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Handling and transport of fish

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Abstract

The tropical fisheries comprising of several species of fish in varying sizes impose several problems in their handling and preservation. This is one of the reasons for substantial wastage of the landed wealth. The paper discusses the precautions to be taken in proper handling, temporary preservation methods such as icing, as well as storage in refrigerated / chilled sea water. The need for packaging and containers, both traditional and modern, for short and long distance transportation of fresh fish is indication. A short account of transportation of live fish and the importance of hygiene in maintaining fresh fish quality also are discussed.

Introduction

Fishes are one of the most perishable of foodstuffs. There are a large number of species of edible fish, small to large in size. They are caught from different environs - marine, brackishwater and freshwater sources and exhibit wide variations in their chemical composition, particularly fat and water. Some fishes contain very high amounts of highly unsaturated fat. Many of the fish species are available from different locations on a restrictive seasonal basis. These are some of the difficulties responsible for slower development of technology and its utilisation.

It has been estimated that on a global basis, around 27 % of the harvested fish are being discarded as inferior due to quality considerations such as the meat yield. A sizeable quantity of low value fish is being thrown out to the sea by many deep-sea trawlers in India also. Large quantities of valuable protein food is thrown away as waste or processed into fishmeal or even converted to manure. Secondly any lapse in proper handling, processing, storage, and distribution system can also lead to quality deterioration and consequent wastage.

Fish is perhaps the cheapest source of high quality protein. Fish has the easily digestible protein containing all the essential amino acids in a most balanced state. The perceived health benefits of eating fish have triggered a general shift in demand from meat to fish rather on a global basis. The scenario is not much different in the Indian context also (Ghafforunissa, 2001). To feed the population even at the present level of fish consumption of 4 kg/person (9.5 kg assuming 56 % of Indians are fish eaters), it is estimated that the country will have to produce at least 0.2 m t of fish per annum (Gopakumar, 2000). All these call for besides increasing the production, the most effective utilisation of landed fish without waste. To minimise the wastage, the primary need is proper care of the catch and appropriate methods of handling and storage. Proper handling should start right from the time the fish is landed aboard.

Fish consumption, at least in the developing countries like India, had been restricted to the areas of production and the nearby localities. Lack of knowledge of the necessary methods of handling and short/long term preservation, absence of network of roads connecting the landing centres to the potential areas of consumption in the hinder land, absence of the required type of containers and transport vehicles have been the major impediments standing in the way of distribution and thus resulting in wastage of the landed fish. However, during the process of planned development of the country, adequate care has been provided to development of fisheries and the development of necessary infrastructure for handling and transport of fish, which has been instrumental in minimising the wastage, and distribution of fish in high quality to the consumers, even in areas located far away from the landing cites.

Fish become spoiled as a result of various physical, chemical and other post-mortem changes taking place in them (Shamasundar, 2001). They may be distributed fresh or processed into different products and marketed. The prime concern is that it should reach the consumer in an acceptable condition. Whether distributed fresh or further processed, the quality of the end product will depend on the quality of the initial material. In either case the quality will depend on how the fish was handled onboard, how it was preserved, packaged, transported. Primary responsibility of ensuring the quality of landed fish rest with the initial handling practices and personnel involved.

Fish handling

The most important factors to be considered in the initial handling and transport are the temperature, duration of storage/transport and the hygiene in all respects including that of the handlers. Good handling practices should ensure that the fish retains its natural freshness to the maximum possible extent. The important requirements are cleaning the fish from dirt and other debris, chilling it immediately to prevent its temperature from rising and maintaining high standards of cleanliness at all stages (Iyer, 2000). Fish will spoil quickly depending on several factors including fishing methods, feeding conditions, maturity, sex and so on. Fish, which has struggled for long in the net or onboard, is likely to spoil more quickly than a fish, which dies instantaneously or is killed quickly. Similarly fish with its stomach full while catching will also spoil quickly and fish, which is bruised while catching or handling, will spoil more quickly than a physically sound fish (Nair, *et al.*, 1974).

Even though the flesh of live fish is sterile, it may harbour bacteria in its intestine, gills, body slime. Under favourable conditions, the bacteria will multiply rapidly and bring about spoilage. A hundred-fold increase in bacterial load has been observed in bruised fish, compared to physically sound ones at different stages of preservation in crushed ice. Even after death of the fish the enzymes remain active and bring about autolytic changes leading to degradation of chemical constituents, fat and resulting in deterioration in flavour, texture and taste (Shamasundar, 2001) Therefore the immediate need is to arrest or at least retard these changes.

Washing & sorting

Immediately after unloading, the catch should be washed well with water to free from dirt and other extraneous matter. Clean seawater, when taken from distant open sea is ideal; however, the sea water may also be chlorinated to 10-ppm to make it safe for use. Washing cleanses the fish of most of the surface bacteria. The catch may consist of several species of fish, big and small in size. Therefore, the fish should be sorted species-wise as also size-wise. Bruised, deceased, decomposed or otherwise damaged fish shall be separated and either thrown back to the sea or kept separately for probable conversion to fish manure. High value fish are generally carefully sorted out and suitably preserved.

Evisceration and removal of gills

Gills and viscera harbour several spoilage bacteria in large numbers, which can multiply and infiltrate into other areas. Partially digested food in the viscera may become sour or putrid due to bacterial action. The powerful digestive enzymes in the viscera can bring about accelerated spoilage of fish. Therefore, wherever possible, it is advisable to remove the gills and viscera before the fish is preserved and stored. Evisceration should not cause any bruise on the exposed belly portion. Retention of any visceral parts can easily contaminate the soft belly whereas bruises can cause accelerated spoilage by permitting easy penetration of bacteria. Removal of viscera and gills should be done without contaminating other parts. After each operation the fish should be washed thoroughly.

