contraction Reaction

On death, the circulatory system stops and the A TP levels drop. Calcium ions leak forming actomyosin. However, there is insufficient ATP for the calcium pump to operate, and so the actomyosin complex remains unbroken. The muscle is now in a continual state of rigidness, known as rigor mortis. Fish is edible in this condition.

Rigor mortis has many technological consequences. If, for example, the bones were removed prior to rigor mortis the length of the fillet shortens by 30%. At the same time, the fillet becomes wider and thicker because its volume does not change. This tightness very often causes the connective tissue of individual myomeres to break; this process is termed "gaping" and results in muscle separation which is considered a quality defect. "Gaping" depends on temperature; the higher the temperature of fish at the beginning of the rigor mortis process the greater the gaping of the muscle. Therefore, during rigor mortis fish temperature should be as low as possible. For example, for roach and •perch kept at DoC, rigor mortis begins 24 hours after death and lasts for 72-80 hours. When the same species is kept at 35°C it begins 20-30 minutes after death and stops after about 3 hours. The time rigor mortis begins and its duration depend on the fish species (e.g., for carp at DoC it starts after 48 hours, for roach and perch at DoC after 24 hours), on the fish catching technique, and on fish temperature. It was also found that fast swimmers, for example trout, undergo rigor mortis faster but for a shorter duration than slow swimmers like carp. In those fish which are in good condition (well-nourished) rigor mortis is more intensive. Fish put to death just after removal from the water reach a state of rigor mortis later than those fish which died after a long agony. In the case of carp put to death just after capture rigor mortis

begins after 48 hours, but if the carp died after a long agony it sets in after 24 hours (at 00 C). Unnecessary and rough handling of the fish can shorten the time of occurrence and duration of rigor mortis. Such treatment causes stress in live fish.

Fish body temperature is a decisive factor in the onset and duration of the rigor mortis process. The higher the temperature the sooner it begins and the faster it ceases. This is evidenced by enzymatic reactions whose speed increases with increased temperature. At high temperatures it results in greater changes in proteins, the latter causing higher loss of tissue juices; e.g., during processing. Usually, the later rigor mortis begins and the longer it lasts, the longer are the storage life of the fish and its use for consumption.

Post-rigor condition

Fish spoilage begins due to two causes, autolysis (digestion of fish muscle and fat by tissue enzymes) and bacterial growth.

Autolysis:

The spoilage of fish can be defined as irreversible changes occurring in post-mortem fish muscle making it unacceptable consumers. Such changes are enhanced as a result of careless handling and faulty pre-processing or storage. Spoilage can be broadly classified into two types; bacterial spoilage and autolytic spoilage. Bacterial spoilage results from growth and multiplication of microorganisms at the expense of muscle constituents. Even though bacterial growth is the major cause of spoilage of fish, it can be effectively controlled by proper processing methods.

The rate and extent of autolytic spoilage in fish are considerably less than bacterial spoilage, but at first autolysis play an important role in flavor development and the onset of bacterial spoilage. Absolutely fresh and healthy fish is impermeable to bacteria due to the intact skin. Further, the absence of simple and easily available nutrients in absolutely fresh fish makes it difficult for bacteria to grow and multiply. However, after the death of the fish, autolysis sets in, making the fish skin permeable to bacteria and at the same time releasing simple sugars, free amino acids, free fatty acids, etc.. These nutrients provide a nutrient-rich medium for bacteria to grow and multiply..

In simple terms, autolysis is defined as the degradation of muscle and skin constituents by endogenous enzymes. Since the enzymes causing autolysis arise from within the fish

muscle, the prevention and control of autolysis is very difficult unless drastic treatments are used. However, a clear understanding of autolysis would be useful in devising suitable methods to effectively reduce spoilage, thereby preserving the delicate flavor.

Role of enzymes in autolysis

The nature of enzymes and their distribution

Live fish contain numerous enzyme systems required for the complex metabolic reactions taking place. These enzymes are distributed both in the intracellular and extracellular compartments throughout the fish muscle. Their individual concentrations vary with the nature and function of the tissue. In live fish all these enzyme systems are used metabolic processes. Consequently, most of the enzymes occur as some sort of inactive precursors as in phosphorylase b, chymotrypsinogen, etc., whose conversion to active forms require the presence of certain cofactors, while in certain other cases the enzymes are kept isolated from their substrates, as in the case of a group of hydrolases kept inside lysosomes.

Once the fish is dead, the ability of its body to regulate the enzymes is lost .The absence of blood circulation, depletion of oxygen, depletion of energy sources such as CTP (creatine triphosphate) and ATP (adenosine triphosphate), and the breakdown of the body's scavenging mechanism bring an end to all anabolic or biosynthetic processes. In effect, in post-mortem fish muscle, only the catabolic and degrading reactions are active. These changes lead to the accumulation of catabolic products.

Glycolysis and decrease in pH precedes autolysis

The major catabolic reactions occurring in post-mortem fish muscle relate to three groups of compounds, viz. carbohydrate, fat and protein. Even though the amount of carbohydrate in fish muscle is very low compared to protein and fat, its metabolism in live and post-mortem fish muscle is of paramount importance in deciding the extent of rigor mortis and subsequent autolytic spoilage in fish. Most fish are caught after vigorous struggles. During this period the fish utilizes almost all its blood glucose and a substantial quantity of tissue and liver glycogen for deriving energy through the glycolytic pathway. Phosphorylase, the prime enzyme responsible for initiating glycogenolysis, is distributed widely in almost all tissues in substantial quantities. The almost neutral pH optimum and the high activity of phosphorylase at ambient as well as near subzero temperatures considerably augment glycogenolysis/ glycolysis in fish muscle leading to accumulation of lactic acid which will

be reconverted to glycogen if the fish is allowed to rest. However, this does not occur in a fish catch, as the fish struggle until they are dead. The fish are then usually frozen or chilled and stored pending utilization.

As a result of the glycolysis, a considerable amount of lactic acid accumulates in fish muscle. Lactic acid is neither neutralized nor removed from the site of formation resulting reduction of the tissue pH.

Contribution of lipolysis to muscle pH

Another set of enzymes that are active during struggling as well as post-mortem are lipases. These enzymes are widely distributed in almost all fishes, especially the fatty fishes and the ones with red meat. Most lipases from fish and shell fish pancreas and muscle showed lipolysis in the pH range 6-10 and at all temperatures from -20 to 40°C.

The properties of lipases, as well as their environment in fish free of inhibitors are extremely favorable for lipid breakdown in fish muscle at ambient as well as low temperatures. The primary products of lipolysis are free fatty acids and glycerol. In dead fish products of lipolysis also accumulate at the site of formation. Of these products, free fatty acids, although weak, will make a significant contribution towards increasing the hydrogen ion concentration or lowering the pH of the tissue.

The fatty acids of carbon chain (lower free fatty acids) formed as a result of lipolysis will also impart off flavor to fish muscle and is known as hydrolytic rancidity. The higher carbon chain unsaturated fatty acids released will easily become vulnerable to oxidation by atmospheric oxygen, resulting in oxidative rancidity. During oxidation of fat peroxide is formed. Therefore, peroxide value gives a measure of oxidative rancidity.

Acidic pH activates many autolytic enzymes

The cell cytoplasm of fish muscle contains small circular organelles called lysosomes. Lysosomes contain number of hydrolytic enzyme systems capable of degrading almost all of the tissue components such as carbohydrate, fat, protein, nucleic acids, etc. The normal function of lysosomal enzymes in live fish or any other living organism is to digest dead cells, as in pinocytosis/phagocytosis, for further processes of synthesis or oxidation for energy generation. This function has led to lysosomes also being called “suicide bags”, as the breakage of lysosomal membrane will result in self-digestion.

Fish-muscle lysosomes are rich in proteolytic enzymes, especially the cathepsins and proteases.

Most cathepsins and other proteolytic enzymes are highly active at acidic pH. They are also achieving at a wide range of temperatures from -10 to 60°C. Thus, of the lysosomal enzymes released into fish muscle, have the most favorable conditions for vigorous activity in post-mortem fish muscle and bring about partial break down.

Role of gut enzymes

Another group of enzymes actively engaged in autolysis of whole fish is the digestive enzymes of the gut. Fish gut contains a wide spectrum of enzymes capable of hydrolyzing protein, fat and carbohydrate. The major enzymes of fish gut are proteases, including pepsin, trypsin and chymotrypsin, followed by lipases and carbohydrases.

Even though proteases are the major enzymes present in viscera, their optimum pH is in most cases around 3; a condition seldom found in fresh fish. However, the neutral pH of fresh fish very much favors carbohydrase and lipase activity, producing acidic pH favorable for protease activity. The enzymes hydrolyse and perforate the stomach and intestinal walls and leak into the surrounding tissue, causing general hydrolysis. This is the mechanism of belly bursting seen in fatty fish's capelin and oil-sardine resulting in belly bursting. This is a clear index of spoilage

However, the potent autolytic enzymes of the gut are effectively contained by the stomach and intestinal walls for about 4-7 days in fish stored at 0°C- 4°C. Moreover, for processing storage gut enzymes can be effectively removed by evisceration.

The autolytic changes described above relate to the spoilage of fish muscle. There are also some autolytic changes which are considered beneficial for fish as food material. An important group of enzymes responsible for such beneficial changes in post-mortem fish are the nucleodepolymerases. They are enzymes responsible for hydrolyzing nucleic acids to mononucleotides. Two important enzymes of this category are acid ribonuclease and acid deoxyribonuclease. As the name suggests, these enzymes are also active in acidic pH and are of lysosomal origin. The nucleotides produced as a result of the activity of these enzymes greatly enhance the flavor of fish and meat in general. Disodium salts of inosine 5' –monophosphate and guanosine 5'-monophosphate are the most important flavor-

generating nucleotides produced by these enzymes. Inosine monophosphate is also formed in small amounts by the degradation of ATP.

Thus, as a result of lowering of pH glycolysis and lipolysis, cathepsins and other proteolytic enzymes are activated and released into the tissue. These enzymes start degrading the tissue proteins tenderizing the muscle (6-10 h after death). Up to this stage the fish will be in prime condition for cooking and consumption. As time passes, the autolytic process proceeds further and results in gradual loss of texture, taste and flavor due to the formation of polypeptides, peptides, free amino acids, free fatty acids, hypoxanthine, etc. All these are spoilage indices which are chemical in nature. Due to these changes, the fish skin will become easily permeable to bacteria. Bacteria also enter through the gills. The products of autolysis provide a nutrient-rich medium for bacteria to grow and multiply. Once bacterial access to tissue is established, spoilage becomes rapid, resulting in total breakdown of fish tissue producing a multitude of metabolites, including the foul-smelling amines, characteristic of spoiled fish.

Protein Denaturation

Denaturation of protein involves the destruction of its secondary, tertiary and quaternary structure, reducing the protein to a simple polypeptide chain. A number of factors, including slow freezing and variability of storage conditions, cause this denaturation. A denatured protein has not only lost its ability to function as an enzyme, but also its "water-holding" ability. This results in denatured fish flesh dripping excessively when thawed (a situation known as "drip-thaw"), and appearing white, dull and spongy, and upon chewing becoming fibrous and tasteless.

Decreasing flesh pH

A living fish has a flesh pH of 7.0. However, after death residual glycogen is broken down via glycolysis to pyruvic acid and then lactic acid. Phosphoric acid is produced due to breakdown of ATP. As this happens, the flesh becomes more acidic. If the pH remains above 6.6, the texture is reasonably soft, but below this level the flesh becomes firm and eventually unacceptably tough.

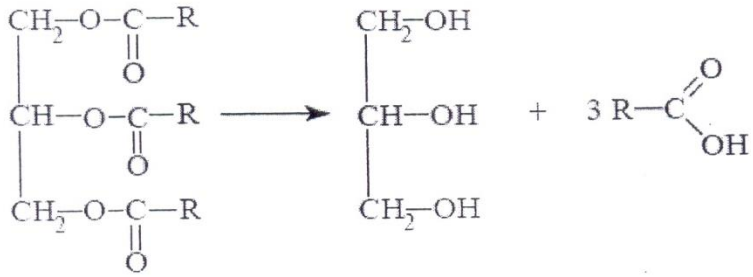
TVB-Total Volatile Base

TVB is a measure of the total amount of a variety of nitrogen-containing substances which are produced during storage. An example of a volatile base present in the flesh is a trimethylamine (TMA), which is formed from the reduction of trimethylamine oxide. Marine fish contain a small amount of trimethylamine oxide, the function of which is unknown. This odorless and tasteless compound is reduced by invading bacteria to TMA, which is characterized by its "fishy" smell. TMA, though, only becomes useful as a quality index, during the middle and late stages of spoilage after the bacteria have invaded the fish. Trimethylamine oxide is converted in the muscle tissue into dimethyl amine (DMA) and formaldehyde by enzyme action during frozen storage. This formaldehyde is able to crosslink with protein, denaturing the muscle structure. The fish loses water when it is thawed, and when cooked has a tough and fibrous texture.

Lipid Oxidation and Hydrolysis

The two major deteriorative changes which occur in fish are:

(i) The enzymatic hydrolysis of lipids (fats) to produce free fatty acids and glycerol:



(ii) The oxidation of fish oils yielding the rancid odours and tastes which are the major problems encountered in fish storage.

Measures to reduce fish spoilage during storage

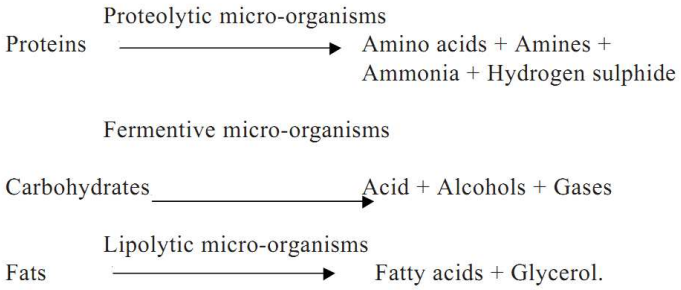
Fish should be consumed fresh or should be properly preserved so that its palatability and nutritive value are not seriously impaired. A substantial percentage (25-30%) of the catches landed at present in India reaches the consumer in sub-standard condition due to unsatisfactory methods employed in catching fish, their preservation and transport, and

inadequate and insufficient marketing facilities. After bringing to the factory, the fish are washed with flowing water to remove the heavily contaminated slime.

Shrimp contains greater amount of free amino acids than fish and also highly active proteolytic enzymes. Shrimps are highly susceptible to melanosis, a characteristic black spot development caused by an enzymatic reaction. They are highly perishable, and require adequate refrigeration and expeditious handling to prevent decomposition.

Fish often get contaminated through wooden-boxes, ice, and dressing-tables etc., which usually carry heavy bacterial load. Proper treatment of surfaces, equipment etc., with disinfectants and detergents, and use of potable water for washing and ice-making are necessary to reduce bacterial contamination. The initial bacterial load and the nature of contaminants play a vital role in the deterioration of fish in the later stages. These bacteria are thermophilic in nature and grow faster with the rise in temperature, thereby produce unpleasant end-products. Therefore, the practical way to preserve fish in good condition is to store fish at low temperature.

Microbial action – Microbial action involves bacterial decomposition of the fish flesh. The bacteria are found in the lower part of the gastrointestinal tract and on the general body surface of the fish. They may also be contributed from the surrounding in sanitary a most suitable place for their growth and multiplication. Proteins, constituting 70 - 90 % are degraded by proteolytic organisms such as *Pseudomonas*, *Proteus*, *Chromobacterium*, *Halobacterium*, and *Micrococcus*, etc. The Carbohydrates, present in small amount in the fish flesh are spoiled by carbohydrate fermenting organisms like *Streptococcus*, *Leuconostoc*, *Micrococcus*, etc. Fats constituting 3 - 5 % of the flesh are digested by relatively few gram-negative bacteria.



Micro flora in fishes

Every fish has a native flora of microorganisms. The nature of this native microflora largely depends on the habitat of fish. Based on salinity the habitat of fish can be classified into three categories. They are the Marine, brackish and fresh water habitats. The natures

of micro-organisms in these habitats are found to vary. About 80% of the bacteria in marine waters are gram –ve. They are highly salt tolerant and in fact they require 2-3% salt in the medium for normal growth. Even though marine microbes are potent spoilers, they are not pathogens.

The microbes of fresh water are mostly a mixture of gram +ve and gram –ve organisms. They are less tolerant to salt; rather, they are killed or inhibited by salt concentrations above 0.5%. The fresh water microbes are also found to be a mixture of spoilage organisms and human pathogens. The presence of human pathogens can be traced back to the close association of human life and fresh water availability.

The brackish water is actually a mixing area of fresh water and marine water. Consequently it will have salinity and microbial characteristics in between that of fresh water and marine water. Thus the brackish water will have a salt content of 0.5 to 2% with a microbial flora with and without salt tolerance, characterized by the presence of gram +ve and –ve species. However due to the salinity the existence of human pathogens are rare in brackish water.

The bacteria in these waters are free swimming and they occur in association with plankton. As fish move in such waters, they exchange the water through gills, and consume plankton. As a result of this the skin, the gills and gut of the fish get a compliment of the microorganisms present in the water. Even though the brackish water and fresh water micro flora vary widely due to several types of contamination, the micro flora of marine water show a stable pattern, with reference to various species.

As long as fish is live whatever be the type of bacteria they cannot attack the fish muscle, due to the immune systems and the intact membranes. Consequently the muscle of live fish is sterile. On death the immune system fails and the membranes break down due to autolysis exposing the sterile fish muscle to bacterial invasion. Post mortem changes, particularly autolysis brings about a partial breakdown of the macro-molecules, converting fish muscle into a fertile medium for bacteria to thrive. Marine fish with a high content of non protein nitrogen (NPN) will be a better nutrient medium for bacteria and hence is more susceptible to bacterial spoilage than fresh water fish with a lesser NPN (non protein nitrogen) content.

The growth and multiplication of microbes will bring about an all-round hydrolysis of various biological molecules in fish muscle. Of the different molecules affected, the

changes in proteins are of paramount importance as they form the basis of fish spoilage. The products of bacterial spoilage on carbohydrates and lipids, though give some spoilage indices their contribution to changes in organoleptic properties is insignificant.

On bacterial spoilage, the proteins will be broken down to polypeptide, peptide and to amino acids by bacterial proteases and peptidases. The amino acids are further metabolized by bacteria in different routes depending on certain conditions. The final effect of these metabolic reactions is either a decarboxylation to give a corresponding amino compound or deamination to give an acid. The major metabolic reactions thus occurring as a result of microbial activity are:

1. Reductive deamination of amino acids: In this, a molecule of amino acid is reduced to produce ammonia and an acid. In other words during reductive deamination amino group of an amino acid combine with hydrogen to form free ammonia and an organic acid.
2. Oxidative deamination of amino acids: In presence of oxygen some bacteria can bring about removal of amino group of an amino acid to produce ammonia and a keto acid. Such reactions are called oxidative deamination.
3. Oxidative decarboxylation of amino acids. In this the bacteria brings about oxidation of amino acids to produce carbon dioxide and an amino compound.

The effect of bacterial growth and multiplication on nucleoproteins and sub units also cause damage to the quality of fish. Bacterial decomposition of nucleoproteins, produce xanthine and hypoxanthine along with a host of other compounds. These two compounds add an unpleasant bitter taste to fish. In extreme condition these compounds also break down further to give ammonia. All these are clear chemical indices of spoilage.

Bacteria are also known to decompose the non-protein nitrogen fraction of fish. The most important compounds of this category are trimethyl amine oxide (TMAO) in marine fish and urea in elasmobranches. Marine bacteria elaborate the enzyme called TMAO reductase, which decompose TMAO to trimethyl amine. Trimethyl amine is responsible for the typical spoilage smell of marine fish while TMAO gives the typical sea weedy smell of fresh marine fish. These are also clear indices of spoilage of fish. Similarly, bacteria decompose the urea in elasmobranches to produce carbon dioxide and two molecules of ammonia.

The growth and activity of microbes in fish also bring about changes in lipid and carbohydrate components of fish. But in most cases these changes are marginal and insignificant compared to the changes in protein. The contribution of these products to spoilage and spoilage indices is insignificant compared to the products of protein decomposition by bacteria.