Bleeding

The blood in the fish can clot and turn black or brown in colour adversely affecting the colour and appearance of the meat. Therefore, bleeding is considered a desirable step before preservation of fish. Bleeding or evisceration is not possible with small fish and is generally restricted only to fish of reasonably large fish like tuna, seer, and catfish. Slitting the throat followed by hanging the fish by tail or slitting the throat and immersing in cold water will serve to bleed to satisfactory levels.

Icing

Temperature is a very important factor deciding the shelf life of fish. Elevated temperature can bring about quick spoilage of fish. One of the best methods of preservation involves lowering the temperature. The easiest, cheapest and reasonably efficient method of lowering the temperature of fish is by icing. As a cooling medium for fish, ice has a great deal in its favour. It has a very large cooling capacity for a given weight or volume. Ice is harmless, portable as well as cheap. It is especially valuable for chilling fish since very rapid cooling can be achieved through intimate contact between the fish and small pieces of ice. Icing will maintain the fish at a temperature slightly above, that at which fish will freeze. Ice will keep the fish cool, moist, glossy and will control deterioration.

The rate, at which fish spoils, vary linearly with temperature in the range -1 to 2.5°C. The rate of spoilage is twice as fast at 2.5°C as at 1.1°C. At 5.5°C it is twice as fast as at 0°C. Growth of spoilage bacteria is significantly reduced by small decreases in the temperature, in the range -1 to 5°C. This emphasises the need for avoiding any exposure of fish to sun or to elevate the temperature and of chilling immediately to a temperature at which bacterial and enzymic activities are kept under control. Therefore, the fish should be washed, sorted, eviscerated, bled and again washed and stored in ice or chilled employing any of these methods as quickly as possible.

Icing does not prevent spoilage, but controls it. Fish can be stored in ice and maintained in good condition for 3-15 days depending on the species and several other intrinsic factors. Fatty fish like sardine has a limited shelf life of 2-5 days only in ice. Such fish become rancid due to oxidation of fat. The belly portion becomes soft and ruptured due to the action of enzymes and bacteria. This problem will be more aggravated if the fish is caught while in active feeding stage. Freshwater fish keep longer in ice compared to their marine counterparts; so also the tropical species keep longer in ice than the cold-water species. Theoretically about 30% of ice by weight of the fish is needed to bring the temperature down to 0°C. However, ice is needed to maintain this temperature during storage and distribution, to cool the containers as also to account for the melting caused by air ingress. Therefore, in practice the ice fish ratio is maintained at 1:1.

Quality and type of ice

A potential source of contamination of fish during the primary preservation is the ice itself. The beneficial effects of hygienic handling and other precautions taken can more than be offset if the ice used is of poor quality. The bacterial count of ice made of water of the prescribed quality is in the range 10^2 to 10^3/g; but this may be several-fold if contaminated water is used for making ice or if the ice is allowed to be contaminated during its subsequent handling and storage like dragging on dirty floors or using contaminated crushers and storage bins. Use of such ice will negate the very purpose of icing fish. It is also important that ice left over from any previous icing operation should not be used to ice fresh batches of fish, even if such ice is unused.

Block ice, rapid block ice, flake ice, plate ice, tube ice and soft ice are some of the important types of ice used in preservation of fish. Each type has its own advantages. Block ice is finely crushed before icing fish, as it provides a large surface area for unit mass and cover more fish enabling its rapid cooling. It has also the advantage that block ice can be carried onboard and crush it, only whenever needed. One major disadvantages of crushed ice is that it will have sharp contours, which can cause bruises in the fish.

An improvement in ice making process, which yields ice with soft contours, and in the shape of very thin plates, usually 100-1000 mm^2 and 2-3 mm in thickness is flake ice. Flake ice also has a very large surface area for unit mass and can cover larger quantity of fish for a given weight compared to crushed ice. No bruise or rupture of fish will take place by using flake ice. Plate ice has all the advantages of flake ice and also the added advantage that its thickness can be varied at will and its production process is very quick. Tube ice is generally made as a hallow cylinder of 50 x 50 mm with a wall thickness of 10-12 mm. Being of bigger in size than that used in icing fish, tube ice will have to be crushed to the required size before icing fish. Tube ice also has all the advantages of flake ice. Soft ice is generally used in the form of slurry hence it can make perfect contact with the fish. It does not cake nor forms air pockets as can happen in other types of ice.

Storage characteristic of fish held in ice

Ice cools the fish by absorbing heat from it, which results in its meltage. The beneficial effect is that it slows down the bacterial and chemical reactions leading to spoilage. However, this melt water will carry away with it a considerable percentage of soluble proteins, salts and other flavour bearing components as well as nutrients. The extent of spoilage and the accompanying chemical changes will vary considerably depending on the type and species of the fish concerned. For example glycine, the amino acid responsible for sweet flavour in the shrimp meat as also minor components like sugar, sugar phosphates, nucleotides. Responsible for characteristic flavours are rapidly lost during iced storage. The loss of solids by leaching will also depend on the form, in which the fish is iced; for example the extent of loss will be higher in the case of pealed shrimp and fish fillets compared to whole shrimp / fish.

Refrigerated seawater storage

Refrigerated seawater system is used primarily onboard fishing vessels to maintain fish at 0 or -1°C, cooling slightly lower than that can be achieved using ice. Seawater cooled by mechanical means (refrigerated seawater, RSW) is circulated through tanks installed onboard fishing vessels. Fish is kept in the tanks and being less dense than the seawater will float in it. Alternately fish can be suspended in perforated vessels immersed in RSW. The fish may be stored in the tank until docking or may be removed after sufficient cooling to chill or frozen storage. Agitation is provided in the tank by pump, mechanical stirrer or compressed air.

Chilling in RSW is faster than chilling in melting ice because of the intimate contact possible between the fish and the cooling medium (Chapman, 1990). Preservation in RSW is satisfactory for non-fatty fish of varying sizes and can have a longer shelf life than in ice. More fish can be packed per unit volume compared to icing preservation causing no undesirable physical damage to the fish. However, with fatty fish like oil sardine, development of rancidity is a limiting factor. Uptake of salt by the meat, which often reaches objectionable levels, is another disadvantage. Uptake of salt, however, will depend on the size and species of fish, whether the fish is gutted or whole, the ratio of fish to water and the length or duration storage. Eyes of the fish stored in RSW will become opaque and the gills become bleached earlier compared to iced fish. However, RSW stored fish will have greater firmness and better appearance compared to iced fish. Some bacteriological problems are also associated with RSW storage. Even at the low temperature of operation the liquid in the tank will act as a favourable substrate for bacterial build up.

Bubbling carbon dioxide gas through the water can increase Shelf life of the fish held in RSW. The system is then referred to as modified RSW. Addition of carbon dioxide to the RSW system lowers the pH, retards bacterial growth and prolongs storage life (Barnett *et al.*, 1978; Bullard & Collins, 1978). Carbon dioxide is usually bubbled through diffusers in the bottom of the tank or introduced into the suction side of the circulating pump.

Chilled seawater storage

Another method of temporary preservation that can be employed onboard the vessel is in chilled seawater. In chilled seawater storage (CSW) ice is added to the seawater or dilute brine made up to the concentration of seawater. The resulting cold mixture is often called slush ice, which extends the shelf life longer than direct icing (Thomas *et al.*, 1996; Durairaj & Krishnamurthy, 1986; Chapman, 1990; Anon, 1991, Anon, 1992; Dos O Sullivan, 1993; Bibi, 1993). In CSW storage, a mixture of water and ice thereby achieving the maximum possible contact between the fish and the cooling medium surrounds the fish. In practice mixing one part by weight of ice with two parts by weight of seawater makes chilled seawater. Seven parts by weight of fish can be stored in this mixture.

As the ice melts, the water salinity in the system will fall and will have to be adjusted to the required level by adding solid sodium chloride. CSW is considered relatively inexpensive to install and operate, and can be handled by unskilled workers. Whereas in RSW it is necessary to circulate the water by pumping to ensure even mixing and cooling, it is not generally considered necessary in the CSW system. The motion of the vessel will be sufficient to ensure adequate mixing. There is no risk of the fish getting frozen which is often a possibility in RSW storage.

Packaging and transport of fish

India has a very long coastline and the fish landing centres are scattered all along. The availability of fresh fish in the interior consuming centres has been very limited because of the non-availability of appropriate functional packages and absence of a properly designed transportation system. This has been, to some extent, responsible for wastage of fish. Functional, cost effective containers can play a very significant role in preservation and transportation of fish to distant locations. This together with the availability of a network of motorable roads to the landing sites and other infrastructure for distribution and marketing can ensure proper use of the landed fish without waste. Concerted efforts have been made, particularly during the last two decades, to develop and employ different types of containers for fish transport as also the necessary infrastructure for its distribution and marketing, which has brought down the extent of wastage considerably.

Survey carried out in different fish landing centres has shown that only around 25% of the fish landed were of excellent quality, around 50% very good, around 20% fair to good and the remaining of unacceptable quality. However, there is no uniformity of the figures. In certain cases sizeable quantities have been considered only as acceptable. These reflect the variations in the handling practices before the fish is ultimately landed for distribution. Much of the downgrading of fish leading to loss in quality can be attributed to the unhygienic handling/bad packaging. Therefore, it becomes very important that the subsequent handling, packaging should be adequate enough to maintain the quality during transport until it reaches the consumers.

Mode of transport

The physical flow of fish for the domestic marketing indicated that about 50% of the transported fish is consumed within the distance of 40 km, another 45% within 200 km and the remaining 5 % beyond 200 km from the coastline (Prabhu, 1993). In general about 87.5 % of the fish catch is consumed within the state and remaining quantity moves out for interstate trade. The principal mode of transport, by and large, is by road. A portion of the fish meant for interstate sale is also transported by rail. However, transport by road even for distances upto 200 km, mostly within the state, is carried out by road in view of certain advantages like flexibility and service facilities. Rail transport is adopted for small consignments and involving long duration of transport. The flow of fish by rail and road within the state is around 20 % and 80 % respectively and interstate flow is 45 % and 55 % respectively by rail and road. Consumption of fish in the rural sector is 30-45 % and the urban and metropolitan areas account for the balance. For road transport open trucks covered with polythene, insulated trucks or refrigerated trucks are employed depending upon the distance and duration of transport involved. Bicycles, handcarts, pick up vans are the popular modes of transport for short distances by road. The fish transported by rail are always packaged, though often in primitive forms. The fish transported by road may be in packed or unpacked condition, which is often decided by factors such as ready market availability, distances involved, and species and quality of fish involved. There is no fixed ratio of ice to fish used and it always varies according to its availability, cost and transport time. Practically no ice is used when the fish is transported for the marketing in areas near to the landing sites or when the duration of transport involves 4 hours or less. The average transit time of fish by road is 4-20 hours for distribution within the state and around 65-70 hours for long distance travel by rail.