Thus as a result of bacterial spoilage a variety of bases like ammonia, mono amines, diamines (putrecene, cadaverine, histamine) tertiary amine (TMA), etc. are produced which the bacteria is unable to decompose further. With extent of spoilage these compounds accumulate in fish tissue. All these compounds are basic and together they will increase the pH of fish muscle to neutral or above neutral (pH≥7). The moment pH goes above 7 these amines will be slowly released from muscle as volatile bases. Most of these amines as well as the sulphur containing compounds are toxic and foul smelling and so impart stale or putrid odour to the spoiled fish. Most of the bases produced being volatile in nature, a measure of total volatile bases is found to increase with spoilage. This is the basis of using total volatile basic nitrogen (TVBN) as a spoilage index.

A careful analysis of the concentration of certain products of autolysis and bacterial spoilage with extend of spoilage is shown to provide a direct relationship between spoilage and their concentration. A measure of such products of spoilage will give a clear objective idea about the extent of spoilage. Since these products are chemical compounds they are called chemical indices of spoilage. The most important chemical indices of spoilage are:

1. pH. As a result of increasing spoilage the amounts of basic substances produced in the fish tissue increase steadily producing an increase in pH from acidic side to neutral and to alkaline pH. Thus an alkaline pH (>7) for fish muscle is a sure indication of spoilage.
2. The content of total volatile bases or content of ammonia (TVBN) in fresh water fish/content of TMA in marine fish also increases with spoilage. For fresh water fish the total volatile base nitrogen (TVBN) content will be <20-25mg per 100g. fish. On the other hand total volatile base nitrogen content of fresh marine fish will be <30 to 35mg per 100gm muscle. TVBN values above these tolerance limits are an indication of spoilage.
3. The nucleotide degradation product hypoxanthine is also found to increase with spoilage. Consequently a measure of hypoxanthine will give an index of spoilage and in

fresh fish hypoxanthine content is found to be less than 25 micro grams per 100gm. fish muscle.

4. Free ammonia and hydrogen sulphide are also found to emanate from spoiled fish. The presence of ammonia can be detected by white fumes when exposed to hydrogen chloride gas. Similarly the emanation of hydrogen sulphide gas can be detected by blackening of a piece of lead acetate paper exposed to the vicinity of fish.

Organoleptic Qualities

You must realize that apart from health hazards there are certain properties of the food, which are disliked by the consumer. Some of these characteristics can be evaluated by human sense organs, for raw as well as ready to eat products. They are generally referred to as organoleptic quality characteristics. Color, odor, appearance, texture and taste are the most common organoleptic characteristics. By experience and training one can easily evaluate qualitatively as well as quantitatively (score) any change in color, appearance, texture, odor and taste. As fresh raw and freshly cooked food items have typically characteristic organoleptic properties, any significant variation can be evaluated and the reason for change namely the extent of spoilage or decomposition can be quantified to decide on the suitability for human consumption. Organoleptic evaluation is widely used for deciding the quality of fish and shellfish. The organoleptic changes due to spoilage will also show certain chemical changes in the form of increasing levels of total volatile nitrogen (TVN) in meat of the fish, Trimethyl Amine Nitrogen (TMA-N) in marine fish, indole in protein rich foods, rancidity in fatty foods etc. Their presence above a certain level is found to reduce consumer acceptance and hence these indicators are called chemical quality parameters or quality defects.

Apart from the above chemical effects, growth and multiplication of bacteria also bring about certain changes which are perceptible by human sense organs. These changes can also be evaluated to determine the extent of spoilage. Such physical changes are called organoleptic indices. The important organoleptic indices of spoilage are:

4. **Texture:** In case, of fresh fish the texture of fish meat on pressing with finger will be firm and elastic. In other words the distortion created by finger pressing will be removed immediately and the pressed surface will regain original shape. On spoilage,

with extend of spoilage the texture will gradually change to soft and flabby with retention of finger impression or distortion of finger pressing.

5. **Eyes:** In case of fresh fish the eye balls will be protruding and the eye lens will be transparent and pupil jet black. On spoilage the eye balls will sink (Sunken eyes), the eye lens will become opaque and cloudy.
6. **Gills:** The gills of fresh fish will be bright red and free from mucus deposit. With spoilage the bright red color turns brown and then gets bleached. The gills also get covered with thick mucus. This mucus covering also changes its thin transparent nature to thick and yellow in color on spoilage.
7. **The appearance of anal opening:** The anal opening of fresh fish will be normal and constricted. On spoilage it will become red and swollen.
8. **Fish surface:** The color and surface of fish body also undergo changes with spoilage. In fresh fish the body surface will show a characteristic color with metallic sheen. The surface also will be covered with a thin and transparent layer of slime. On spoilage the characteristic color and metallic sheen will be lost and the surface will get covered with thick cloudy or yellow slime.
9. **Cross section:** A critical observation of the cross section of the fish is also found to give a clear indication about the extent of spoilage. In case of fresh fish the tissue around back bone at the cross section of fish will be bluish and transparent without reddish brown color. On spoilage the muscle will turn waxy and opaque with or without reddish brown discoloration.

The tolerance for organoleptic criteria (as applied to fish and shellfish) are shown in following table –

	Excellent	Very good to Good	Satisfactory to Poor
Appearance of Eyes	Convex, Jet black pupil, Translucent cornea.	Flat, Grey pupil, slight opalescent cornea and lens.	Sunken eyes, Milky white pupil, Opaque cornea and lens.
Gills	Bright red and without slime.	Darkening of gills with mucus smear	Gills dark brown or bleached with thick slime.
Skin/scale	Characteristic shining and thin transparent slime.	Outer slime, Viscous and milky. Bleaching / dull color of skin	Viscous and opaque outer slime. Bleaching of the characteristic color, loose scales.
Cross section around back bone	Bluish translucent flesh. No reddening around backbone.	Muscle with waxy appearance. No reddening around backbone.	Opaque muscle. Light reddening around backbone.
Belly Flap	No discoloration of belly flap	Some discoloration along belly flaps	Yellowing of belly flaps* (* In case there is clear discoloration around back bone with severe discoloration and breakage of belly flaps, the sample shall be summarily rejected)
Odor (*Bring the fish close to the nose and try to get exact odor)*	Fresh sea weedy odor	Neutral odor like bready, malty, yeasty smell. (Slight fermented smell)	Smell of hydrogen sulphide / indole / skatole etc. (foul smell)
Finger impressing	Firm and elastic. Scales tight. No retention of finger press impression.	Light softening but firm scales, Takes long time to regain shape after finger pressing	Soft and flabby muscle and loose scales. Finger impression permanent.
Flavor	Characteristic fresh flavor, juiciness and sweetness	Faintly sweet and neutral taste, but juicy	Some off flavor. Reduction in juiciness and slight bitterness.
Texture on cooking and chewing	Firm and thick with no discoloration	Firm but woolly with slight yellowing	Cheese / Soapy texture with yellow / brown discoloration.

Preservation of Fish – Fish Drying

Drying of fish is one of the oldest known methods of fish preservation of food. Though the technology of preservation and processing has undergone revolutionary changes over the years and several new methods have employed in the market, drying still continues to be the most widely used method for preservation of fish. It is also considered as the least expensive method of fish preservation.

Principles

Drying involves the removal of water contents from the fish body which can check the growth of microbes as the water us essential components for cellular activities. Water is essential for the activity of all living organisms including microbes. Reduction of water contents or its complete removal will proportionately retard or totally stop the microbial activity and are resulting the preservation.

Dried fish products have following advantages –

- dried products are highly concentrated foods compared to any other preserved forms
- drying can perfectly stops the activity of microbes
- in dry condition enzymic and many chemical process are retarded
- the process of preservation is cheap, the products are less expensive in markets
- the products are stable in most ambient temperatures

Traditional drying process – sun drying

Traditionally the fish is dried under the sun. Sun drying is carried out in open air using the solar energy to evaporate the water in the food. The evaporated water is carried away by the natural air currents. Main disadvantages of the process are:

- The process is entirely dependent on the environment and the operation is only carried in the dry season with bright sunlight.
- Duration of drying is also long and the process in unhygienic due to the infestations.
- Possibilities of the contamination with dust and sands.
- No possible controls to the parameters
- Poor quality of the products
- Short shelf life

Process of Drying – Preprocess Operations

Before drying the fishes are often subjected to different preprocessed operations. These are mainly dependent on the size and nature of the fish.

a) Cutting/Splitting

Conventionally small fishes are dried whole without cutting and salting. Some small fishes are salted before drying. However, the large sized fishes are gutted and cleaned before the salting followed by drying, which improve the quality of the dried products. Cutting will increase the area of exposed flesh for greater contact of the salts and best drying.

b) Salting

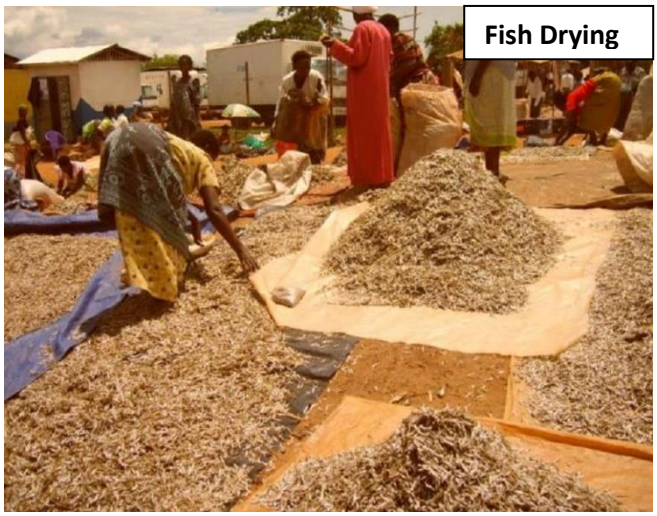
Fish may be dried by using of salts. Salts remove the water, kill the microbes and in fatty fish, reduce the chances of rancidity.

Drying in Nature

Solar and wind power are made use of in natural drying process. Some essential requirements of the production of high quality dried fishes are –

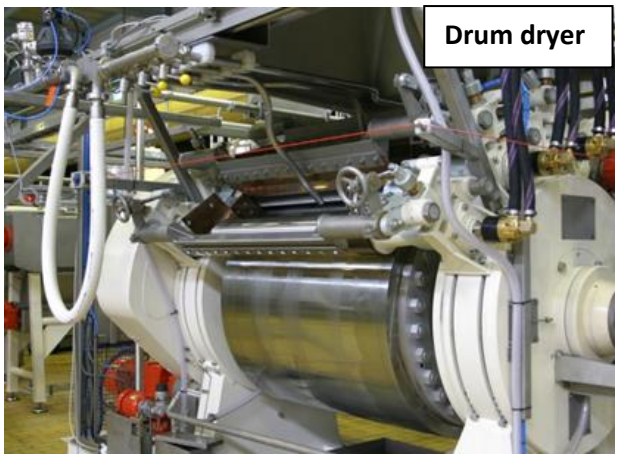
1. Sufficient high air temperature. Temperature in the range 35-40°C will be ideal. In many tropical countries, temperature often becomes higher.
2. Sufficient low humidity which permit the perfect drying of fish. Humidity above 70-75% is not desired for fish drying.
3. Use of raised platforms is essential. Air movement at ground level is sow. Better air movement can ensured if the fish is kept raised by about one meter above the ground.
4. Use of drying racks is necessary. Keeping the fish on racks kept them above the ground level, which will facilitate the movement of air both under and over the fish, thus allowing drying from both upper and lower surfaces. Contamination of fish with dust or sand also will be minimized. Racks with sloping tops will allow easy drainage of any surplus water on the fish surface in the beginning.

Solar Drying


Fish Drying

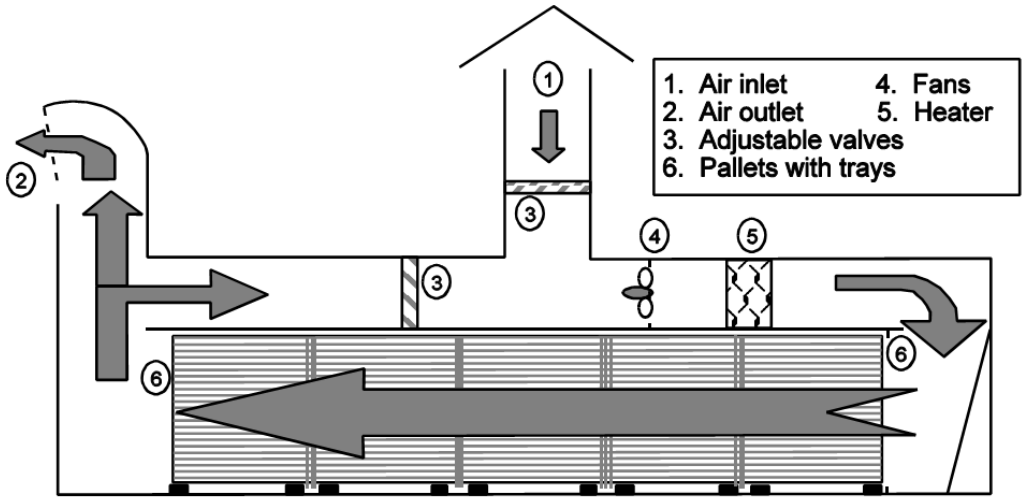
Solar tent drier – One of the simplest forms of driers to use the solar energy for drying of fish is the solar tent drier. This is working on the principle that black surface absorbs sun's energy far more effectively than lighter surface. The air thus heated is allowed to pass through the fish and escape out through a vent in the top simultaneously admitting fresh air inside through a vent provided at the bottom of the tent. In solar tent, the temperature is know to rise 60 degree Celsius or more in tropical climate with no energy cost, very low equipment cost, shorter drying periods, no contamination of dusts, insects and produces hygienic product with low moisture.

Mechanical Drying of Fish

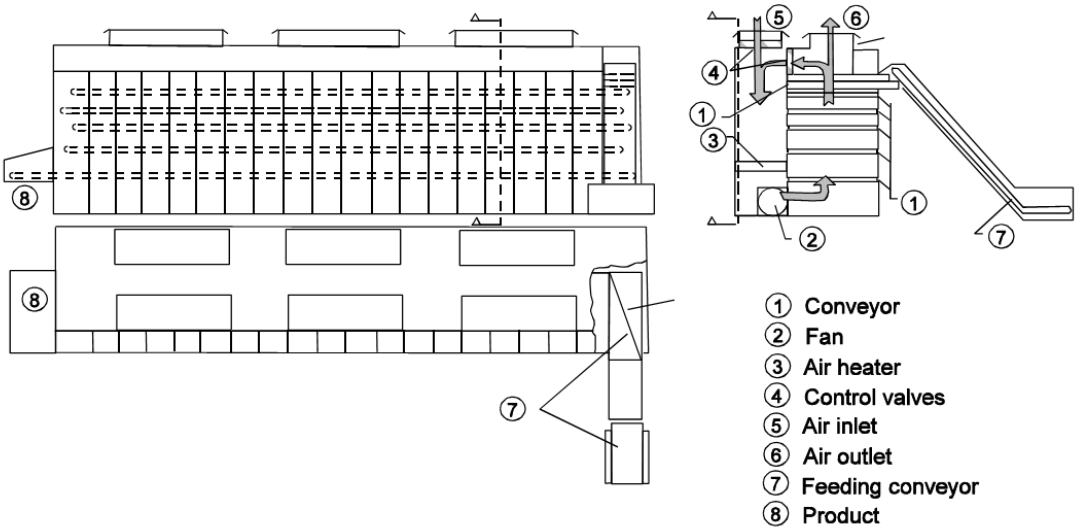

Drum dryer

Mechanical dryers can be broadly classified into two types. In one type, the heat is transferred into the product through a hot gas, usually air. A heat / water vapor exchange takes place at the contact point of hot air with product and outgoing air will carry the water vapor away. Kiln drier, tunnel drier etc. are the example of such class of driers.

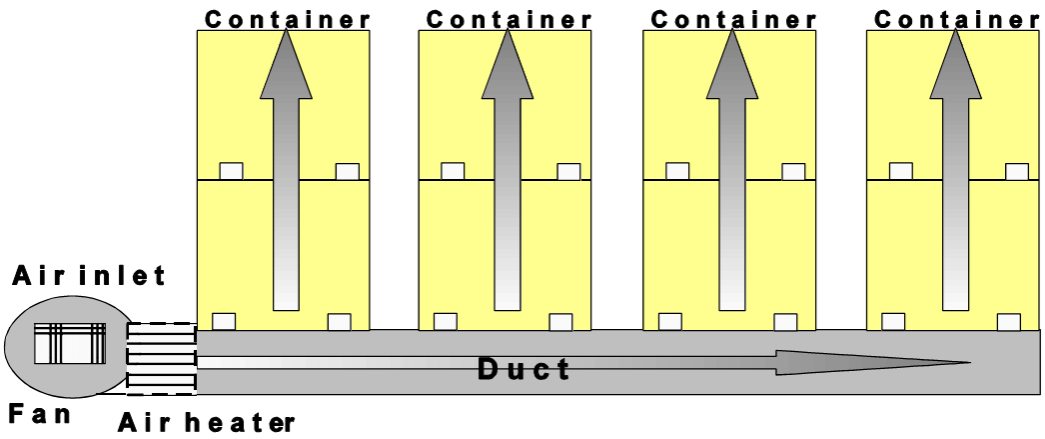
In second type of drying, heat is transferred to the product through solid surfaces which may also be used as the carrier of the products to be carried. A typical case is a vacuum shelf drier where the hollow shelves serve both as heat transfer medium and also hold the material to be dried. The whole drying cabinet is evacuated and the water vapor produced is removed using vacuum pump. Drum drier, vacuum shelf drier are the examples of such type of drier.



Rack drying cabinet



Continuous conveyor dryer for primary drying



Secondary air drying unit

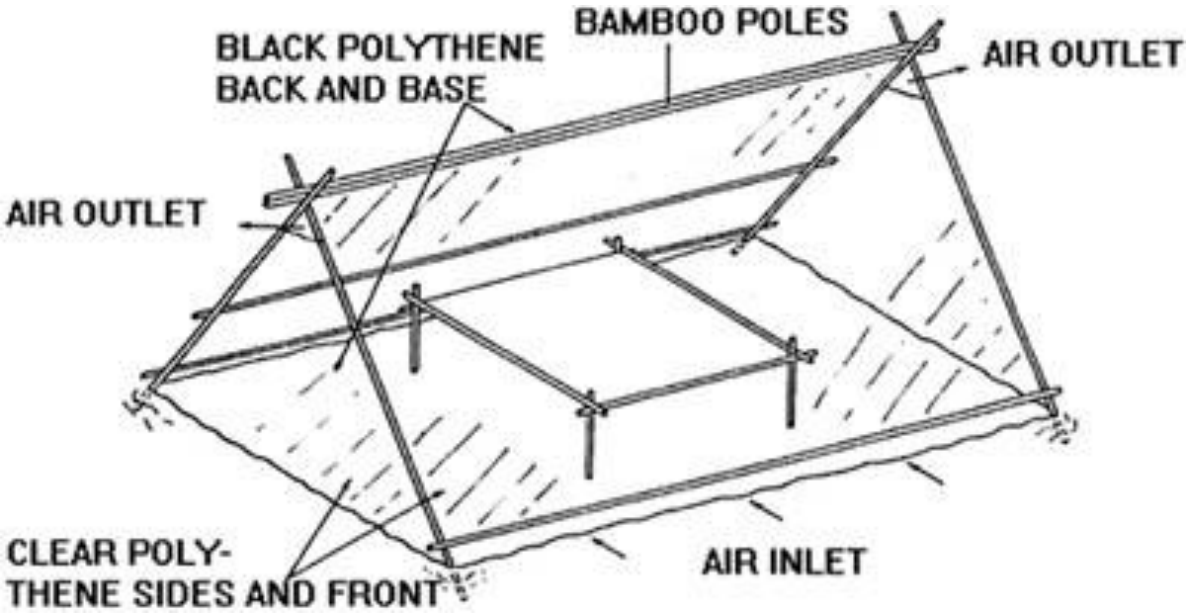
Effects of Drying

1. **Shrinkage –** the major problem which can result the structural changes of fish muscles during drying.
2. **Case hardening –** Water contains dissolve salts, proteins and other organic compounds. Water moving to the surface of the fishes carries all these to the surface, while that leaving the fish surface is only pure water depositing the dissolve substances on the surface and form a dry impervious layer on the surface preventing further diffusion of water. The final product becomes brittle.
3. **Denaturation of protein and toughening of texture –** As the drying progress, the concentration of the dissolved materials in the body increases. Reduce due to case hardening will result in increase of temperature of fish muscles. These bring about the denaturation of protein and texture becomes tough besides loss of juiciness of the meat.
4. **Rehydration** – Air dried fish is hard in texture. The proteins are denatured and the water holding capacities of the proteins become irreversibly lost. Therefore, penetration of water will be greatly retarded resulting in poor rehydration.
5. **Effects on Color/ Flavor –** pigments, fats etc. are susceptible to the oxidation. Prolonged drying of fish exposed to hot air can accelerate this process. Therefore dried fish often suffer from discoloration and rancid odor and flavor.
6. **Spoilage during drying –** Dried or drying fish are susceptible for many types of spoilage which reduces the quality of the products.
7. Molds – this can grow on salted or unsalted dry fishes if the moisture content is high and the humidity is above 75% in storage and leads to many types of spoilage.
8. **Insect infestation –** this is the common problem and the products are often infested with blowflies and others. Adult flies are attracted to the wet fish and their larvae fed on it. Small fish may dry quickly hence the larvae may perish, before damaging the fish. In larger fish damages will be more.