In order that the quality of the fish is maintained until it reaches the consumer, proper care has to be taken in its packaging and transport. Temperature is the most important factor controlling the deterioration of the quality of fish particularly in tropical climates like that in India. Rapid chilling of fish with crushed ice and maintaining it at or close to the temperature of ice is the simplest and most economical method of short-term preservation of fish. Though icing is the widely accepted method for cooling fish adopted by the trade in India the commercial icing practices are far from satisfactory. Unscientific methods of icing often result in temperature of the fish reaching upto 13-18°C at various stages of storage and distribution. A substantial quantity of the fish landed is by non-mechanised fishing sector, where no fish is iced onboard. In several cases fish is not iced even

2-4 hours after landing, which will help spoilage to begin before packing and distribution. Non-availability of ice at the landing/fishing centres, high cost, limitations of space in small fishing vessels and problems in carrying ice to the craft are some of the factors responsible for not icing the fish immediately after catch. During storage, if the fish is not previously chilled, a quantity of ice amounting to 30-40 % of weight of fish is needed to cooling down to 0-2°C from the ambient. This process will take 3-4 hours for a 10-cm thick layer of fish iced from both sides. Unlike in temperate climates ice losses will be excessive in warm climates and therefore particular care is to be taken to reduce the meltage of ice in designing the containers, mode of packaging and transport.

Containers for commercial transport of fish

Until about two decades back traditional containers like baskets made from split bamboo, palmirah leaf mattings, used deal wood, plywood boxes, which were normally used for packaging other food commodities were also used for packaging and transport of fish (Rao & Perigreen, 1964). Bamboo baskets are the popular containers in the southern states of India. They are considered cheapest and the cleanest non-returnable single service type containers by the fishing community. They can be made in varying sizes, shapes, depths and capacities. Bamboo baskets that can take a load of 40-100 kg (fish +ice) are common. The baskets are given an inner lining with some dry leaves of plantain, palmirah in different localities according to their availability. After packing fish and ice the baskets are wrapped in gunny bag outside and sewed. Bamboo baskets though popular as packages for fish have some limitations. They do not possess adequate mechanical strength and can easily get deformed under packaging loads transferring the compressive loads to the fish underneath which may eventually get crushed. Sharp edges of bamboo can cause bruises on the skin of the fish, which can become the potential areas of quick spoilage in the fish. Wooden boxes made of cheap species of

Figure. 1. Traditional bamboo baskets used for fish transportation

wood as well as plywood boxes of capacities varying from 20- 120 kg (fish + ice) are popularly used for transporting fish by rail as well as by road in the western parts of the country (Venkataraman, 1975). Similar materials have been used for transportation of fish by road as well as by rail (Perigreen & Govindan, 1969; Rao *et al.*, 1978, 1979, 1980, 1981; Govindan *et al.*, 1977, 1978; Varma *et al.*, 1980). The fish is re-iced enroute, if needed. Often these boxes are again used at the receiving point for transportation of fish to other places. Though comparatively inexpensive, these containers suffer from some inherent disadvantages. They absorb moisture and increase the weight of the pack. The porous surfaces of the container tend to accumulate slime-enabling harbouring of bacteria, which can contaminate the fish held in them. Studies have shown that the porous moist surfaces of the wooden fish containers in commercial use often have surface bacterial counts as high as $5x10^8$ per cm^2 (Govindan, 1984; Iyer *et al.*, 1966). They cannot be easily cleaned or dried making their reuse for transportation of fish unsafe. On becoming wet, the boxes also lose their insulation properties. The containers most popular for transportation of fish for short distances are aluminium vessels or bamboo baskets. Considering the short duration of transport and holding time, this can be considered ideal, if some improvement is brought about to provide insulation and hygienic maintenance.

Improvements in the traditional containers

Traditional type containers are still popular for transport of fish. They can be made more effective and functional by resorting to simple modifications. One of the main drawbacks of such containers is their poor insulation capacity. To a great extent, this can be overcome by providing additional linings of polythene and gunny or water resistant kraft paper. By these modifications meltage of ice can be very well controlled and the shelf life of iced fish can be enhanced by 50-80% of that normally obtainable in non-modified containers. Requirements for containers for fresh fish transportation have been discussed by Nair *et al.*(1980).

The efficiency of used plywood boxes, commonly used for iced fish transport in the western region, could be increased very well by providing 2.5 cm thick foamed polystyrene slabs (in polythene sleeving) along all the inner walls of the container. This will improve the insulation property and can hold fish and ice for very long periods without spoilage. These containers have been found to be extremely beneficial for transport of fish in ice for long distances involving a duration upto 60 hours by employing a ratio fish to ice of 1:1. However, wooden boxes, even if modified by these methods, were not found ideal particularly because of the problems of getting wet and the accompanying disadvantages.

It has been demonstrated that if the fish is packed in the form of frozen slabs in the ply wood boxes insulated with polystyrene, it can be transported to distant places involving journeys of 60-80 hours duration, where the fish will be received in a thawed condition, the temperature of the fish often reaching only upto 5°C (Rao & Perigreen, 1964). This opens up the scope for reaching the fish in very good condition to the consumers situated far away from the landing places. Another improvement over the traditional fish containers is the development of a drip proof insulated container based on bamboo baskets (Dani, 1968). This consists of two baskets made of split bamboo, one kept inside the other between which an insulation material consisting of a double layer bitumen-polythene coated lesion cloth sandwiching 2.5 mm thick coconut fibre.

An ideal container for packaging and transport of fish in a tropical country like India, where the transportation is carried out under rather unfavourable conditions of temperature should have some specific characteristics. From the physical point of view, they should have high net volume to surface area ratio, high insulation value to minimise their heat process and should have smooth interior surface (Chattopadhyay, 1971). They should be light, cheap in relation to their life span, hygienic so as not to act as a source contamination by itself and rigid enough to withstand the hazards of handling and transportation. They should be easily stackable and allow for maximum nesting, when empty to conserve space and to be compatible with the mode of transport and storage. In the case of reusable containers, they should preferably be of collapsible type so that the freight charges for the empties can be reduced. Such an ideal container is rather difficult to develop: however, a compromise can be arrived at with the functional requirements and properties of packaging materials. In this context it will appear advisable to go for returnable plastic boxes made of plastic material like high density polythene or polypropylene, which can resist impact, moisture and chemicals (Lisac *et al.*, 1988).

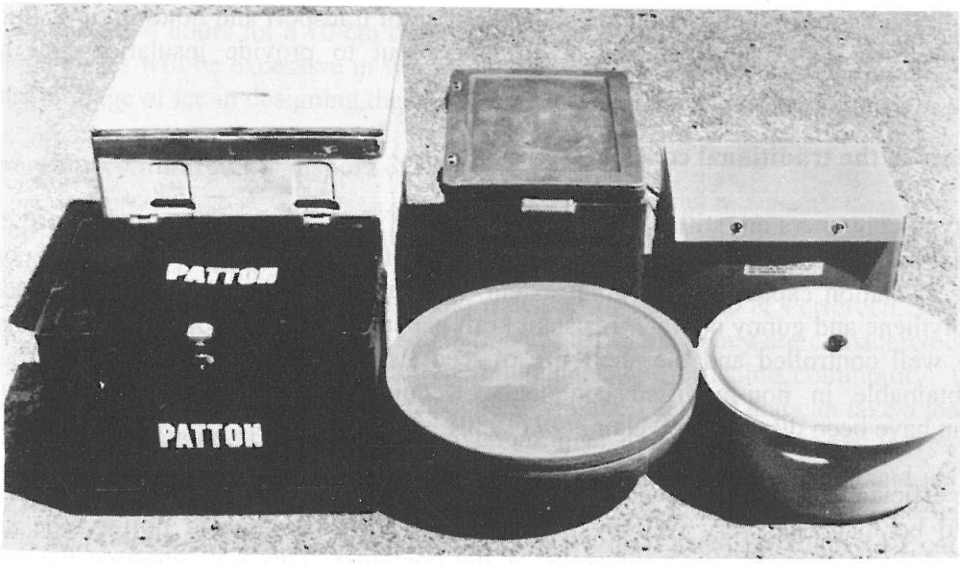

Figure. 2. Modern insulated containers

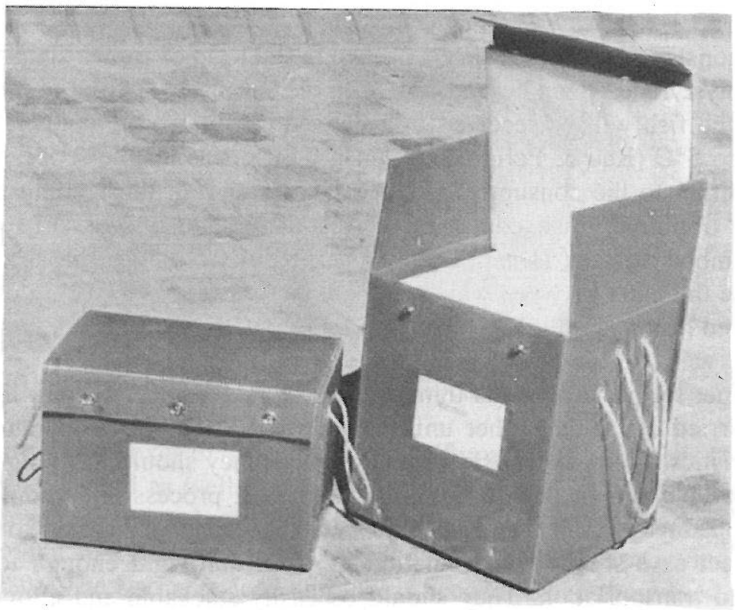

Figure.3. Corrugated polypropylene box developed by CIFT for carrying fish on board

An insulated corrugated plastic container developed at the Central Institute of Fisheries Technology is perhaps the lightest among all the packages available in the country for transport of iced fish (Rao & Antony, 1989). A container, which can hold 30 kg of iced fish weighs less than 2 kg, and keeps the fish chilled and fresh for 60 hours or more. It is collapsible and reusable. Each container can be used for the minimum of 5 transportation trips. Being light in weight, the return of the empties is very cheap. Having a smooth finish inside, they are easily cleanable and hygienic.

A dismantlable container made of double layer galvanised iron sheet between which 25 mm thick expanded polystyrene is introduced as insulating material is yet another innovation in this field. It is made in six pieces as above and assembled using nuts and bolts. This container can be dismantled at the receiving end and packed compactly for returning. They have the added advantage of ensuring better safety, ease of handling and facilitating easy cleaning and disinfection (Govindan & Gupta, 1978). Tables 1 & 2 illustrate the performance of different containers used in trade.

Transport of fish by air

Considering the fact that the time taken in air transport is very short, there are areas where some economy measures can be introduced. An area in which economy can be effected, is reducing the proportion of ice, which can permit packing more fish per container. Use of inexpensive and non-returnable containers is another possibility in reducing the transportation costs. Fish transported by air can reach the consumers within the shortest possible time with minimum loss of quality and can fetch better price in the market. Considering the fact that fish can reach the urban consuming centres in prime condition within 3-4 hours compared to 50-60 hours bay rail/road, transport of fish by air is a worthwhile proposition to be seriously considered. The increased freight charges can be compensated by the increased returns from the sale of top quality fish.