Flow Sheet of Drying of Fish

Fish

Small Fish	Medium sized fishes/ Large Fishes
↓	↓
Washing in ice water	Dressing, Gutting, splitting
↓	↓
Brining (Saturated brine, for 10-15mts)	Mixed with salt (1:4)
↓	↓
Draining for 5 minutes	Putting in salting tank layer-wise
↓	↓
Drying using sunlight and artificial method	Washing in water - desalting
↓	↓
Packing	Dipping in brine, contain calcium propionate & BHA
↓	↓
Storing	Draining – 5 mts
	↓
	Drying in sunlight/mechanical
	↓
	Packing in polythene bag
	↓
	Storing

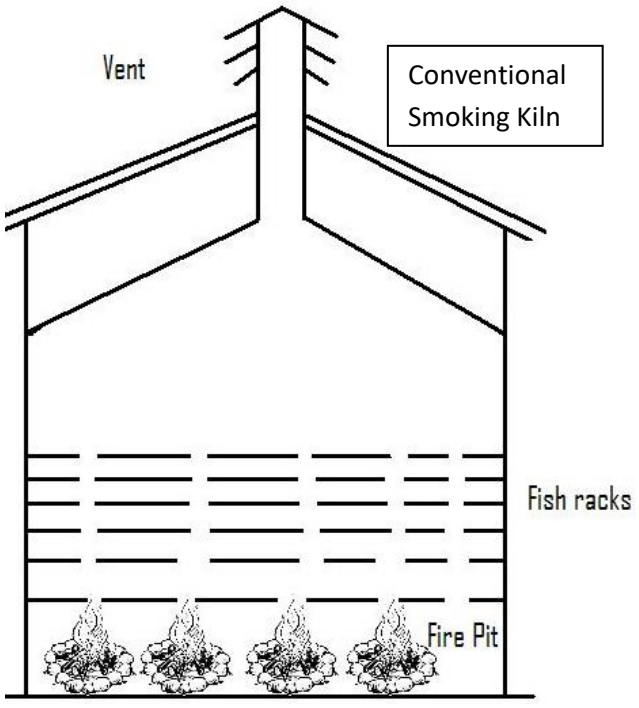


A solar tent drier

Fish Preservation – Smoking of Fish

Preservation of fish by smoking is also an age-old practice throughout the world. Preservation in smoke is due to the combined action of salting, drying and deposition of natural chemicals produced during the thermal breakdown of wood. The smoke has antibacterial properties due to presence of chemicals such as formaldehyde, phenols, organic acids and other organic compounds that make the tarry constituents of the smoke. In hot smoking number of microorganisms is reduced due to the high temperature effects.

Hardwoods are made up mostly of three materials: cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are the basic structural material of the wood cells; lignin acts as a kind of cell-bonding glue. Some softwood, especially pines and firs, hold significant quantities of resin, which produces harsh-tasting soot when burned; these woods are not often used for smoking. Cellulose and hemicellulose are aggregate sugar molecules; when burnt, they effectively caramelize, producing carbonyls, which provide most of the color components and sweet, flowery, and fruity aromas. Lignin, a highly complex arrangement of interlocked phenolic molecules, also produces a number of distinctive aromatic elements when burnt, including smoky, spicy, and pungent compounds such as guaiacol, phenol, and syringol, and sweeter scents such as the vanilla-scented vanillin and clove-like isoeugenol. Guaiacol is the phenolic compound most responsible for the "Smokey" taste, while syringol is the primary contributor to Smokey aroma.



A number of wood smoke compounds act as preservatives. Phenol and other phenolic compounds in wood smoke are both antioxidants, which slow rancidification of animal fats, and antimicrobials, which slow bacterial growth. Other antimicrobials in wood smoke include formaldehyde, acetic acid, and other organic acids, which give wood smoke a low pH—about 2.5. Some of these compounds are toxic to people as well, and may have health effects in the quantities found in cooking applications. See Health Effects.

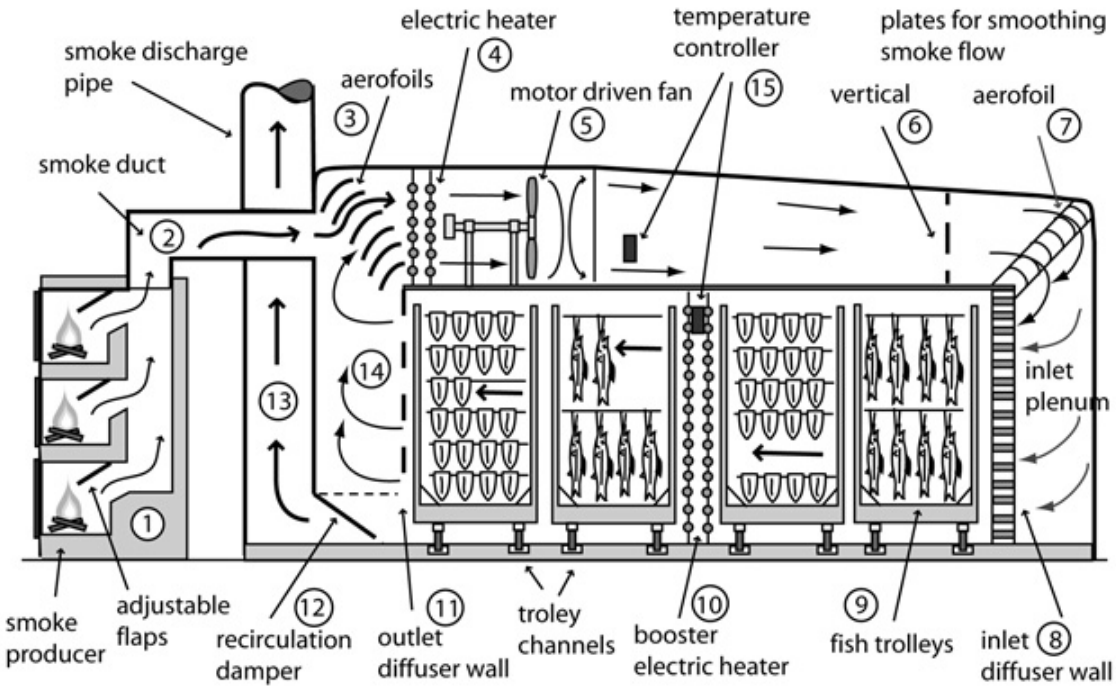
Since different species of trees have different ratios of components, various types of wood do impart a different flavor to food. Another important factor is the temperature at which the wood burns. High-temperature fires see the flavor molecules broken down further into unpleasant or flavorless compounds. The optimal conditions for smoke flavor are low, smoldering temperatures between 570 and 750 °F (299 and 399 °C). This is the temperature of the burning wood itself, not of the smoking environment, which uses much lower temperatures. Woods that are high in lignin content tend to burn hot; to keep them smoldering requires restricted oxygen supplies or a high moisture content. When smoking using wood chips or chunks, the combustion temperature is often raised by soaking the pieces in water before placing them on a fire.

Preparation of Fish for Smoking

Pre-smoking operation

a) Different species of fish need different preparation techniques. Generally large fishes are gutted and in some cases the backbones are removed. The fishes are cut into small pieces which can increase the surface area for smoking. Small fishes must be headed and gutted before brining. Some small fishes are smoked totally without gutting and splitting. During the cutting of fish, the pieces must be uniformly sized that will help more uniform absorption of salts and reduce the risk of localized over salting.
b) Cleaning of fish properly to remove blood, slime and harmful bacteria is necessary. The fish is cleaned in fresh tap water or chlorinated water in cold condition may remove lots of microbes from the fish. Thawing of frozen fish is a cool place or in cool water.
c) Salting is necessary before smoking. Fish with higher water contents require more salts to remove the moisture. The salting is generally done in strong salt solution (brine). Salting in a brine that is 1 part table salt to 7 parts water by volume for 1 hour will do in most cases. However large oily fish will require more time for salting. In some cases dry salting is done for 18 – 24 hours in some cases before smoking.
d) Before smoking the fish can be semi-dried. This not only gives the smoke a chance to deposit evenly but also helps to prevent surface spoilage during smoking. Smoke will not deposit easily on a wet surface.

e) Cooking of fish in some cases may be done. It may increase the quality of the product and increase the lifespan of the smoked products.



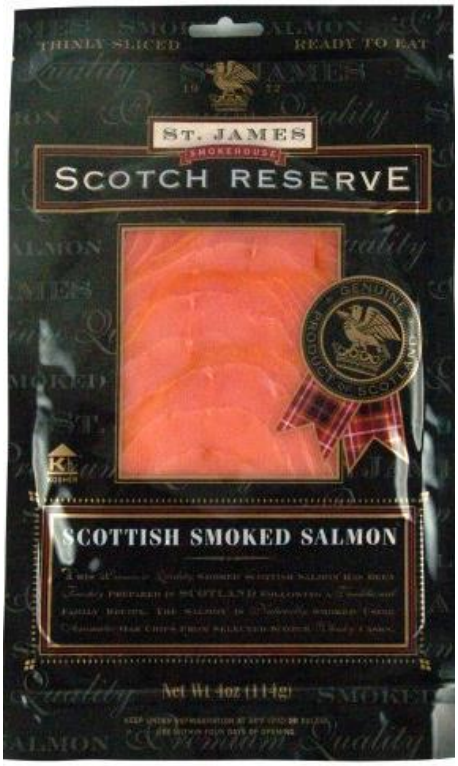
Mechanical smoke kiln

Generation of Smoke

Wood is the source of smoke used the world over for preservation of foods. Cheap woods saw dust and moist straw are being used for smoke generation. Lower temperature and limited supply of oxygen produces lots of smoke. Frictional smoke generators are used in modern smoking process. In this process the end of a piece of wood is pressed against a rapidly revolving drum or disc. Due to the friction the temperature of wood rises up to 350°C and the smoke is generated. Frictional smoke contains approximately four times the quantity of volatile acids, weight times of the quantity of volatile aldehydes and ketones and three times of the quantity of phenols compared to the smoke from charring wood.

Process of Smoking

Cold smoking – This is still carried out in more or less the conventional styles, mostly using traditional ways of smoking. Fishes are kept hung or spread in mesh trays in an upward draft of smoke produced in the floor by burning fire. In initial stages the fishes are moist and the smoke is highly humid. In this condition high temperatures may cook the fish.



To avoid this, the temperature of the chambers should not be raised to the maximum employed in the process. In second stage, when the surface of the fish becomes dry, the temperature inside the chamber could be raised. The temperature should not exceed 40°C and the fish absorbs aromatic substances of the smoke which helps to preserve the fish.

Hot smoking – several designs of kilns or smoking tunnels are available for hot smoking of fish. The fuel is burnt either directly in the chamber or in external hearths located near the tunnel. The fishes are charged into the tunnel in cages. The wall of the tunnel contains lots of cages and can hold the fishes. In hot smoking fish is dried and cooked in the kiln before it is smoked. Drying is done in an intense draught of hot air at 75°C to 80°C produced by burning fire. The skin of fish becomes dry while the flesh becomes cooked well. At this stage the fish is considered ready for smoking. Smoke is produced by covering the burning logs with sawdust and temperature of the chamber is maintained at or above 100°C. A schedule of operation in hot smoking can be considered as drying at 75-80°C for an hour followed by smoking at 95-100°C for another one hour. The requirements will vary with the sizes of the fish.

Smoke roasting – Smoke roasting or smoke baking refers to any process that has the attributes of smoking combined with either roasting or baking. This smoking method is sometimes referred to as "barbecuing", "pit baking", or "pit roasting". It may be done in a smoke roaster, closed wood-fired masonry oven or barbecue pit, any smoker that can reach above 250 °F (121 °C), or in a conventional oven by placing a pan filled with hardwood chips on the floor of the oven so the chips smolder and produce a smoke bath. However, this should only be done in a well-ventilated area to prevent carbon monoxide poisoning.

Electrostatic Smoking – This process of smoking is popular in some countries. The smoke is produced as a result of the electro kinetic properties of smoke in a high voltage field of the order of 40kW or more. Salted fishes are passed through the drying chamber heated by infrared lamps. The fish is heated 3 – 4 minutes at 40-50°C in the chamber when they lose

around 5% of the weight. Then they are taken to the electrostatic smoking chambers. The advantages of the process include –

- Considerable saving of time as the whole process is done within 20 minutes.
- Consequent increased output.
- Reduction of losses due to the short processing time.
- The process is continuous and carried out in mechanical equipment

Post Process Handling

On removing from the kiln, the smoked fish is warm and is generally allowed to cool before grading and packing. If the smoke fish is packed in warm condition, moisture will condense and deposit inside the containers. This may give the chances of molds growth.

N.B. Cold smoked products have soft texture, but short shelf life, but hot smoked products have hard texture but long shelf life.

Fish Preservation - Salting

Salting is a process where the common salt, sodium chloride, is used as a preservative which penetrates the tissues, thus checks the bacterial growth and inactivates the enzymes. Salting commences as soon as the fish surface of the fish comes in contact with common salt and the end product shall have the required salinity with taste and odor. Some of the factors involved in salting of fish which play an important role are purity of salt, quantify of salt used, method of salting and weather conditions like temperature, etc.

Salt:

Source – Pure common salt is sodium chloride. However commercial salt may contains certain impurities. The most common source of the salt is either solar salt or rock salt.

Advantages of Salt Curing:

1. Does not require elaborate equipment,
2. Capital outlay is small
3. Methods are simple and the process are comparatively inexpensive
4. The finishes products do not require any special storage facility
5. The products have reasonably good shelf life and nutritionally the products are comparable to the fish processes by other methods.

Salt Concentration and Bacterial Growth

Presence of salt at 4-10% in fish flesh is known to prevent most of the spoilage bacteria as well as autolytic decomposition. According to the salt concentration capabilities the bacteria can be classified as follows:

a) **Halophobic or Salt Sensitive –** Most of the pathogens and putrefactive types, cannot grow in the medium where the salt concentration is more than 6%.
b) **Halotolerant –** This can tolerate more than 6% salt concentration and also can formed spores. But the growth of these types may decreases with the increase of concentration.
c) **Halophilic –** These are the salt loving bacteria, which can survive even higher than 20% salt concentration and causing red or pink spoilage in salted fishes.

Action of Salt

During salting the Sodium Chloride penetrates the fish tissues. While doing, so, salt alters the colloidal properties of the protein and changes the nature of hydration. Sodium chloride being strong electrolyte releases some of the bound water of protein and this affects its state of existence. In higher concentration of salt the fish muscles are depleted with the water at considerable amount and this will partially account for the hard texture of fish flesh. NaCl exerts high osmotic pressure giving rise to reduction in moisture content of the fish and plasmolysis in the bacterial cells as a consequence. This blocks the protein nuclei, which are affected by the enzymes. It alters the state of protein in such a way that the protein becomes impervious to the action of enzymes. Enzymes are also destroyed or made inactive by the salt, thereby preventing autolytic degradation.

Preparation of fish for Salting:

For successful salting it is essential to ensure that the whole surface of the fish is in contact with the salt. To achieve this fish is dressed. Usually the gills and entrails are removed and the fish is split open along the vertebral column. In the case of big fish, deep scores are also made at several places in the split fish, or they are filleted. However when very small fish are salted, they salted whole. Principally, it is size of the fish that decides whatever the fish should be salted whole or split open or made into the fillets.

Dry salting – In this process the fish is first rubbed in salt and packed in layers in the tubs and cemented tanks. The salt is applied in between the layers of fishes in the proportion of 1:3 to 1:8 salts to fish. The proportion of salt to fish varies with the fish since the oily fish require more salt. A solution of the salt or self-brine is formed with the water exerted from fish body and the fish will remain in the brine solution. The fish may float in this brine. In order to ensure proper salting weights are often used to keep the fish immersed in the self-brine. At the end of 10 - 24 hours or 2 or 3 days, the fishes are removed from the tubs and washed in salt brine and dried in the sun for 2 or 3 days. Large fish lose about one third and small fish about one half of their dressed weights.

Kench Salting – This is essentially a method of dry salting except that that the self-brine is formed is allowed to drained off. Split fish after rolling up in crystalline salt or rubbing salt into the surface, is stacked in layers interspersed with thin layer of salt between each layer

to a height of 1 to 1.3 m. in the lower layer the fish is stacked flesh up and top layer is is kept skin up. The self-brine formed is allowed to drained away.

Wet salting/Brine Salting – The cleaned fish are put in the previously prepared salt solution. It is stirred daily till it is properly picked. In some fishes like seer, black pomfret, Indian salmon etc., the gut is removed and filled with salt in 1: 3 proportions. First the salt is filled in the gut region of the fish and stacked; on the following day further addition of salt is done since the salt settles down at the bottom. Finally the process is repeated to ensure the proper filling up of salt and left undisturbed for 7 - 10 days allowing the liquor to flow off. This method is mostly followed in eastern parts of our country. In western parts the gut is removed and the salt is applied in one lot and they are arranged in bamboo baskets. The fishes preserved in wet salting process are to be consumed before the rain sets in and the fishes are marketed without drying.

Mixed salting – In this process, simultaneous use of salt and brine is followed. The salting process is continued till the concentration of salt in the surrounding medium equalizes with the concentration of salt in the fish tissue. The salting process may affect the shape, structure and the mechanical features of muscle tissue.

Pit curing – It is another process employed in south and south east of our country. In this process the fish treated with salt are buried in pits lined with leaves. After 2-3 days they are removed and marketed directly.

Pickle salting - fish are covered with salt and then packed in water-tight containers in layers with salt sprinkled between each layer. The pickle which forms covers the fish; if the fish are not completely covered in 3 - 4 hours; saturated brine is normally added to completely immerse them. A cover should be placed on top of the fish to hold them below the surface of the pickle.

With most brine salting techniques, a saturated brine solution is used. The presence of impurities may reduce the actual concentration of sodium chloride in solution and, in practice, the brine strength ranges between 80 and 100 per cent, which corresponds to 270 - 360 grams of salt to each liter of water. When fish are placed in saturated brine, the concentration of the brine begins to fall as soon as salt begins to penetrate the fish and water is removed. Unless plenty of brine is used and the fish are stirred frequently, the rate of salt penetration and water removal may be seriously reduced.

Preservation of Fish – Freezing

Freezing food preserves food from the time it is prepared to the time it is eaten. Since early times, farmers, fishermen, and trappers have preserved their game in unheated buildings during the winter season. Freezing food slows down decomposition by turning water to ice, making it unavailable for most bacterial growth. The low temperature reduce the chemical reactions and enzymatic reactions which can lower the rate of autolysis, delay breakdown of ATP consequently delaying the onset of rigor mortis, and also delay the bacterial spoilage. This forms the basis of preservation of foods by freezing. Commercial freezing involves cooling to very low temperatures such that the water in the fish is converted into ice.

Process

The fishes are generally pre-processed before freezing. The following preprocessed steps are followed during the freezing of fish.

a) **Gutting and splitting –** In any case the fishes are iced or freeze directly without gutting or splitting. But in case of long days of preservation the entrails are removed from the body of large. In case of prawns the heads are removed before icing.
b) **Cleaning –** The fishes or prawns are washed properly by fresh tap water or chlorinated water to remove some amounts of microbes from the fish. Washing also clean the unwanted bloods and other organics from the fish body.