Table 1. Storage life of iced fish in different containers in all which ratio of fish to ice kept 1:1 and deepest storage temperatures attained is 3-5 C. The tests were made at ambient temparature 26-32 °C.

Container	Maximum storage (hr.)
Bamboo basket	0-10
Bamboo basket with kraft paper	16-17
Bamboo basket lined with gunny & polythene	16-18
Plywood box (Plain)	14-16
Plywood box with 25 mm thermocole	50-55

Most commonly used container is polystyrene box of approximately 50x50x50 cm, packed in an outer corrugated fibreboard box. Fish is held in chill water in polythene bag and kept inside the PS box. Both polystyrene and outer corrugated box are sealed with gumtape. However, the traditional polystyrene box is being replaced by modified aerated fish transport boxes made of fibreglass or HDPE (Subasinghe, 1997).

Hygiene in fish handling

The major cause of spoilage of fish is by the action of bacteria. If the fish is contaminated with pathogenic bacteria, it can cause various illnesses in the consumer, some of which may result in death. The best way to minimise bacterial contamination and their further proliferation in fish is to ensure hygienic handing and keeping the fish clean and chilled. Some of the important requirements in hygienic handling of fish are discussed below.

Table 2. Comparison of different containers used for transportation of fresh fish

Characteristics	Basket	Polythene container	Aluminium container	Wooden box
Ruggedness	Good	Very Good	Fair	Fair
Suitability when stacked	Poor	Very Good	Good	Fair
Suitability for nesting	Bad	Very Good	Good	Fair
Ease of filling & emptying	Good	Very Good	Good	Good
Ease of cleaning	Bad	Very Good	Fair	Bad
Noise	Good	Very Good	Fair	Very good
Fish arrangement	Bad	Very Good	Good	Good
Overall quality	Fair	Very Good	Good	Fair

Supply of clean water

Adequate supply of clean water is one of the most important requirements in handling the fish. Washing with water removes more than 90 % of the surface bacteria. However, the water used shall be clean and chlorinated to ensure safe bacterial level; otherwise, it may by itself turn out a source of bacterial contamination including pathogens. This will create a situation, where washing will do more harm than good. Water used shall preferably be of potable quality having residual chlorine level not more than 5 ppm. Water for cleaning premises, utensils, shall have a high level of residual chlorine, 10-100 ppm (Iyer, 2000).

Personal Hygiene

Hygienic handling of fish on board should start with strict observance of hygiene of the fish handlers themselves. Fish can pickup bacteria from several sources during handling including the persons handling them. It is, therefore, very important that the persons handling fish should maintain strict hygiene and be free from any communicable disease. While handling fish they should wear clean uniform including headgear, and also should use waterproof coat or aprons and gumboots. Before start of handling, the persons involved should wash their hands from elbow downwards using soap and water followed by disinfection in adequately chlorinated water. This should be repeated after each break of work, visits to toilets, or whenever there is a chance to contaminate the hands. Those having bruises on palms, fingers, should not handle fish because these are sources of bacteria, whose presence in food is considered undesirable form the hygienic point of view. They should also keep their fingernail neatly trimmed. Spiting, chewing tobacco, smoking and the like should be prevented in the areas of fish handling.

Cleaning and Disinfection

Thorough cleaning and disinfection of the boxes, all handling equipment, utensils are primary requirements in hygienic handling of fish. All these shall be made slime free and clean using appropriate detergents and disinfectants. This should be done at the end of each working day or work schedule. Use of dock water for washing is dangerous, as it will generally be grossly infected. Chlorine is the most commonly used disinfectant. For metallic surfaces, water containing 100 ppm available chlorine will be sufficient, but for wooden surfaces it can go up to 1000 ppm. After a contact period of 15 min, the disinfectant may be washed off using clean water.

Hosing water under pressure can also do cleaning. Clean seawater containing the requisite level of chlorine will be more effective than plain untreated water in removing slime form the deck. Such washing programme may be resorted to at the commencement of the fishing trip as also after unloading the catch on the deck and its clearance there from. Improper cleaning will allow build of slime and bacteria, which will, in turn, contaminate the fish coming in contact with it.

In order that quality fish of high hygienic standards is made available to consumer the following aspects may be given due consideration in catching, handling and distribution of fresh fish.

- Fishing may be carried out only in unpolluted water
- Fish hold and boat deck shall be constructed in such a way that they can be easily cleaned and disinfected
- All fish handling surfaces shall be made of smooth, non-corrosive materials and free from cracks and crevices.
- Use of bamboo baskets, wooden boxes and similar materials that are difficult to clean should be avoided.
- Between fishing trips all fish contact surfaces in the vessel shall be cleaned using suitable detergent followed by disinfection using chlorine of appropriate concentration.
- Fishing vessels shall carry ice made of potable water / clean sea water
- Left over ice from one fishing trip shall not be used in subsequent trips
- After unloading, the fish shall not be exposed to adverse elements of nature and should not be trampled over
- After unloading the catch may be washed with potable water, chlorinated to 10 ppm
- After washing the fish must be sorted, species wise and size wise, immediately iced and kept separately
- Fish de-iced for weighing; after sorting, they shall be re-iced until below 2 ^{0}C is achieved as quickly as possible
- Proper precautions shall be taken to prevent the entry of flies, crows, cats, dogs, rodents in the premises, where the fish is handled
- All containers / contact surfaces used for unloading and weighing shall be cleaned and disinfected immediately
- All vehicles and containers used for transportation of fish shall be constructed in such a way that they can be easily cleaned and disinfected
- Reusable containers as well as vehicles used for transportation of fish shall be cleaned and disinfected before and after the trips
- The interior surface of the vehicle as also of the containers shall always be maintained in such a way that they are free from abnormal odours

Transportation of live fish

Supplying the consumer live fish is, perhaps, the best method of ensuring that he is getting the fish fresh. There have always been ever increasing and ever changing demands for diverse types of processed fish and fish based products from consumers all over the world. With changing life style of people, the demand from many of the affluent consumer markets gradually started shifting towards live fish and shellfish and this is showing an increasing trend. Even though live transport of fish, particularly of farmed freshwater fish, was prevalent in Europe (Norris *et al.*, 1960), transport of several species of fish and shellfish of marlne, brackish water and freshwater origin to distant markets is relatively of recent origin. Affluence of the consumers and the scientific understanding and technological developments in handling and packaging techniques have provided added impetus to the prospects of commercial transportation of live fish and shellfish for human consumption.