Icing

The fishes or other aquatic organisms directly preserved in ice flakes for short distance transport. The fishes are placed into high density polyethylene containers with the layers of ice and fish continuously. The containers are then air tightly sealed. The quantity of ice required to cool the fish depends upon the factors such as stowage, sea and air temperature of fish as they come out of the sea and the length of the voyages.

To determine the quantity of ice to be used for icing fish one needs to know the specific heat of fish (fresh fish which contains 80% water has a specific heat of 0.84), weight of the fish, environmental temperature. Generally, 3.5 kg of ice is required to chill 10kg of fish at 30°C ambient temperature.

In icing of fish, fresh flakes or crushed ice is preferable to blocked, tube or plate ice. Rapid cooling is possible through intimate contact between fish and small pieces of ice. Ice-cold melted water removes the heat from the fish body. The flow of melted water also removes the microbes, stale blood and slime.

Boxes must also be cleaned before stowage. During ice boxing a deep layer of ice, about 5-7 cm deep is placed at the bottom of the boxes as this is the area where maximum melting of ice will occur. The fish will lay over the ice belly down and sprinkled with ice to fill up the gaps between them and cover the fish with 5-7 cm deep layered ice. Further layer of fish is also given and covered with ice again. The boxes are filled up in such fish-ice-fish manner. The top layer is filled with 5cm ice layer which stop the direct contact of hot air to the fishes. The boxes then sealed properly with cover or another box is placed over one box properly.

Sea fish is iced near – 1°C since the mixtures usually include some salts and bloods.

Freezing – Indirect and Direct

Freezing process can be broadly classified into two, the direct expansion system and the indirect system. In direct expansion system, the refrigerant absorbs the heat directly from the material to be cooled. Therefore, evaporator coil is placed directly in place the place to be refrigerated. In indirect system or brine system, the refrigerant absorbs the heat that the brine absorbs from the material to be cooled. Hence the product is cooled by the brine which is cooled by the refrigerator.

Freezing methods can be classified as

- Freezing in air
- Indirect contact freezing
- Immersion freezing
- Cryogenic freezing

Freezing in Air

Air is the most common medium. The methods are of following types.

1. **Freezing in still air –** the freezer consists of an insulated room or a cabinet maintained at – 28°C to – 40°C.
2. **Air blast freezer –** in this process the air is cooled by blowing fan through cooling coil. Cool air passes over the fish to be frozen. The temperature is maintained 35°C to 40°C.
3. **Continuous air blast freeze –** in this type of freezing, the fishes are placed over the conveyor plate. The continuous operation is possible.
4. **Fluidized bed freezer –** fluidized bed freezer is an improvement over the continuous belt freezer. Fluidization is a method of keeping solid particle partially supported in a raising column of cold air.

Indirect Contact Freezing

This may have defined as freezing a product by keeping in in contact with metal surface which is cooled by the refrigerant. In this system refrigerant does not come into direct contact with the product to be frozen. Most common freezer is described below.

1. **Horizontal Plate Freezer –** This type of freezer is used in all land based freezing operation. These freezers, in general, have 15-20 plates. The products to be frozen contained in a metal freezing trays are loaded between freezing plates and are maintained in close contact with top and bottom plates under slight hydraulic pressure to ensure maximum heat exchange. Temperature is maintained between -35°C to - 40°C. Fish freezes in 2-2½ hours.
2. **Vertical plate freezer –** These are most common freezer to freeze the sea fishes. It consists number of vertical freezing plates that form partitions in a container. The spaces between the plates are known as the stations. The temperature ranges between – 30 and – 40°C. The fishes are dropped between the plates until each station is full. The plates are closed together to form fish blocks.

Contact plate method if freezing is economical. Dehydration taking place in the product is minimum and consequently there is practically no need for defrosting. The product remains in uniform blocks without bulging.

3. **Rotary Drum Freezer –** This is a refrigerated stainless-steel drum revolving at a pre-set speed. Freezing time can be adjusted by the adjusting the speed of revolution. Unpacked products like fish fillets, shrimps etc can be rapidly frozen by using these freezers.

Immersion Freezing

In this method, the freezing is done by immersion in or spraying with refrigerant directly to the products. Refrigerated aqueous solutions of propylene, glycol, sodium chloride, calcium chloride and mixtures of sugars and salts can be used as refrigerant which are kept liquid during the operation. Immersion freezing allows the intimate contact with the every surface of the products and ensure efficient heat transfer. Different processes are described bellow:

1. **Freezing in Brine –** The most common immersion category where the aqueous solution is sodium chloride. Saturated brine freezes at - 21°C, however, in practice the temperature is maintained - 18°C. Brine freezing is rapid and adaptable to continuous process. However, the fish will absorbs little amount of salts in it. Absorption of salts can be reduced by using mixture of glucose or corn syrup and salt as the freezant.
2. **Brine Spray Freezing –** Instead of immersion, freezing can also be achieved by spraying the fish with refrigerated brine. Chilled brine is sprayed over the fish placed in trays. Heat is removed from the fish by chilled brine eventually freezing the fish in 1 – 2 hours.

Cryogenic Freezing

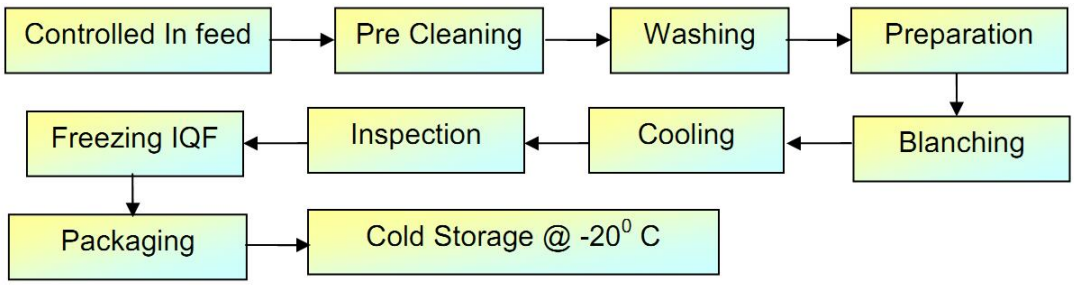
In cryogenic freezing very, rapid freezing is achieved by exposing the fish, unpackaged or with very thin package, to an extremely cool freezant. The difference between the cryogenic freezing and immersion freezing is the change of state in the former while removing the heat from the body. The most common food grade freezant are boiling nitrogen or subliming carbon dioxide. The freezing is much faster. For example, shrimp is frozen in 9 minutes, 12 minutes for fluidized bed freezer and 1-2 hours in contact plate freezers.

1. **Liquid Nitrogen Freezer –** In freezing the LN is spread over the product as it travels in a tunnel over a conveyor belt. The product is pre cooled before reaching the LN zone. After freezing, the product is allowed to temper for a while before

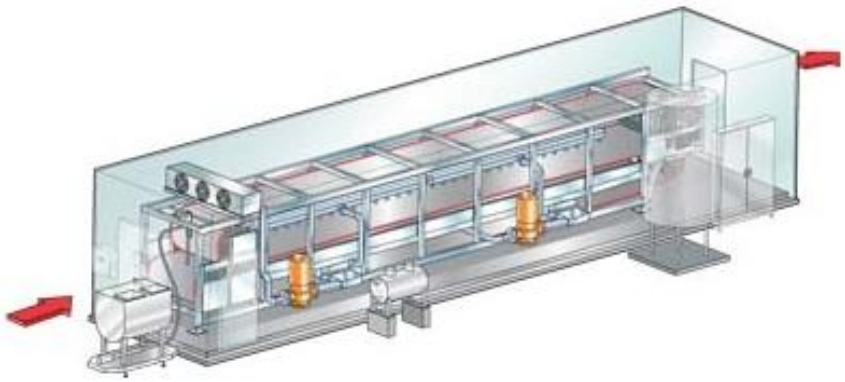
being discharged from the tunnel. The refrigerator has three chambers. The product is placed in conveyor belt is moved on into the zone A where it is precooled by modestly cool N_2 vapor. Zone B is the freezing zone with LN sprayed over the product. In zone C, the product is allowed to temper for a while and give the final temperature. The advantages are –

- Negligible dehydration loss
- Oxygen is excluded, hence the chances oxidation of the product is reduced
- Attains individual quick freezing of the product and freezing damage is minimum.
- Equipment is simple, and operation cost is cheap

Process flow of IQF is given below:

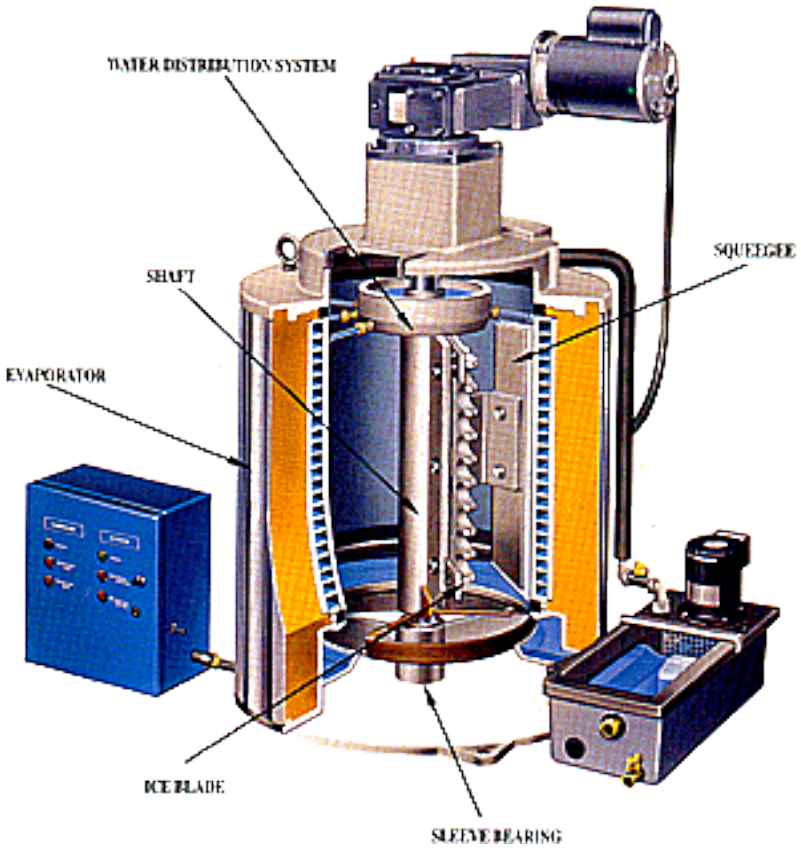


2. **Carbon dioxide Freezing –** In this type, liquid CO_2 is used for spraying over the fish, when it travels through the tunnel on a moving conveyor belt. The CO_2 is spread as liquid. Due to the sudden change of the pressure, 50% of CO_2 suddenly changes into snowy particles which absorbs large quantities of the heat from the products and gets converted into the gas resulting rapid cooling of the fish. Freezing can also be done by using powdered solid CO_2.



Liquid Nitrogen freezer

Plate Freezer



Design of a flake ice maker at NIFPHAT

Preservation of Fish – Canning

Canning is a method of preserving food in which the food is processed and sealed in an airtight container, providing a typical shelf life ranging from 1 year to 5 years and under specific circumstances a freeze dried canned product can last as long as 30 years and can still be safely consumed. The process was first developed as a French military discovery by Nicolas Appert in 1810. The packaging prevents microorganisms from entering and proliferating inside.

Nicolas Appert

To prevent the food from being spoiled before and during containment, quite a number of methods are used: pasteurization, boiling (and other applications of high temperature over a period of time), refrigeration, freezing, drying, vacuum treatment, antimicrobial agents that are natural to the recipe of the foods being preserved, a sufficient dose of ionizing radiation, submersion in a strong saline solution, acid, base, osmotically extreme (for example very sugary) or other microbe-challenging environments.

Advantage of Canning

- ✓ Canned foods offer consumer safety
- ✓ It can be stored at room temperature for long periods of time
- ✓ Canned foods are cooked, hence no need for cooking after buying the product
- ✓ Concentrated food with no wastages
- ✓ Protected against infections through microorganisms
- ✓ Applicable for wide ranges of products

Cans

Cans are made up of tin plates in canning industry. The tin plate is a thin steel sheet coated with tin on both sides. It has a combination of strength of steel and protective properties. The tin plate has corrosion resistance, since it is covered with 4 layers namely alloy, tin, protective oxide and oil, in addition with special enamels or liquors which have been developed. Various types of inorganic liquors are used to absorb sulfur. Sea foods when

canned produce sulfur ions which may react with the coating of tin. These sulfur ions are not detrimental to health but affect the appearance of the product. Other materials like sulfur resistant black plate, steel coated with aluminum, zinc, nickel or titanium have been tried but its application is found to be very little. Glass jars are also tried which requires longer processing time than tin plates. The prepared cans should be protected against damage and corrosion and should be stored in dry closed room. The cans should be thoroughly washed with boiling water before filling to avoid dust and micro- organisms if any present in the tin.

Outline of Canning Operation

1. **Selection and preparation of fish –** Thermal destruction of bacterial being the principle involves in preservation of fish by canning. It is very important that fish used should have only very low bacterial load. Fresh and uncontaminated fishes should be selected for canning.

   Dressing depends on the type of the fish and type of the end products. For small fish like sardine involves heading, gutting, scaling and removal of unwanted body parts like fins and tails. Bleeding is necessary for tuna which is done immediately after catch. Shrimp is peeled and deveined for canning. Bivalves require purification process called depuration to reduce the load of bacteria.
2. **Salting/Blanching/Pre-cooking –** Dressed fish is generally blanched in cold water or hot brine or precooked in steam, the choice being dependent on the fish concerned. During blanching in brine, hot or cold, the fish flesh takes up sufficient salt and its texture gets improved. During heating, as it not blanching or cooking in the steam, the fish flesh releases around 15-30% of the body water before canning. It increases the quality of the product. The advantages are –
   - Sufficient shrinkage of the fish to enable adequate filling in the cans
   - Imparts firm and proper texture to the flesh making its handling easy
   - Cleanness the flesh, reduces the bacterial load
   - Inhibits the enzymatic reactions and maintain nutritive value by retarding browning reactions
   - Sets the natural color to the product
   - Expels repository gases from the tissues, thus helping to improve the vacuum in the can

- Removes the raw flavor of the fish

3. **Filling of Can –** The blanched material is filled in clean cans. Weight filled will depend on the specific requirements with respect to the size of the can. It is then covered with a liquid medium like hot brine, oil and sauce. The liquid medium is constituent of the product and helps in improving the taste, textures and flavor. However, a still greater role it plays is in facilitating proper heat penetration in the product during heat processing. Other additives like flavoring agents, vegetables, etc. may be added with a view to improving the flavor, presentation etc.

   Double refined deodorized vegetable oil is the principal filling medium used in fish cans; the oil should not undergo any change during subsequent heat processing and also should not impart any color or undesirable flavor to the product. Tomato sauce is another important additive in canned sardine, mackerel, oysters etc. It is important that the color of the sauce does not change during the heat processing. Other additives are carboxymethylcellulose, monosodium glutamate, spices, sugar etc. added in specific cases to yielded canned products of specified characters. The headspace of the cans should have sufficient head space, because during filling the hot cans expands and due to the water vapor the internal pressure of the cans increases.

   The cans are filled such that a uniform headspace of 6-9 mm is available above the contents. Can ends may bulge if the head space is too little. They may even cause uneven sterilization of the product. Too high a head space also causes problems because too much air in the can will accelerate product deterioration and container corrosion besides adversely affecting the vacuum.

   The ratio of solids and liquids should be uniform, because this is an important factor influencing the penetration of heat. There should be no air pockets occluded in the pack that cannot be expelled later by exhausting.

4. **Clinching –** while seaming the cans using speed machines there is possibilities of the contents spilling over. To prevent this, the can end is clinched to the can body. Clinching involves the can end being partially secured to the body by a single seam on the opposite sides keeping the lid sufficiently loose to allow escape of air and water vapor during exhausting.

5. **Exhausting –** Exhausting is the step by which air from headspace and the contents is removed prior to seaming the can. It is essential because –

- Minimizes the strains on the can and seams due to the expansion of air during heat processing
- Removes oxygen, which can accelerate internal corrosion of cans or oxidation of fats and vitamins
- Creates partial vacuum in the cans. When the can is stored at higher than normal temperature or higher altitudes, the ends of the cans that are not exhausted. Distortion of the cans can be minimized.
- Preserves vitamin C

6. **Can coding –** it is a statutory requirement to stamp the can ends with a code denoting the contents, date of manufacture and other details as demanded under the law of foods.
7. **Can Seaming –** the seaming is done to get an air-tight seal between the cover and the body of the container so that microorganisms cannot gain entry into the can. Cans are seamed immediately after exhausting or along, with exhausting as in vacuum seaming. Any delay may cause cooling of the cans contents and this should be avoided. A good quality tin plate, adequate sealing compound and an efficient can closing machine combine to produce a strong hermetic double seam. The body and end are brought together in a seamer and held in place by the base plate and chuck, respectively. The base plate provides a sure footing for the can body during the seaming operation and the chuck fits snugly in to the end (lid). The result is the countersink of the end sits inside the top of the can body just below the flange. The end curl protrudes slightly beyond the flange.
   - **Double Seaming -** Invented in 1888 by Max Ams, modern double seams provide an airtight seal to the tin can. This airtight nature is crucial to keeping bacteria out of the can and keeping its contents sealed inside. Thus, double seamed cans are also known as Sanitary Cans. Developed in 1900 in Europe, this sort of can was made of the traditional cylindrical body made with tin plate. The two ends (lids) were attached using what is now called a double seam. A can thus sealed is impervious to the contamination by creating two tight continuous folds between the can's cylindrical body and the lids. This eliminated the need for solder and allowed improvements in manufacturing speed, reducing cost.

     Double seaming uses rollers to shape the can, lid and the final double seam. To make a sanitary can and lid suitable for double seaming, manufacture begins

with a sheet of coated tin plate. To create the can body, rectangles are cut and curled around a die, and welded together creating a cylinder with a side seam.

Rollers are then used to flare out one or both ends of the cylinder to create a quarter circle flanges around the circumference. Precision is required to ensure that the welded sides are perfectly aligned, as any misalignment will cause inconsistent flange shape, compromising its integrity.

A circle is then cut from the sheet using a die cutter. The circle is shaped in a stamping press to create a downward countersink to fit snugly in to the can body. The result can be compared to an upside down and very flat top hat. The outer edge is then curled down and around about 140 degrees using rollers to create the end curl.

The result is a steel tube with a flanged edge, and a countersunk steel disc with a curled edge. A rubber compound is put inside the curl.