Several problems are encountered in transport live food fishes, some of which are the following:

- Low solubility of oxygen in water and its poor capacity to dissipate the end products of metabolism.
- Sensitivity of the fish to the handling. In some delicate species, the fish will lose the essential protection from osmotic stress, if the mucus is removed from skin even a fraction of an area by abrasion or by some other means.
- Capture and subsequent handling cause the fish to be excited and stimulated to the extent, that they readily accumulate dangerous levels of lactic acid in their blood.
- Excessive changes in the temperature from catching to handling and live carriage is deleterious to the fish in many ways.

These and the following factors should be given due consideration in developing the techniques for successful transportation of live fish: As the water is likely to become rapidly polluted by metabolic waste, feeding of the fish has to be stopped 24 hours before packaging and transport so that the gut is empty before the transport begins. A serious limiting factor regarding to the number of fish to be carried in a container is the poor solubility of oxygen in water. Aeration can improve the supply of oxygen, but it becomes necessary to remove the carbon dioxide produced in the process of respiration and other metabolic wastes such as ammonia. There is always a limit upto which the fish can tolerate accumulation of free carbon dioxide. It is upto 25 ppm for sensitive species and 50 ppm for insensitive species under adequate aeration. When the levels exceed these limits, any increase in amount of oxygen, provided by aeration or otherwise, will have no beneficial effect.

About half of the nitrogenous excretion of the fish consists of ammonia. Ammonia is also produced by bacterial breakdown of organic compounds. Free ammonia or ammonium hydroxide is highly toxic to fish. The rate of excretion of ammonia is related to the rate of metabolism. The rate of excretion is also related the size of the fish. Large fish of a given species produce less of excretion products than do smaller ones of the same species. Whereas, a fish weighing 20 g excreted 100 g 500 mg/kg/day, a fish weighing 100 g excreted nitrogen at the rate of 120 mg/kg/day only. Large fish are also somewhat more resistant to ammonia toxicity than are smaller fish. At ammonia concentrations as low as 0.5-1.0 ppm only non-lethal toxic effects take place. The Oxygen demand of the water, other than that required for direct respiration of fish, will be higher, if the fish are kept longer in water because of the accumulation of organic metabolic wastes.

Discharge of metabolic waste may be controlled by lowering the metabolic rate of fish and using suitable substances to remove them. Reduction in metabolic rates can be achieved by lowering the water temperature, addition of anaesthetics to water, and thorough conditioning of the fish. Several chemical substances are used for absorption and removal of metabolic wastes. Clinoptiolite or activated charcoal can remove ammonia from fresh water live fish transporting medium. For seawater transport-nitrifying bacteria can be employed for oxidising ammonia and its removal.

To lower the metabolic activity the fish has to be packed in water at low temperatures. Sudden changes in the temperature will cause a shock to the fish, a shock resulting from the failure of the nervous system and another from the failure of the physiological function such as respiration. Warmer water can hold only less oxygen than cold water. Carbon dioxide and ammonia are more damaging at high temperatures. Therefore, fish is acclimated gradually to a cold temperature before packing and transport. A fish, that has struggled too much during catching and handling, is not advisable for live transport. In struggled fish there will be accumulation of too much lactic acid causing acid-base disturbances leading even to death.

The bacterial population in a fish tank will multiply rapidly, when organic matter build up takes place. Antibiotics have limited value in controlling the bacterial population in transport tanks, as they appear to kill only susceptible species while allowing others to multiply rapidly. Anaesthetics are often used in the transport medium to produce a stage of sedation in the fish as also to reduce the metabolic rate. Smaller fish are more resistant to anaesthetics than are larger specimens. In some cases some prophylactic or quarantine measures may become necessary because of the possibility of induction of infectious diseases, parasites in fish consignments. Antiseptics, antibiotics and germicidal chemicals may be used for this purpose. A short duration chemical bath prior to transportation will help in preventing further transmission of infections in fish consignments.

In many instances formation of foam on the surface of the water has been experienced in the live transport of certain species of fish. Thick foam develops from the mucus and organic matter particularly, when the water is aerated. The foam will cover the surface of water reducing the availability of oxygen and resulting in accumulation of carbon dioxide, which may lead to acidification of water. So it is customary to use some antifoaming agents in the transport system.

Methods of transport of live fish

Many molluscan shellfish like clams, mussels, oysters and crustaceans such as some species of shrimp, crab and lobster and air-breathing fishes like murrel, can remain live out of water for quite some time, if suitable environment is provided in the package and hence can transported without water. A plastic bag method is generally used for transportation of ornamental aquarium fish, and fry, fingerlings and post-larvae of cultured fishes. A method employed for bulk transportation of fish is called the tank method, which involves shipping live fish in well boats or tankers. Transport of live fish is commonly resorted to few species of fish and shellfish, and the techniques employed in some individual cases are briefly outlined.