8. **Can washing –** cans leaving the seaming machine may have the pieces of fish flesh, sauce, oil adhering to surface. Therefore, the cans are washed in hot water and detergent solutions. The washed cans again rinsed with hot water to remove detergent residues which may cause further erosion of the can surfaces.
9. **Sterilization –** the sealed cans are heated for predetermined time-temperature schedule in saturated steam. Thermal processing should take care of the following aspects:
    - Consumer safety
    - Ensuring non- spoilage under ordinary conditions
    - Proper cooking of the product
    - Retention of organoleptic characters

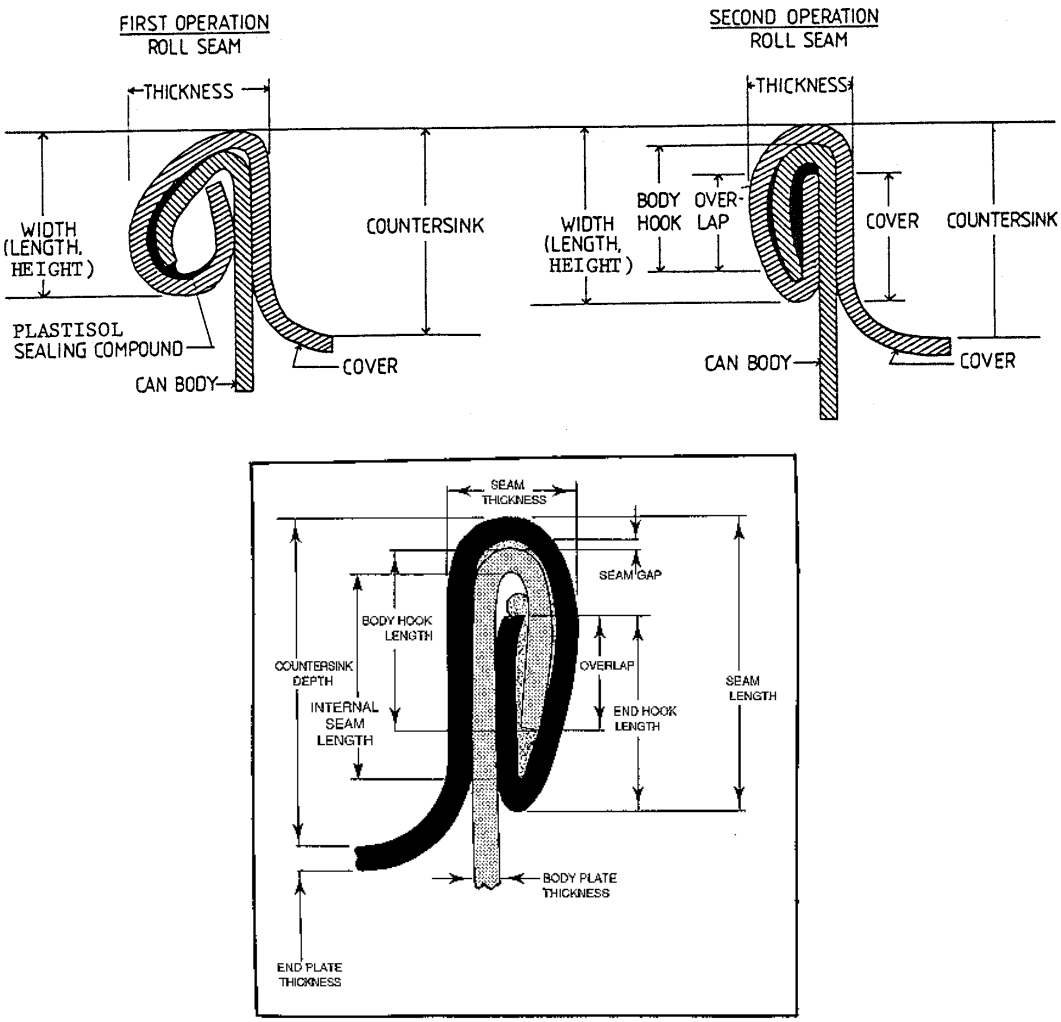
    The heat treatment should be such that it is sufficient to kill the microorganisms only causing spoilage without overcooking the product.

Microbial Spoilage

Sometimes the canned fish show signs of microbial spoilage which may be due to insufficient pre-treatment especially inadequate cooling or improper preservation of raw material. It exhibits signs of spoilage accompanied by the presence of dead bacteria. These bacteria may at times withstand the processing during cooling and storage. Insufficient processing leaves back a number of heat resistant spores forming bacteria in the canned

product. The commonly observed spore formers are mesophilic anaerobes (*Clostridium sporogenes, C. putrificum*). They produce putrid swells, mesophilic aerobes (*Bacilus* sp) produces flavor and changes color and soften the contents. Thermophilic bacilli produce flat sours which are rare. The bacteria have got ability to produce gas and to interact with the material inside the can. The gas accumulated at the head region in the can helps in determining the kind and cause of spoilage. The swelling of cans may also be due to CO_2 and hydrogen formed due to microbial spoilage.

Finally the canned product is thoroughly examined by various methods like examining the product organoleptically, chemically and microbiologically for the quality of final product. Then it is properly labeled which should exhibit the name of the product, meat contents and any specific information if required. The processed cans can be stored at a room temperature which should be just above the freezing point of canned products.



Can seaming

Canning at NIFPHATT Plant

Canned Tuna

Fishery by Products

Fish Oil

Fish oil is oil derived from the tissues of oily fish. Fish oils contain the omega-3 fatty acids eicosatetraenoic acid (EPA), and docosahexaenoic acid (DHA), precursors of eicosanoids that are known to reduce inflammation throughout the body, and are thought to have many health benefits.

The fish oil is two types –

1. Fish body oil
2. Fish liver oil

Fish body Oil

Body oil is extracted from fish body of oily fishes by various processes described below:

a) **Wet rendering –** this process is suitable for high oil content fishes. The stick water is reheated, if necessary and then centrifuged and separated into fish body oil and fish soluble. Oil can be separated from the stick water by using settling tanks.

b) **Dry rendering –** if there is enough oil left in the fish meal after wet rendering, the meals are subjected to the dry rendering to remove the oil. In this process the fish meal is pressed in hydraulic press. However, the oil is likely to be inferior to the oil processed by wet rendering process, particularly in the color that may get darkened by reaction with the heated metal surfaces of the cooker drier.

c) **Solvent Extraction –** this is an expensive process and hence it is not used in extraction of fish body oil in many cases. This process is mainly used for liver oil extraction.

Fish Liver Oil

Therapeutic value of fish liver oil is known since early days. The oil is the important source of natural vitamins A and D. However, with the advent of synthetic vitamin A at economic prices, the importance of liver oil has been lost. Still they are considered the good source of vitamin D.

Extraction of Oil

a) **Alkali Digestion –** liquefaction of liver using mild alkali is the simplest method applicable for releasing the oil with high vitamin A potency. The liver is first ground and mixed with 1 – 2% by weight of NaOH or 2 – 5% of $NaHCO_3$. The mixture is heated with live steam maintain the temperature at 82°C to 87°C. The mixture is kept stirred while cooking is continued. The digested liquor is centrifuged to separate the oil.

b) **Acid Digestion –** The acid digestion method involved grinding the liver, adjusting its pH to 1.5 with an acid and cooking under constant stirring. The oil is separated from the digested mass by centrifuging.

c) **Solvent Extraction –** the liver has to disintegrated and desiccated for efficient recovery of the oil in the solvent extraction process. The liver is therefore, first ground and as much water as possible is removed by steaming the ground mass at 70-75°C for an appropriate length of time, generally 30-45 minutes, under stirring followed by draining off the released water while the mass is still hot. The residue is covered with a layer of paraffin or CO_2 gas and rapidly cooled to around 20°C. The oil is extracted with one of the solvents like acetone, ethyl ether, dioxane, benzene etc. the solvent with the extracted oil is filtered and vacuum distilled to recover the oil.

Fish Meal

The waste obtained after the fish processing for oil extraction is called as fish meal. It is prepared either by wet or dry processing, depending on the raw material. The good quality fish meal is used for animal feeding and other is used as manure. The chemical composition of fish meal has 50 - 70 % proteins, 5 - 10 % fats, 10 - 20 % minerals and 6 - 12 % moisture. The fish meal is considered as very rich source of proteins. Calcium 5%, phosphorous 4%, a variable amount of iodine and vitamins B1, B12, A, D, K are also found in fish meal, which promotes the growth of animals. It constitutes a valuable source of feed for farm animals.

In dry method the fish meal is exposed to high temperature like in flame dryers or in steam drums under partial vacuum. In wet method large sized fishes are chopped and boiled to extract oil. These are then covered with canvas and screw-pressed to form the cakes. Dried

cakes are pressed in hydraulic pressure to recover oil and are re-dried in steam, before being sterilized and packed for marketing. The fish meal is stored in gunny or coir bags as they are insect and vermin proof. The tin containers under an atmosphere of nitrogen are also employed.

Fish Glue

Fish glue is an adhesive that is created by prolonged boiling of animal connective tissue. These protein colloid glues are formed through hydrolysis of the collagen from skins, bones, tendons, and other tissues, similar to gelatin. The word "collagen" itself derives from Greek κόλλα kolla, glue. These proteins form a molecular bond with the glued object.

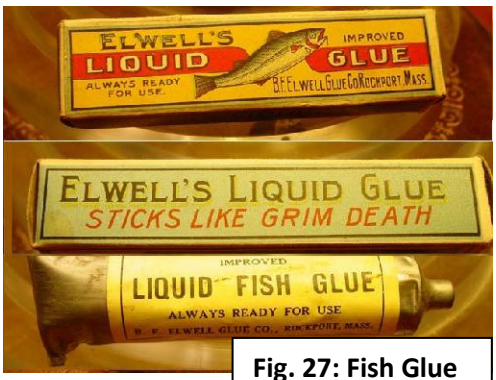


Fig. 27: Fish Glue

Glue was the most common woodworking glue for thousands of years until the advent of synthetic glues such as polyvinyl acetate (PVA) and other resin glues in the 20th century. Today it is used primarily in specialty applications such as lutherie, pipe organ building, piano repairs, and antique restoration. Glass artists take advantage of hide glue's ability to bond with glass, applying hide glue to glass. As the glue hardens it shrinks, chipping the glass.

It has several advantages and disadvantages compared to other glues. The glue is applied hot, typically with a brush or spatula. Glue is kept hot in a glue pot, which may be an electric unit built for the purpose, a double boiler, or simply a saucepan or crock pot to provide a warm water bath for the container of glue.

Glues are soluble in water, useful for joints which may at some time need to be separated. Alcohol is sometimes applied to such joints to dehydrate the glue, making it more brittle and easier to crack apart.

Production

Fish bones and skins are soaked in water to produce 'stock'. The stock is then treated with lime to break down the hides. The hides are then rinsed to remove the lime, any residue being neutralized with a weak acid solution. The hides are heated, in water, to a carefully

controlled temperature around 70 degrees Celsius. The 'glue liquor' is then drawn off, more water added, and the process repeated at increasing temperatures.

Fish flour

Fish meal is prepared by solvent extraction process on commercial scale. This can be blended with wheat or maize flour and is used as enriching component in bread, biscuits, cakes, sweets and soups. It forms an ideal protein supplement to human diets. Groupers and seer fishes are used commonly for preparation of fish flours.

Fish flakes/wafers

Thread fin breams and cat fishes are used in the preparation of flakes or wafers. Fish flesh is boiled, and then mixed with maida, salt, etc. to prepare flakes or wafers.

Isinglass

Isinglass is a substance obtained from the dried swim bladders of fish. It is a form of collagen used mainly for the clarification of wine and beer. It can also be cooked into a paste for specialized gluing purposes. Isinglass was originally made exclusively from sturgeon, especially Beluga sturgeon, until the 1795 invention by William Murdoch of a cheap substitute using cod. This was extensively used in Britain in place of Russian isinglass. The bladders, once removed from the fish, processed and dried, are formed into various shapes for use.

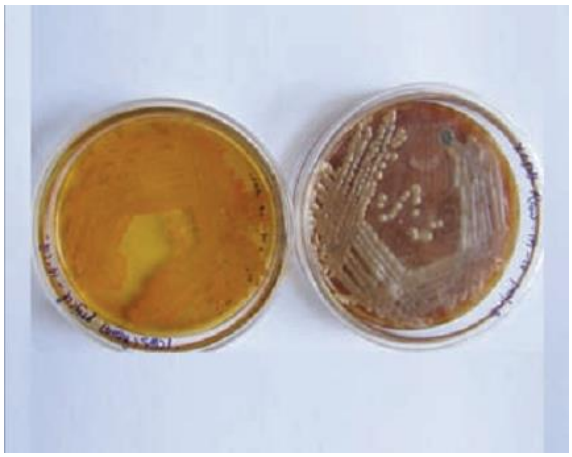
The air bladder after washing well in water and scrapping of the outer layer is split open longitudinally and washed well further. It is then dried in sun to a final moisture level of around 15% by hanging or placing in trays. The dried product is fish maws.

The dried bladder is immersed in water until it becomes soft. Soaking for several hours may ordinarily be needed. It is then rolled, often after cutting into small pieces, between water cooled iron rollers to convert it into thin strips or sheets 3 – 6mm thick. They are the further compressed by ribbon rollers into the ribbons about 0.4 mm thick. These ribbons are dried and rolled into coils. This is the final isinglass.

Uses

Prior to the inexpensive production of gelatin and other competitive products, isinglass was used in confectionery and desserts such as fruit jelly and blancmange. Isinglass findings are widely used as a processing aid in the British brewing industry to accelerate the fining, or clarification, of beer. They are used particularly in the production of cask-conditioned beers, known as real ale, although there are a few cask ales available which are not fined using isinglass. The finings flocculate the live yeast in the beer into a jelly-like mass, which settles to the bottom of the cask. Left to itself, beer will clear naturally; however, the use of isinglass finings accelerates the process. Isinglass is sometimes used with an auxiliary fining, which further accelerates the process of sedimentation. Non-cask beers which are destined for kegs, cans or bottles are often pasteurized and filtered.


Training Programme at NIFPHATT

Seafood Microbiology at NIFPHATT

Minced Products

The most common way of separating edible flesh from waste is by filleting, but a greater amount of flesh can be recovered in the form of a coarse mince by putting either the un-filleted fish, or the waste left after filleting, through a bone separator.


Fish Finger

Fish fingers – Fish fingers, known as fish sticks in North America, are a processed food made using a fish which have been battered or breaded. They are commonly available in the frozen food section of supermarkets, and on children's menus in family-oriented restaurants. They can be baked in the oven, grilled, shallow fried, or deep-fried. The fish used may be either fillets cut to shape or minced/ground fish reformed to shape. Those made entirely from fillets are generally regarded as the higher quality products and will typically have a prominent sign on the box stating that the fish is 100% fillet. Minced fish is more commonly used in store brand economy products.

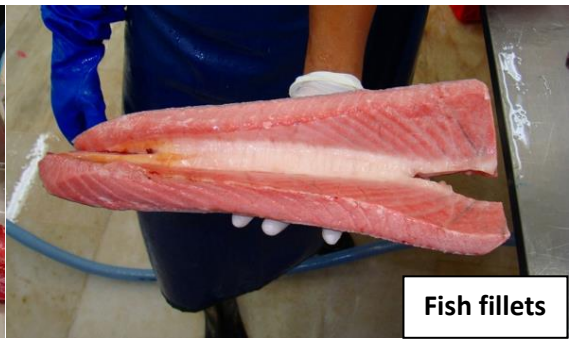

SURIMI

Surimi – Surimi is a Japanese loan word referring to a fish-based food product intended to mimic the texture and color of the meat of lobster, crab and other shellfish. It is typically made from fleshed fish that has been pulverized to a paste and attains a rubbery texture when cooked. The term is also commonly applied to food products made from lean meat prepared in a similar process.

Surimi is a much-enjoyed food product in many Asian cultures and is available in many shapes, forms, and textures. The most common surimi product in the Western market is imitation crab meat. Such a product often is sold as sea legs and crab in America, and as seafood sticks, crab sticks, fish sticks or seafood extender in Commonwealth nations.

Utilization of Fish Products and by Products

Source	*Products/by-product*	*Uses*
Fat of liver and body	1. Fish liver oil + Vitamin A	Pharmaceutical
	2. Fish body oil	Pharmaceutical
Protein of muscle	3. Fish flour, sausage, ham	Human consumption
And other tissue	4. Fish meal	Animal feed
	5. Fish silage	Animal feed
	6. Fish soluble	Animal feed
	7. Fish manure	Agricultural
	8. Fish guano	Agricultural
Collagen of body tissues	9. Fish glue	Industrial
Collagen of air bladder	10. Isin glue	Industrial
Skin	11. Fish leather	Industrial
Scales	12. Animal charcoal	Industrial (Purification of liquids)
	13. Guanine	Industrial (artificial pearls)
	14. Shagreen	Industrial (abrasive)
Fins	15. Dried fins	Human consumption (soup)
Eggs	16. Fish roe	Human consumption
Sterols	17. Cholesterol	Pharmaceutical
	18. Squalene	Industrial (mordant in dyeing)
	19. Lecithin	Industrial (Antibloom agent in chocolate industry)
Enzymes & harmones	20.Enzymes & harmones	Pharmaceutical



Fish fillets

Conclusion

Fishing communities in developing countries are generally extremely under-privileged. Fish produced by them often represents a vital component of the food supply. This is especially the case for many low-income groups in urban and rural areas, for whom fish is the only available animal protein, and particularly in India, where so much of the fish production is converted into traditional types of cured fish. Fishing communities, and those who are depending heavily on fish, definitely among those who need help to make tomorrow better. However, it is much easier to identify what ought to be improved than to achieve real and lasting improvement. This paper describes some of the problems involved in post-harvest operations. Much of what follows is obvious, and basically common sense, but unfortunately all too often a key issue has been overlooked, and attempts to help fishing communities have achieved much less than expected.

In developing countries, where tropical weather and poorly developed infrastructure contribute to the problem, losses are sometimes staggering proportions. Losses occur in all operations from harvesting through handling, storage, processing and marketing. They are according to the influence of factors such as the perishability of the commodity; ambient temperature and relative humidity which determine the natural courses of decay; fungal and bacterial decay; damage by pests-insects, rodents and birds; the length of time between harvesting and consumption; and practices of post-harvest handling, storage and processing.

Most often, post-harvest losses are symptom rather than the problem. Knowledge of their cause is, therefore, essential deciding measures to prevent them. Such measures may have to be taken by the small farmer, the private trader, a cooperative, the marketing board or other operator, handlers and transporters, wholesale and retail markets, etc.

Post-Harvest Technology is concerned with although situations where fish is used as a food commodity, from the point of captured to the point of consumption. It embraces handling, transportation, processing and preservation (chilling, freezing, smoking, salting, drying etc.), distribution, marketing product innovation and development, nutritional considerations, standards and specifications, quality control.

PART - II

HAZARD ANALYSIS

AND

CRITICAL CONTROL POINT

HAZARD ANALYSIS AND CRITICAL CONTROL POINT

Traditionally, the Hazard Analysis and Critical Control Point (HACCP) methodology has been considered to be a food safety management system. It aims to prevent known hazards and to reduce the risks that they will occur at specific points in the food chain.

The 5 days training programme on HACCP basic concepts was conducted from 4-3-2013 to 8-3-2013 to us. The training program highlighted on the significance of implementation of HACCP in the seafood industry to ensure safety of the products exported from the country and emphasized on the role of seafood processing technologists in the industry to safeguard quality and safety of products by way of effective implementation of HACCP.

The intensive training programme dealt with different areas of HACCP like principles hazard analysis, determination of critical control points, control measures, good manufacturing practice (GMP) and quality management system. Dr. N. Anandavally, Managing Director, Food Safety Standards of India and FAO expert and Dr. M.K. Mukundan, Director, CFRD and Principal Scientist (Retd.), CIFT were the expertized external faculties who led the theoretical session of HACCP training. A total number of 21 students of our college have successfully completed the above training programme.

Definitions related to HACCP

HACCP plan – A document prepared in accordance with the principles of HACCP to ensure the control of hazards which are significant for product quality in the production and supply chain.

Hazard – Any circumstance in the production, control and distribution of a product which can cause an adverse health effect.

Hazard Analysis – The process of collecting and evaluating information on hazards which should be addressed in the HACCP plan

Critical Control Point (CCP) – A step at which control can be applied and is essential to prevent or eliminate a product quality hazard or reduce it to an acceptable level.

Critical limit – A criterion which separates acceptability from unacceptability

Corrective action – Any action to be taken when the results of monitoring at the CCP indicate a loss of control

Control measure – Any action and activity that can be used to prevent or eliminate a product quality hazard or reduce it to an acceptable level

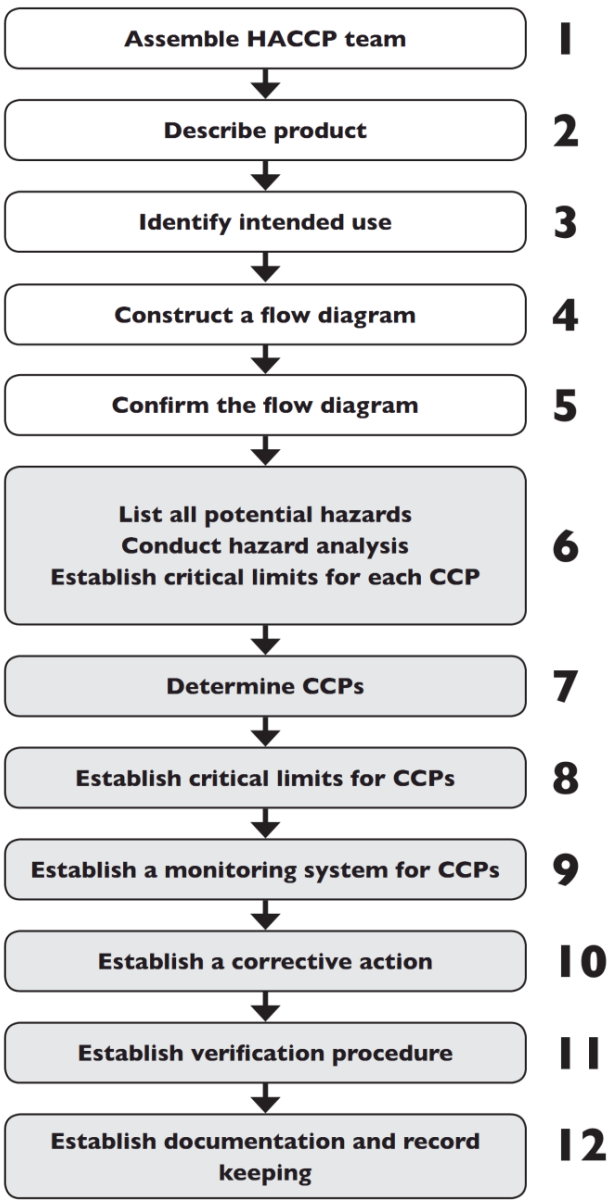
Principles

The HACCP system is based on seven principles. In applying these principles, 12 stages are recommended.