Lobster

A seafood item commanding the highest unit price whether frozen or live, is lobster. Lobster can live for a fairly long time out of water, if maintained under low temperature with sufficient availability of oxygen and fairly high humidity. However, it has to be conditioned to the environment before packaging and transport. Only healthy lobsters identified by their quick response to a prod on the antenna between their eyestalks are selected for live transport. The animals are generally held for 24 hours in holding pans to identify the healthy ones and sort out the weak and the dying. The healthy lobsters are free chilled in water over a 12-hour period to about 4°C. The container used shall be light, leak-proof, reasonably strong and easy to handle. Thick-walled polystyrene containers or corrugated fibreboard cartons laid with polystyrene foam will be ideal containers for live transport of lobster.

Lobsters are transported in the above type containers laid with ice pads and impregnated with silicon to absorb melt water. Pre-chilled lobsters are packed in layers separated by a moistened material such as seaweed, wood shavings or similar materials to maintain the relative humidity at 70 %. A final layer of moistened material is placed on the top and the box is sealed with a lid. The temperature is maintained at 1-7°C.

Crab

Live crab is another delicacy with consumers in the affluent markets. Crabs should be stored at least 24 hours prior to packaging and shipping so that weak, moribund or injured specimens can be removed. They can be held alive on vessels or in tanks onshore. For deepsea crabs, ideal temperature of holding water is 0-5°C. Warm water crabs can be held at higher temperatures; however, to reduce the metabolic rate and cannibalism, lower temperatures are preferred. Normally temperature is controlled to a level slightly lower than that of the natural environment of the crabs concerned and a humidity above 75% is maintained in the packets. However, ice is not used in the package since very low temperature and contact with ice melt water are lethal to most species of crabs. Therefore, frozen gel packs are used to bring down the temperature in the package. A frozen gel pack is first placed in the container or spread with moistened material such as coarse canvas or jute, seaweed or wood shaving (Ismail, *et al.*, 1998; Anon, 1997). The temperature-controlled crabs are then layered over this and the packing is continued with alternate layers of crabs and moisture absorbing material. A final layer of moistened material is placed at the top, and insulated lid is then secured in place and sealed. At the destination, the animals in good condition shall be placed in holding tanks.

Shrimp

Another item popular in demand as live animals is shrimp. Water is the most common medium used in closed or open systems. For species like *Penaeus indicus*, which can stand lower temperatures up to 4°C and survive in a moist atmosphere, transport in chilled moist sawdust is advantageous. If the sawdust is not available or costly, coconut husk, which is a waste material, can be used. In such cases fibreboard box lined with PVC sheets is used as the container. Shrimp, hibernated by holding in aerated tanks and slowly cooled to about 4°C by addition of small blocks of ice, is placed in the box over a layer of chilled sawdust or moist algae, and is immediately covered with another layer of chilled sawdust. This is continued until the box is full. Care should be taken to maintain the temperature inside the package at 4-10°C. Shrimp will remain live under this condition for 14 hours or more and therefore, air transport is possible.

For shrimp species like *P. monodon* or the giant freshwater shrimp *Macrobrachium rosenbergii* a closed bag system or an open tank system using aerators can be conveniently used for relatively shorter journeys. The load density in either case will be depending on the journey time involved. Broodstock and post-larvae of shrimp are transported live employing the closed plastic-bags system; whether for inland transport or for overseas transport by air. The package density of brood stock is 2-10 pieces per 10-litre water. The low package density is to avoid overcrowding which may eventually damage berried females. Fry or post-larvae, depending on their size and distance to be travelled, can be stocked at 1000-2000 numbers per bag.

Fish

Tank method is employed in bulk transportation of live fish. The method involves shipping live fish in live well boats or tankers. Such units are equipped with circulation and aeration systems. The circulated water is aerated before feeding back to the tank. Water can hold more oxygen in solution at low temperatures; however, fish requires more oxygen at higher temperatures. Therefore a tank of a given volume can hold more fish at lower temperatures than it can hold at higher temperatures. That is the reason why the temperature of water in transportation is always kept low according to the levels that the fish species concerned can tolerate. Water temperature is controlled by adding ice and also by insulating the tanks.

One of the factors governing the load of fish in a given volume of water is the species of the fish, because different species of fish have different oxygen demands. An average load of 200-250 kg fish in 1000 litre water is often possible. For short journey it can be even 450-500 kg fish per 1000 litre water. Use of tranquillisers was found to be useful for extension of life of fish during live transportation (Thompson, 1959; Srinivasan, 1962; Chakravarthi, *et al.*, 1998).

Recommendations

- In order to minimise the wastage of landed fish, the most important measure is proper care of the catch employing appropriate methods of handling, preservation and transport

- The most critical factor deciding upon the shelf life of fish is the temperature at which it is maintained. Fishermen should be encouraged to carry ice on board to preserve the catch

- On landing, the fish should be washed, sorted and re-iced
- The traditional containers like bamboo baskets, wooden boxes, though inexpensive, have several inherent deficiencies and hence should be replaced by functional, cost effective modern insulated containers. Once used plywood boxes provided with polystyrene insulation is an ideal container. An insulated corrugated plastic container is another ideal one and should be popularised

- Hygiene in fish handling, including the hygiene of fish handlers and all surfaces with which fish comes in contact, is very important in supplying good quality fish. Therefore there should be a thorough schedule of cleaning and disinfection of equipment, utensils, boat deck, fish holds and any other material with which the fish comes into contact. There should be thorough check of the hygiene of the fish handlers as well

- Transport of fish by air is increasingly become popular. Some effort is needed with regard to economise the operation

- Transport of live fish is another demand from the affluent markets. This trend should be encouraged with necessary technological back-up and developing the necessary infrastructure.

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