The seven principles are:

1. Conduct a hazard analysis.
2. Determine the critical control points (CCPs).
3. Establish target levels and critical limit(s).
4. Establish a system to monitor the CCPs.
5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
6. Establish procedures to verify that the HACCP system is working effectively.
7. Establish documentation concerning all procedures and keep records appropriate to these principles and their application.

[Note: Steps 6–12 are the application of the seven principles of the HACCP system]



Logic sequence for application of HACCP

Guidelines for HACCP system application

Prior to the application of HACCP, the food establishment should be operating according to:

- the Codex General principles of food hygiene
- the appropriate Codex codes of practice
- appropriate food safety legislation

1) Assemble HACCP team

The appropriate product specific knowledge and expertise should be available for the development of an effective HACCP plan. This is best achieved by assembling a multidisciplinary team. Where such expertise is not available on site, expert advice should be obtained from other sources. The scope of the HACCP plan should be identified.

2) Describe product

A full description of the product should be drawn up, including relevant safety information such as: composition, physical/chemical data (including a_w, pH, etc.), microbial/static treatments (heat-treatment, freezing, brining, smoking, etc.), packaging, durability and storage conditions and method of distribution.

3) Identify intended use

The intended use should be based on the expected uses of the product by the end user or consumer. In specific cases, e.g., institutional feeding, vulnerable groups of the population may have to be given special consideration.

4) Construct flow diagram

A flow diagram covering all steps should be constructed by the HACCP team.

5) On-site confirmation of flow diagram

The HACCP team should confirm the processing operation against the flow diagram during all stages and hours of operation and amends the flow diagram where appropriate.

6) List all potential hazards associated with each step, conduct a hazard analysis, and consider any measures to control identified hazards (HACCP Principle 1)

Hazard is defined as a chemical, biological, or physical agent in, or a condition of, food with the potential to cause an adverse health effect, while hazard analysis is the process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and should therefore be addressed in the HACCP plan. Chemical hazards include residues of pesticides and veterinary drugs, certain non-GRAS (generally recognized as safe) additives and preservatives, toxic metals, and chemicals from cleaning. Biological hazards include disease-causing microorganisms such as bacteria, viruses, parasites and fungi, and also certain plants and fish that carry toxins. Table 3 shows the most significant food-borne biological hazards that may occur in food, while Appendix 1 gives more detailed information about their growth limits. Physical hazards include dirt, hair, broken glass and crockery, nails, staples, metal fragments or bits of packaging materials that accidentally enter food. The HACCP team should list all of the hazards that may be reasonably expected to occur at each step of the process and then conduct a hazard analysis to identify for the HACCP plan which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of a safe food. The team must then consider what control measures, if any, exist that can be applied for each hazard.

7) Determine Critical Control Points (CCPs) (HACCP principle 2)

A Critical Control Point (CCP) is a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. If a hazard has been identified at a step where control is necessary for safety, and no control measure exists at that step, or any other, then the product or process should be modified at that step, or at any earlier or later stage, to include a control measure. The determination of a CCP in the HACCP system can be facilitated using a decision tree.

8) Establish critical limits for each CCP (HACCP principle 3)

The critical limit is the criterion that separates acceptability from unacceptability. Critical limits must be specified and validated if possible for each critical control point. In some cases more than one critical limit will be elaborated at a particular step. Criteria often used

include measurements of temperature, time, moisture level, pH, a_w, available chlorine, and sensory parameters such as visual appearance and texture.

9) Establish a monitoring system for each CCP (HACCP principle 4)

Monitoring is the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control. Monitoring procedures must be able to detect loss of control at the CCP. Further, monitoring should ideally provide this information in time to make adjustments to ensure control of the process to prevent violating the critical limits. The task or test, the frequency of testing and the persons responsible for carrying out the task should be detailed in the monitoring procedure. Most monitoring procedures for CCPs will need to be done rapidly because they relate to on-line processes and there will not be time for lengthy analytical testing. Physical and chemical measurements are often preferred because they may be done rapidly.

10) Establish corrective actions (HACCP principle 5)

Specific corrective actions must be developed for each CCP in the HACCP system in order to deal with deviations when they occur. The actions must ensure that the CCP has been brought under control. Actions taken must also include proper disposal of the affected product.

11) Establish verification procedures (HACCP principle 6)

Verification activities that can be used to determine if the HACCP system is working correctly include:

- Review of the HACCP system and its records.
- Review of deviations and product dispositions.
- Confirmation that CCPs are kept under control.
- Auditing methods, procedures and tests.
- Random sampling and analysis.
- System validation (ensuring development of a documented system that meets all Codex requirements, and updating the system when changes are made in processes, steps or materials used in production)

12) Establish documentation and record keeping (HACCP principle 7)

Efficient and accurate record keeping is essential to the application of a HACCP system. HACCP procedures should be documented. Documentation and record keeping should be appropriate to the nature and size of the operation. Documentation examples are:

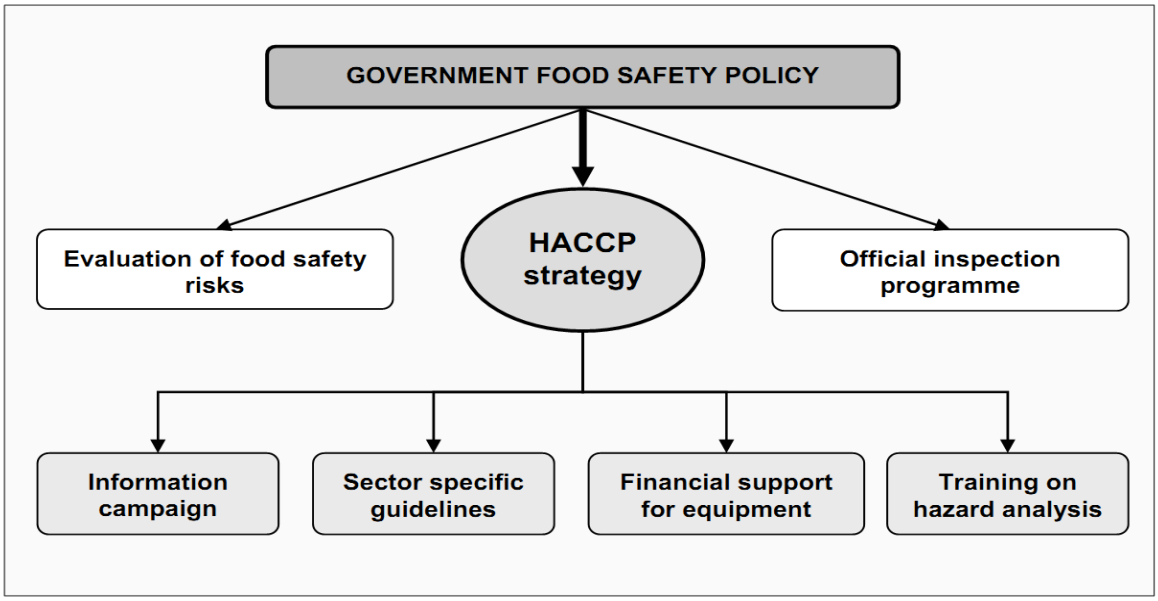
- hazard analysis
- CCP determination
- critical limit determination

Record examples are:

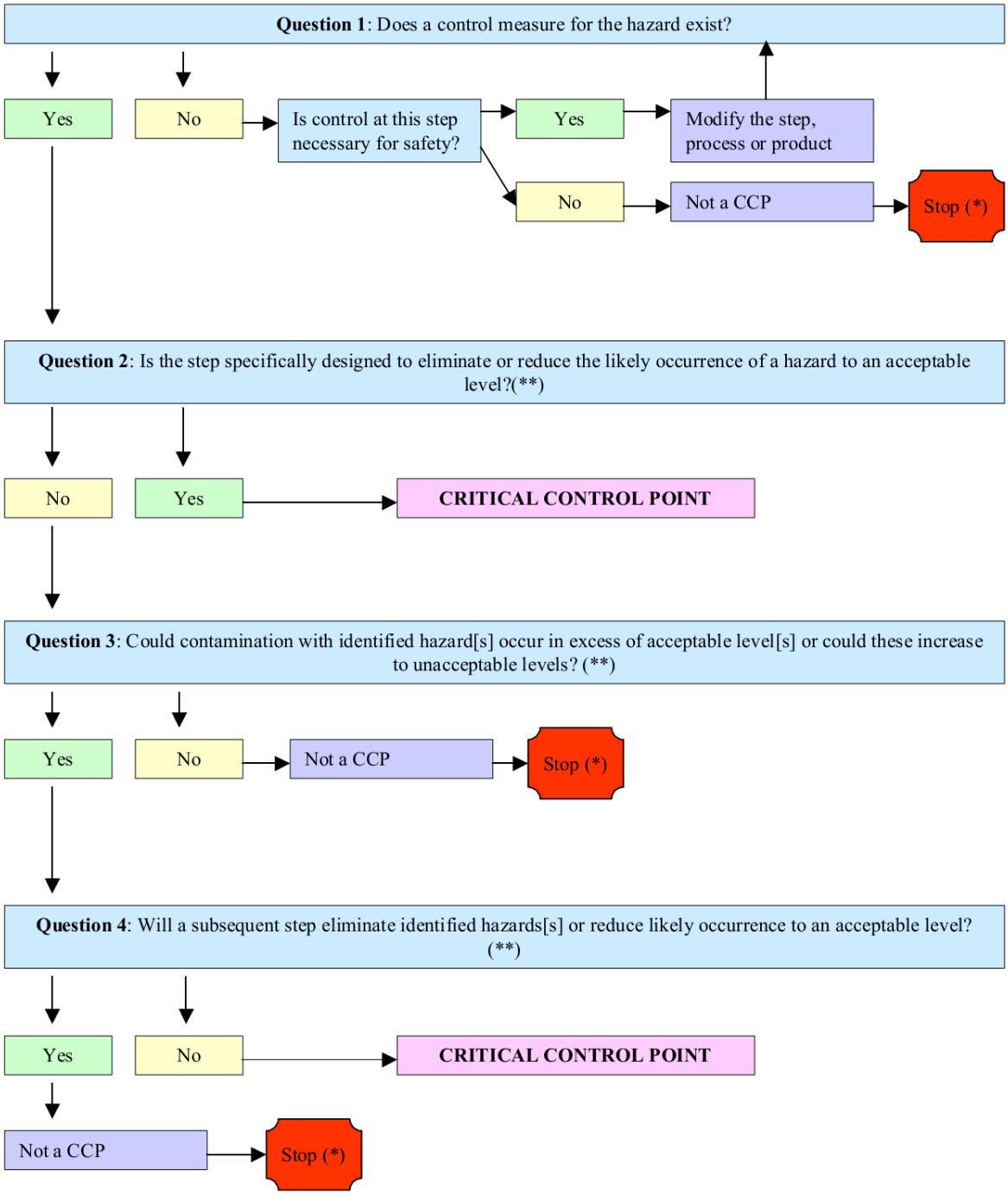
- CCP monitoring activities
- deviations and associated corrective actions
- modifications to the HACCP system

Advantages	*Disadvantages*
+ Output is easy to understand – useful for communication + Fosters holistic and comprehensive understanding of hazards and controls for a process + Emphasis on control not detection	- Requires comprehensive process understanding – not ideally suited for little known hazards or processes - Does not quantify or prioritize risks - Does not quantify impact of additional controls on reducing risk

Government policy and strategies



Example of decision tree to identify CCPs



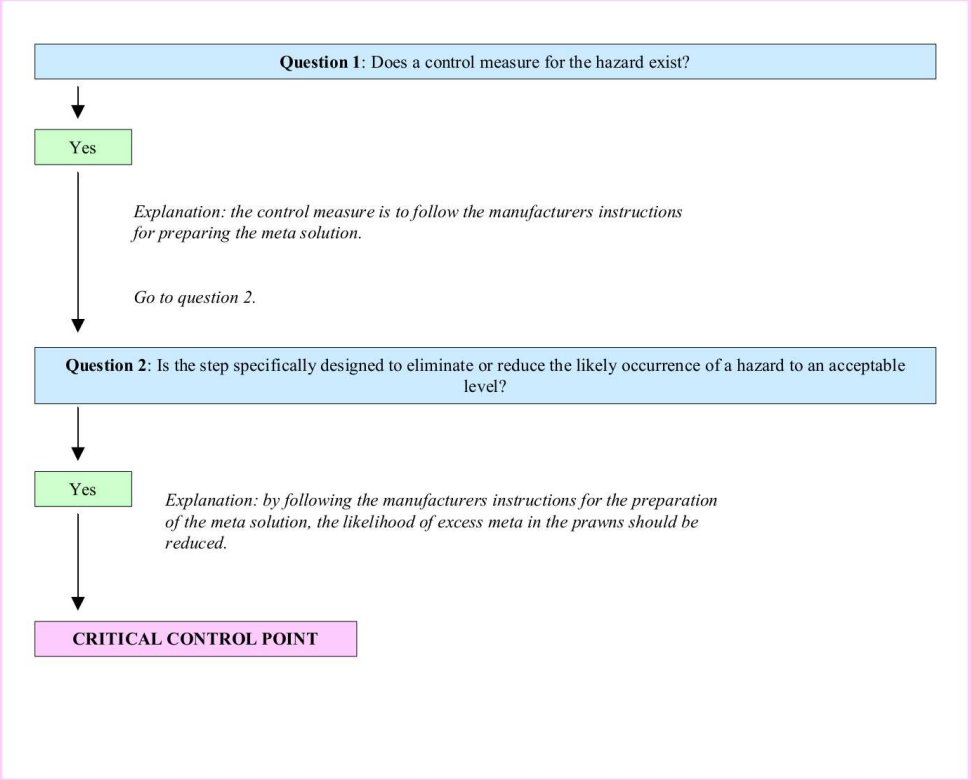
Example identification of a CCP

Example

Process Step: Dipping prawns in a sodium metabisulphite (meta) solution.

Potential Hazard: Excess SO2 (Sulphur dioxide) in the prawns has been identified as a potential hazard.

Using the CCP decision tree (Appendix 4)…



Following the CCP decision tree, this step is a critical control point.

Definitions

Control (verb): To take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan.

Control (noun): The state wherein correct procedures are being followed and criteria are being met.

Control measure: Any action or activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Corrective action: Any action to be taken when the results of monitoring at the CCP indicate a loss of control.

Critical Control Point (CCP): A factor, practice, procedure, process or location that can be controlled in order to prevent, control, eliminate or reduce a hazard, or minimise the likelihood of its occurrence.

Critical limit: The limit to which a hazard must be controlled to prevent, control, eliminate or reduce to an acceptable level the occurrence of the hazard.

Critical step: A step from a process flow chart that is associated with a CCP, which if not controlled, may give rise to a hazard.

Deviation: Failure to meet a critical limit.

Flow diagram: A systematic representation of the sequence of steps or operations used in the production or manufacture of a particular food item.

HACCP: Hazard Analysis Critical Control Point. A system that identifies evaluates and controls hazards, which are significant for food safety.

HACCP plan: A document prepared in accordance with the HACCP principles to ensure the control of hazards, which are significant for food safety.

Hazard: A biological, chemical or physical agent in, or a condition of, food that has potential to cause an adverse health affect.

Hazard analysis: The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan.

Monitor: To conduct a planned sequence of observations or measurements to assess whether the critical control point is under control.

Validation: Providing evidence to demonstrate the effectiveness of a system of controls.

Verification: Applying methods, procedures, tests and other evaluations in addition to monitoring to determine whether a requirement is complied with.

Conclusion

Traditionally, the Hazard Analysis and Critical Control Point (HACCP) methodology has been considered to be a food safety management system. It aims to prevent known hazards and to reduce the risks that they will occur at specific points in the food chain. The same principles are also increasingly being applied, in other industries, such as the car industry, aviation and the chemical industry. This text provides general guidance on the use of the HACCP system to ensure the quality of pharmaceuticals, while recognizing that the details of its application may vary depending on the circumstances. It does not provide detailed information on major hazards.

Hazards affecting quality are controlled to a certain extent through the validation of critical operations and processes in the manufacture of finished pharmaceutical products in accordance with Good Manufacturing Practices (GMP). However, GMP does not cover the safety of the personnel engaged in manufacture, while both aspects are covered by HACCP.

Procedures, including GMP, address operational conditions and pro-vide the basis for HACCP. HACCP is a systematic method for the identification, assessment and control of safety hazards. Such hazards are defined as biological, chemical, or physical agents or operations that are reasonably likely to cause illness or injury if not controlled.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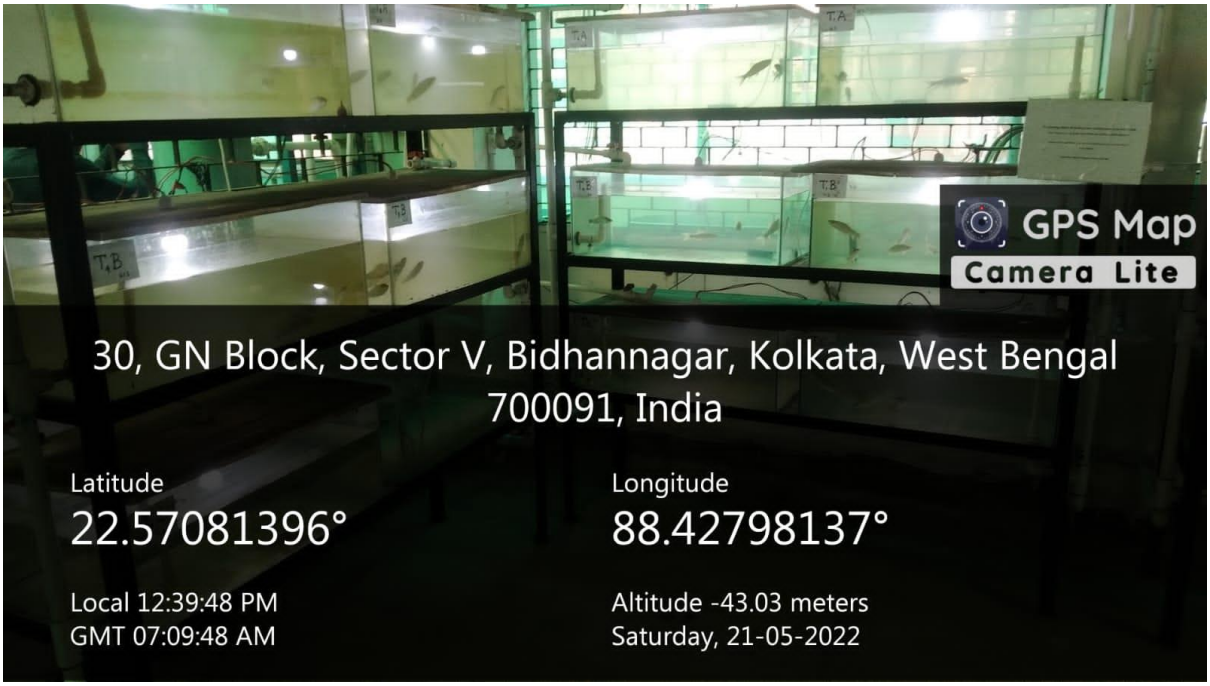
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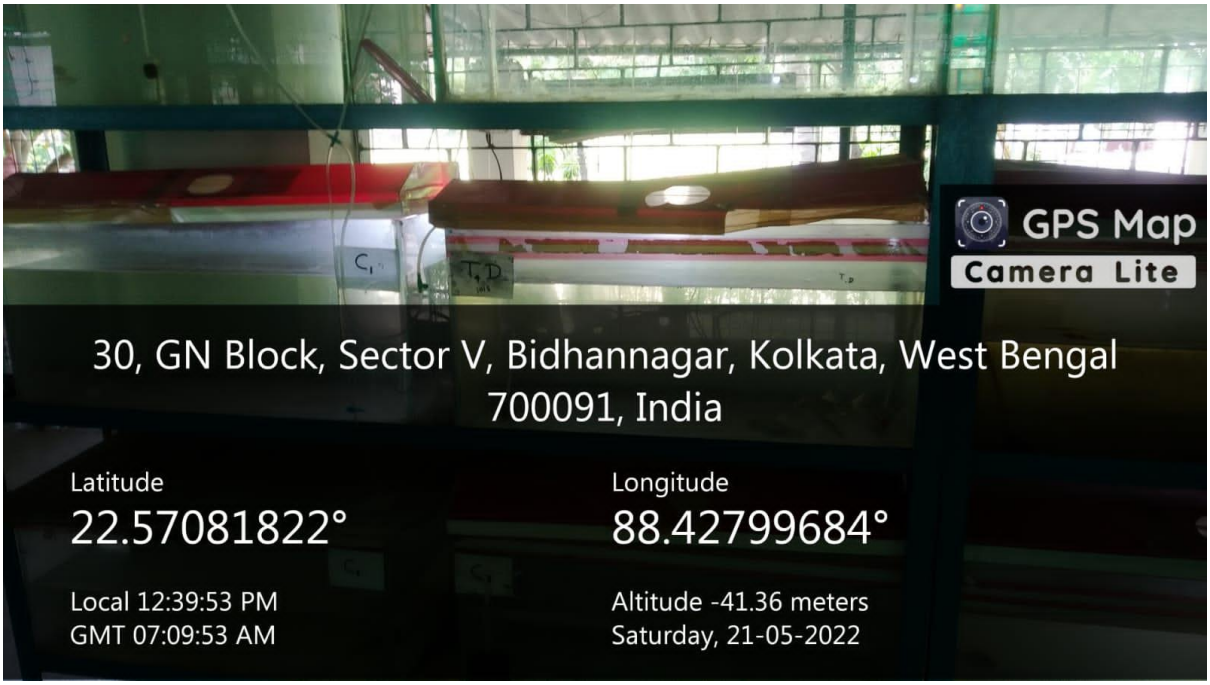
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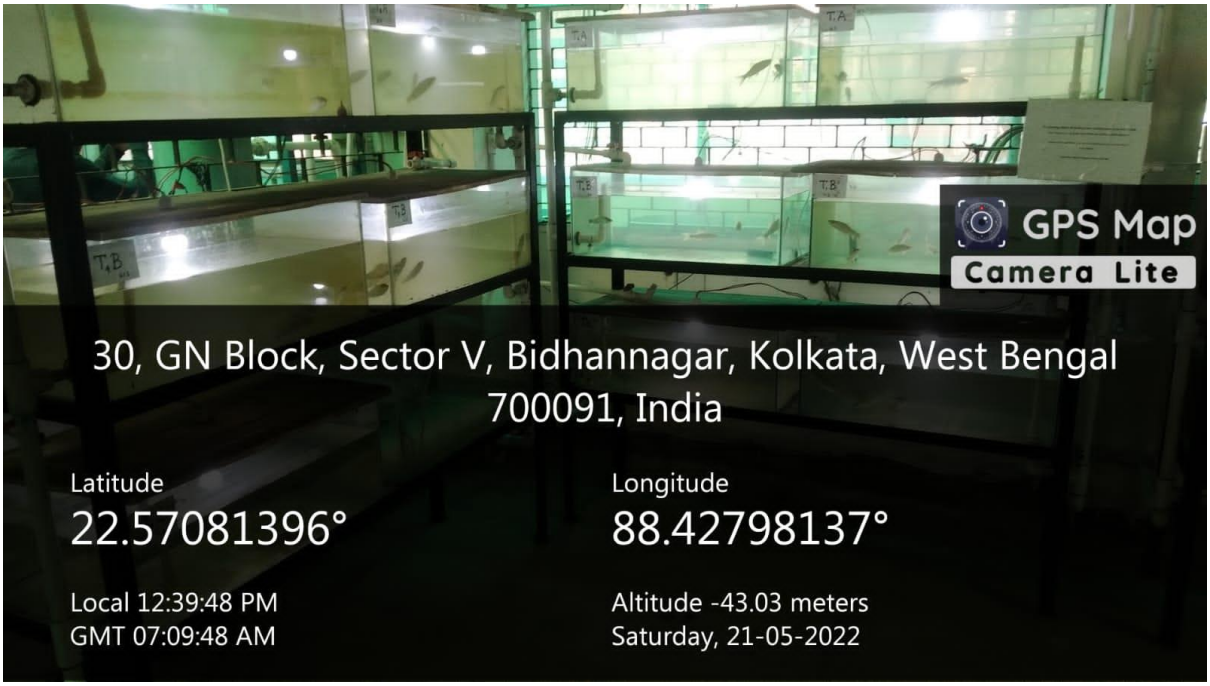
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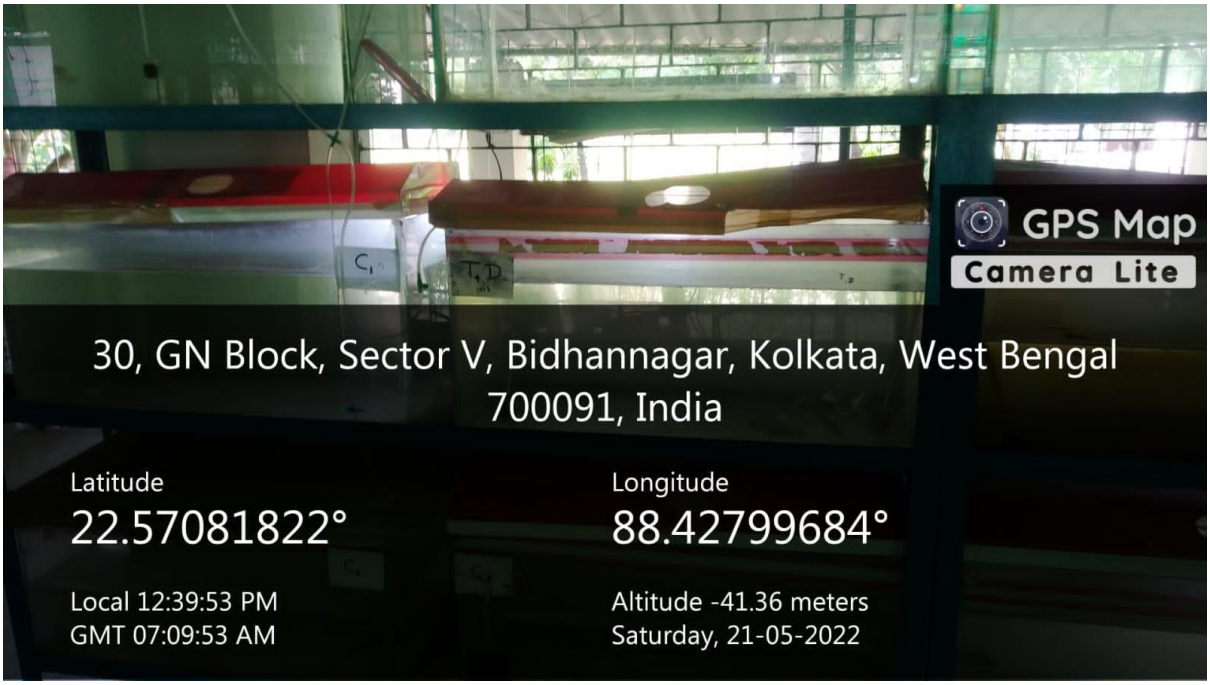
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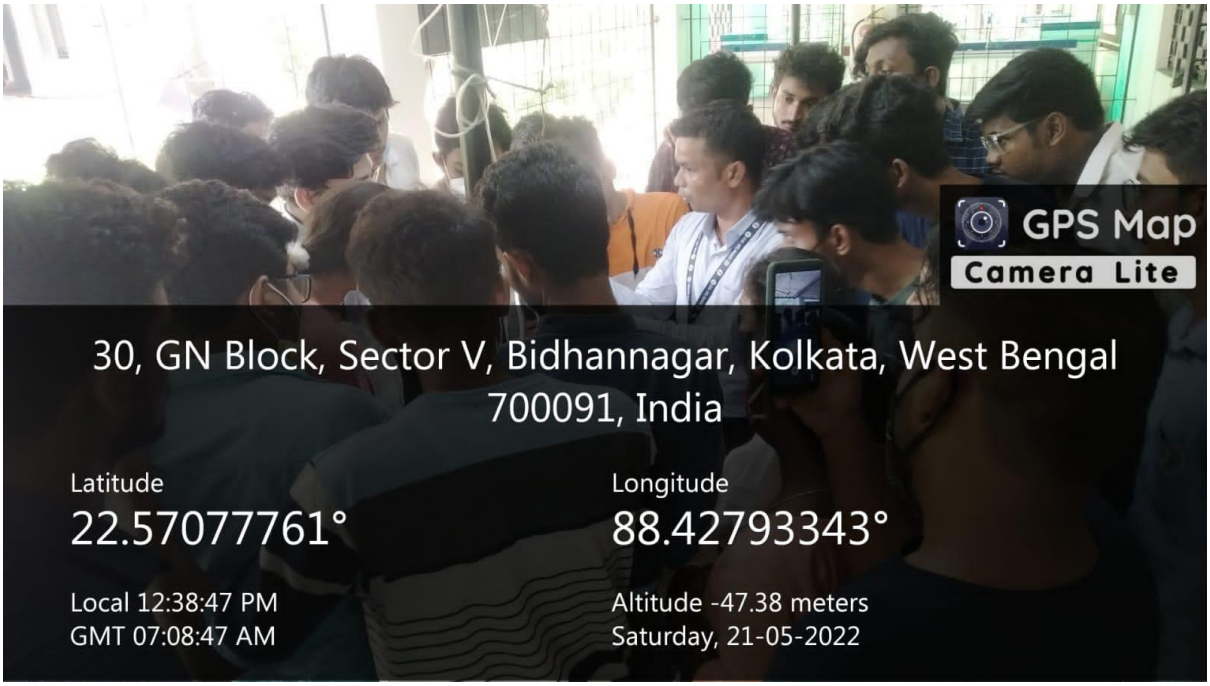
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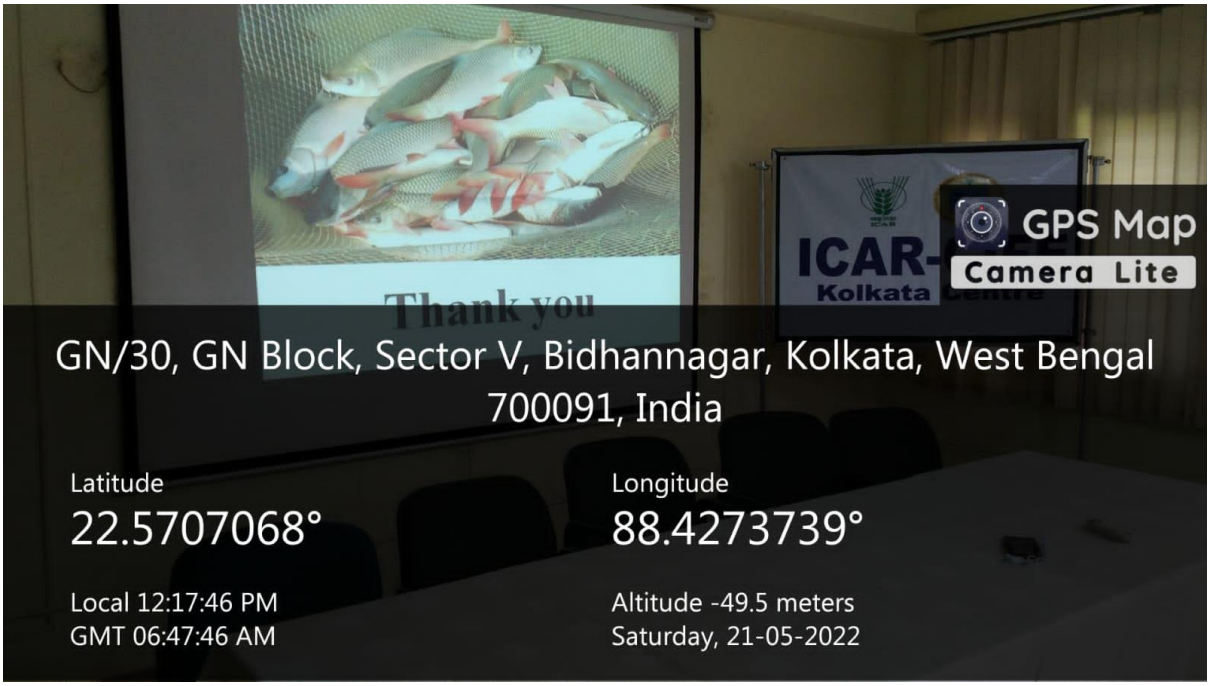
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pH Colour Chart
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4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10
≥11
14
© Dr. Subhendu Datta, ICAR-CIFE
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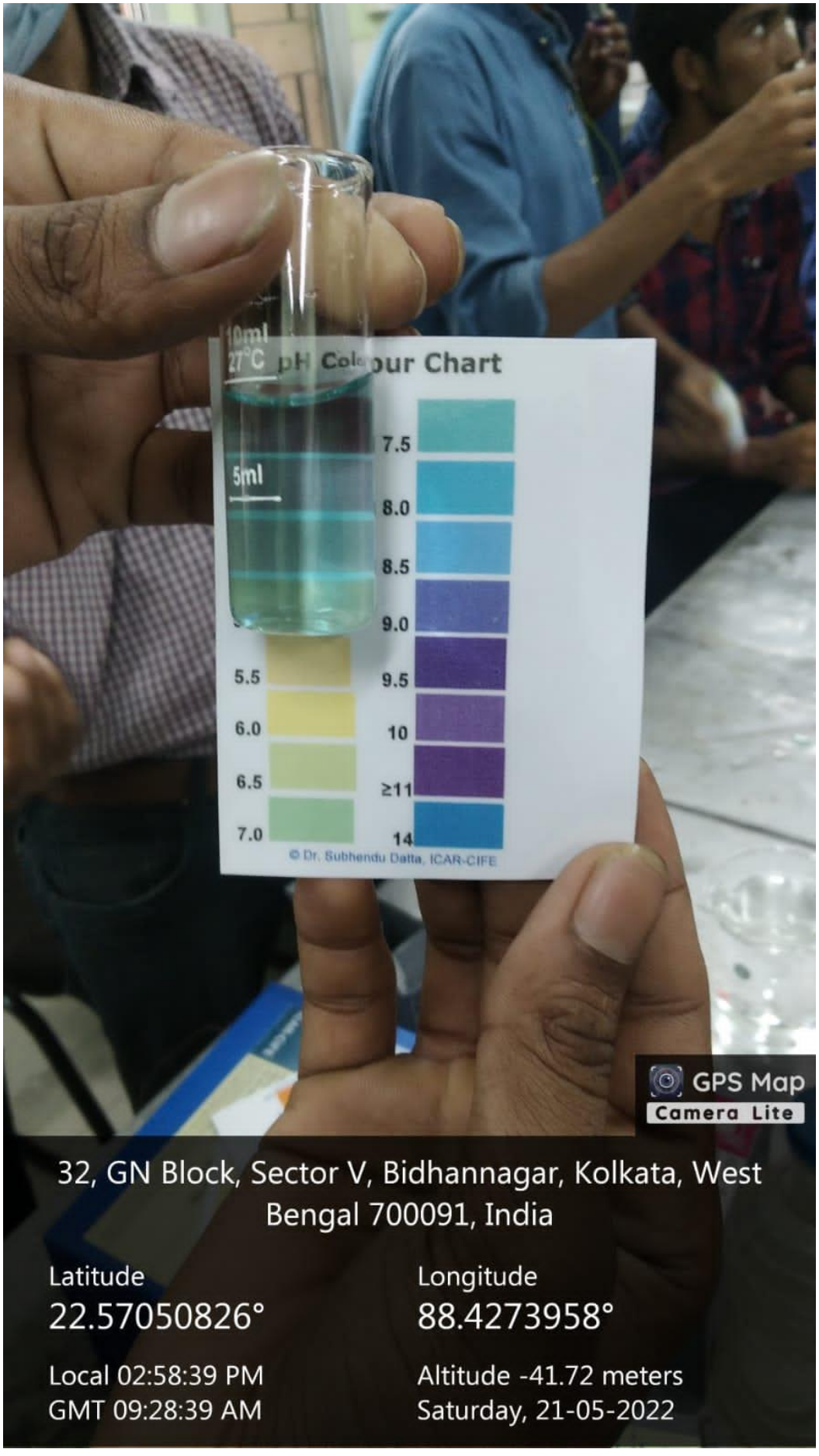
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27°C
pH Colour Chart
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14
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6.5
7.0
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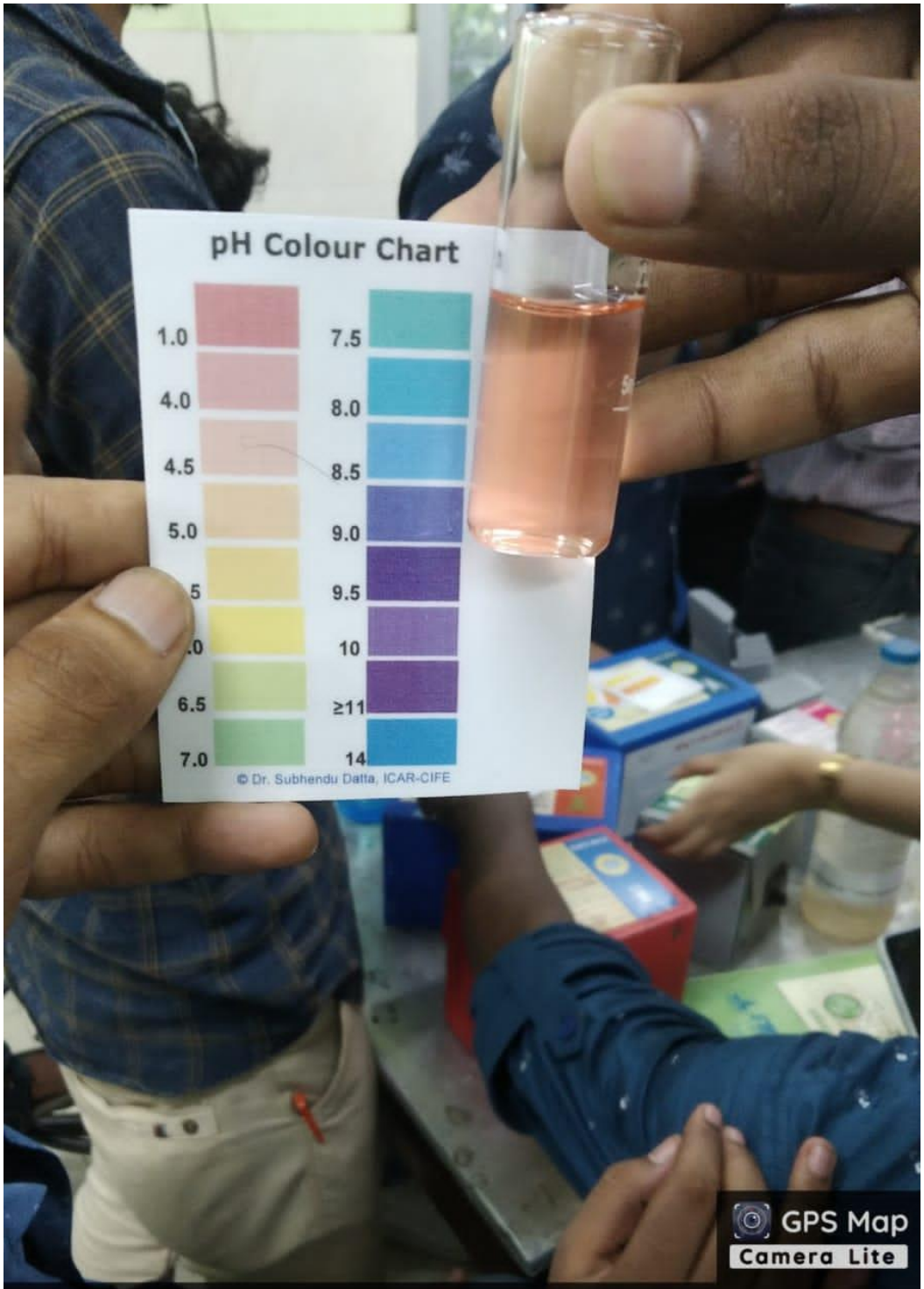

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Altitude -41.67 meters
Saturday, 21-05-2022


भा.कृ.अनु.प.-केन्द्रीय मात्स्यिकी शिक्षा संस्थान ICAR-CENTRAL INSTITUTE OF FISHERIES EDUCATION
कोलकाता केन्द्र KOLKATA CENTRE
EDUCATION FOR BLUE REVOLUTION ● FARMER FIRST AND STUDENT READY
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Kolkata Centre
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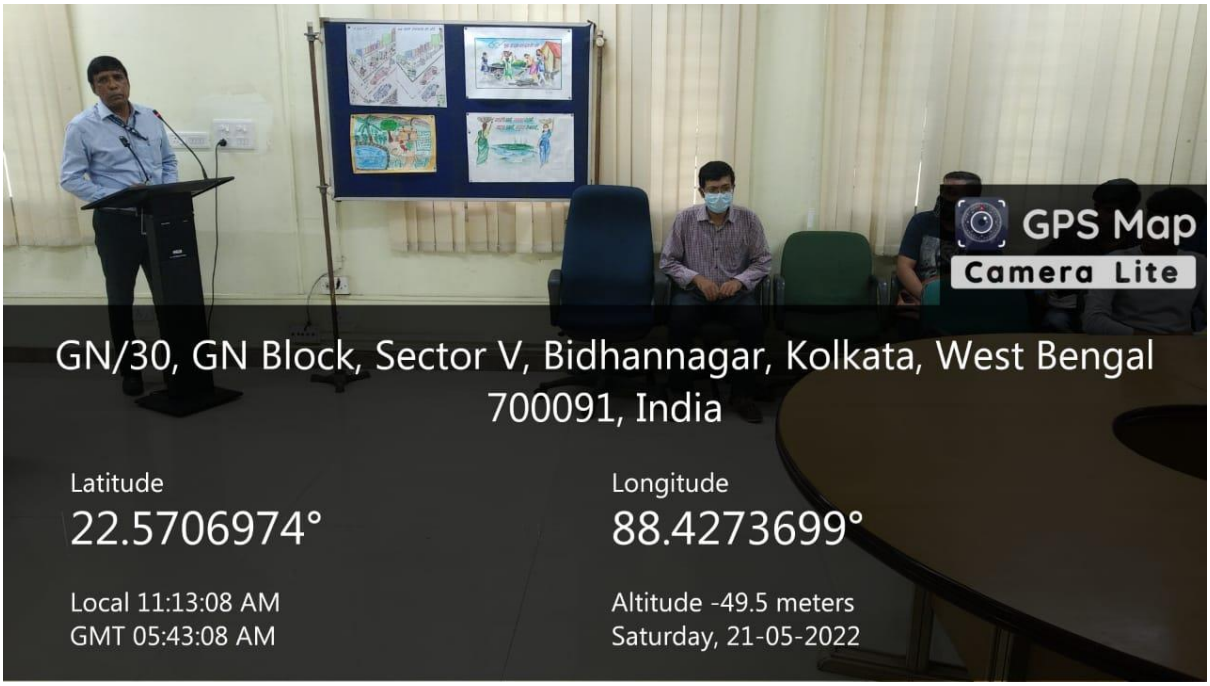
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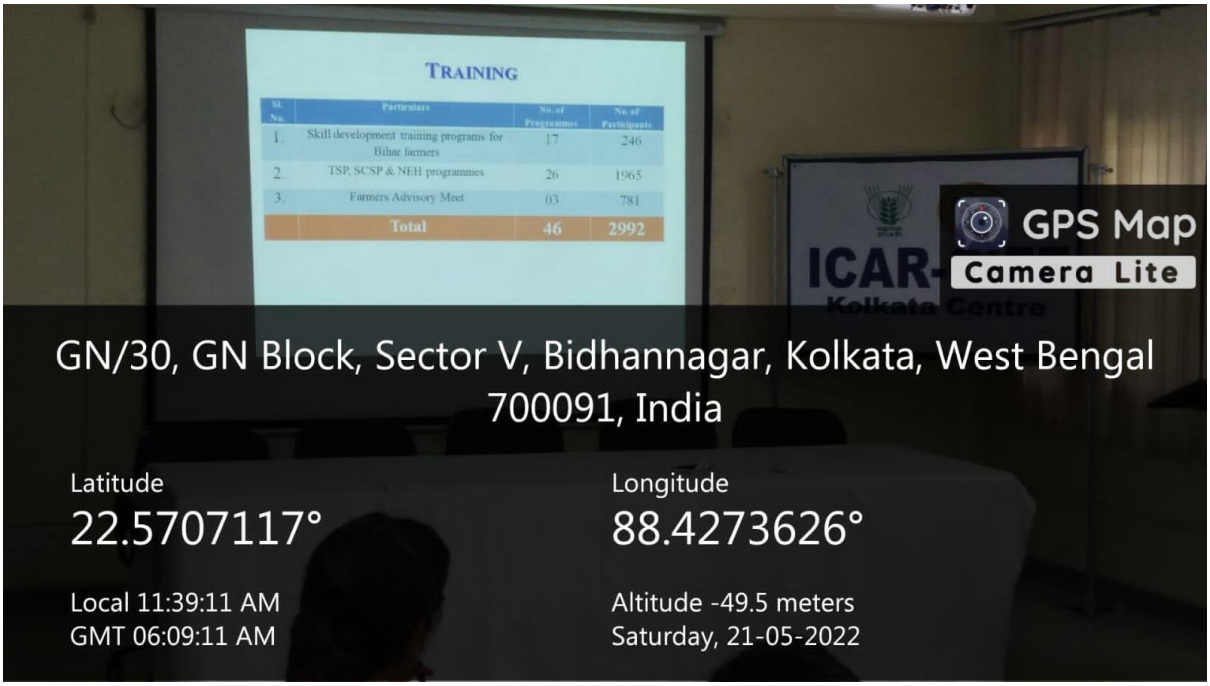
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No. of Programmes
No. of Participants
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2. TSP, SCSP & NEH programmes 26 1965
3. Farmers Advisory Meet 03 781
Total 46 2992
ICAR-
Kolkata Centre
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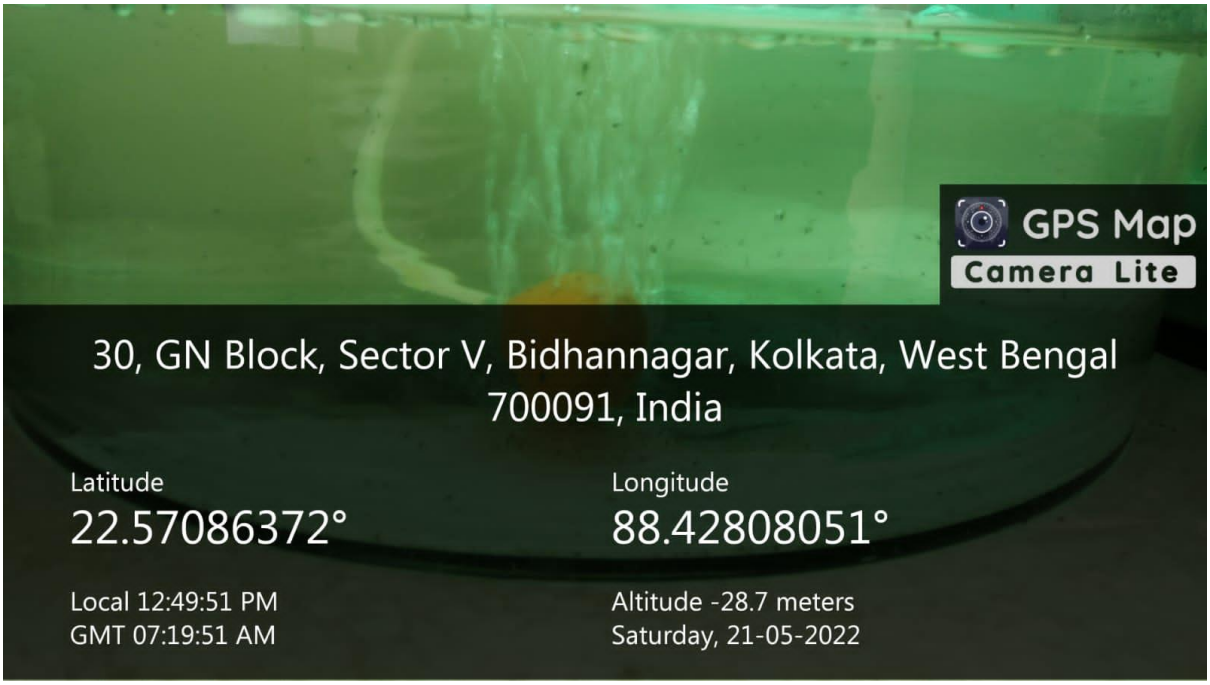
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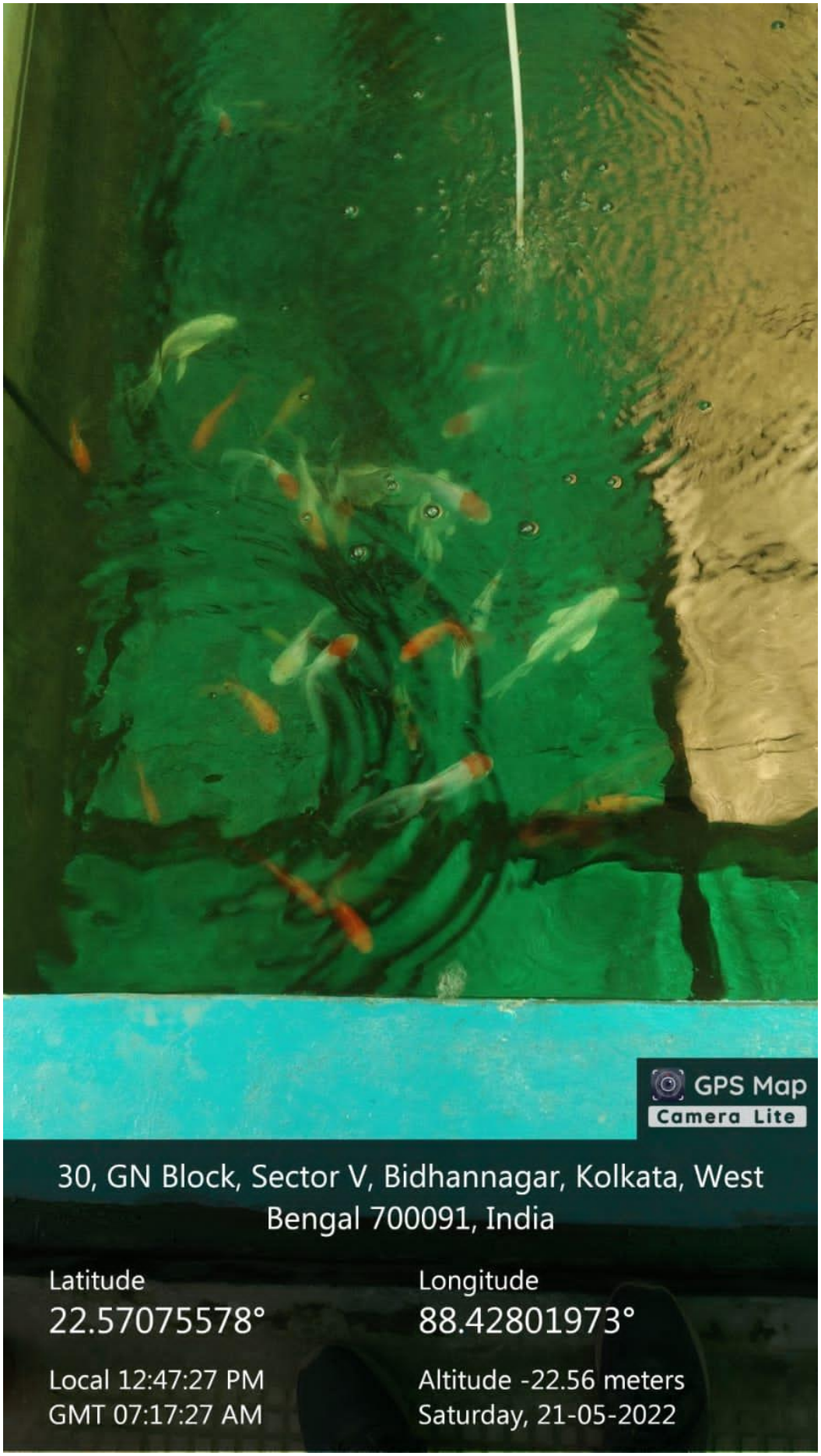
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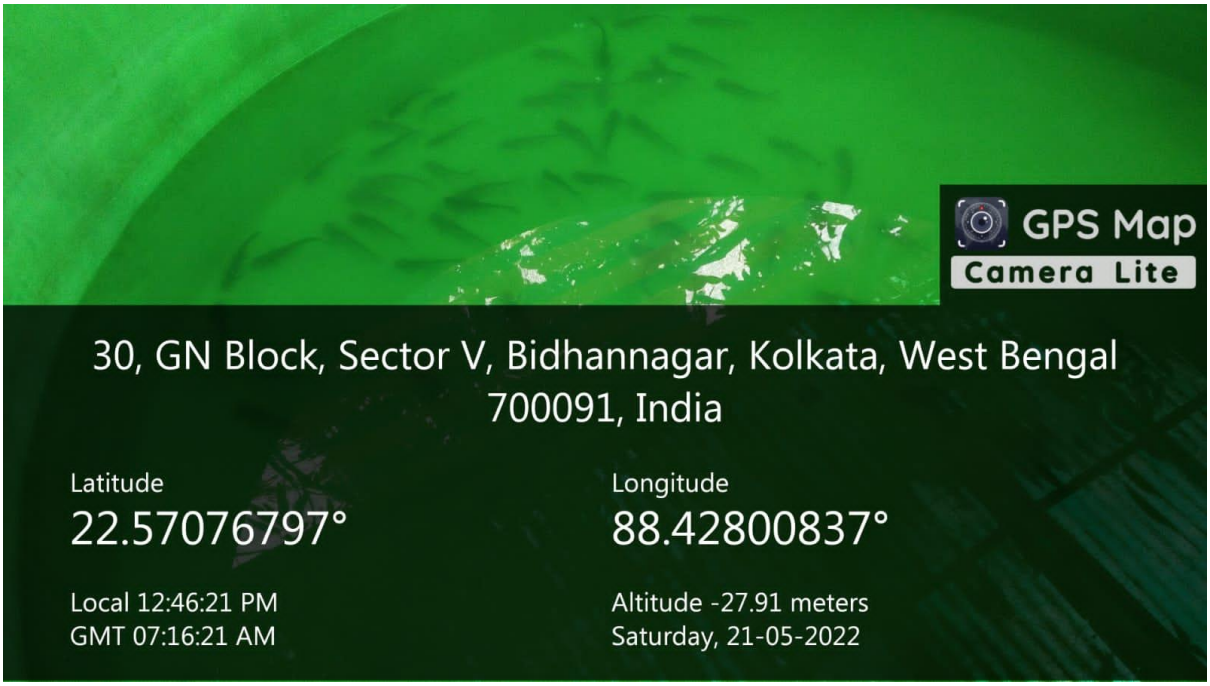
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Altitude -27.91 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57076849°
Longitude
88.42800336°
Local 12:46:04 PM
GMT 07:16:04 AM
Altitude -26.95 meters
Saturday, 21-05-2022

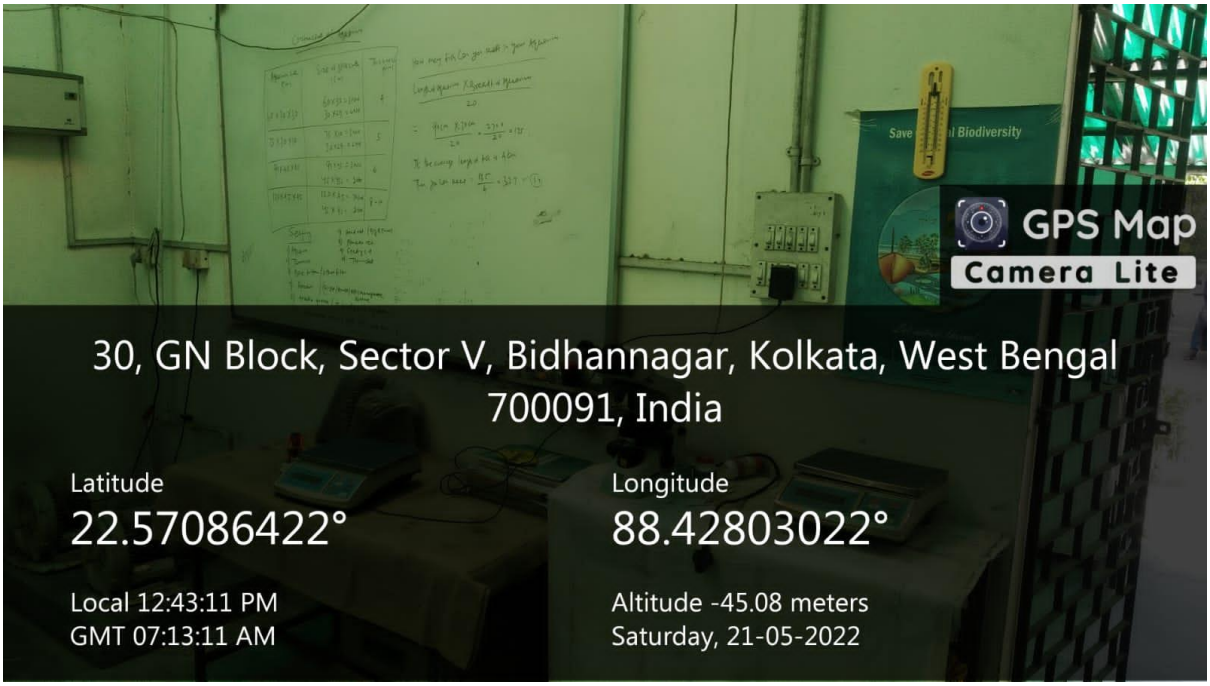

GPS Map
Camera Lite
32, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.5705338°
Longitude
88.4279279°
Local 12:46:02 PM
GMT 07:16:02 AM
Altitude -47.7 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57075246°
Longitude
88.42800224°
Local 12:45:49 PM
GMT 07:15:49 AM
Altitude -34.97 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57086527°
Longitude
88.42802324°
Local 12:43:16 PM
GMT 07:13:16 AM
Altitude -44.1 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57067534°
Longitude
88.42801914°
Local 12:45:44 PM
GMT 07:15:44 AM
Altitude -29.56 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57065376°
Longitude
88.42799648°
Local 12:45:41 PM
GMT 07:15:41 AM
Altitude -27.7 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57086422°
Longitude
88.42803022°
Local 12:43:11 PM
GMT 07:13:11 AM
Altitude -45.08 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57086071°
Longitude
88.42806325°
Local 12:42:54 PM
GMT 07:12:54 AM
Altitude -35.3 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57085905°
Longitude
88.42803498°
Local 12:43:03 PM
GMT 07:13:03 AM
Altitude -43.27 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.5708508°
Longitude
88.4280665°
Local 12:42:50 PM
GMT 07:12:50 AM
Altitude -36 meters
Saturday, 21-05-2022


GPS Map
Camera Lite
30, GN Block, Sector V, Bidhannagar, Kolkata, West Bengal 700091, India
Latitude
22.57082431°
Longitude
88.42807731°
Local 12:42:42 PM
GMT 07:12:42 AM
Altitude -33.58 meters
Saturday, 21-05-2022