Problems in fish distribution and delivery

Ronan Gormley
Teagasc, The National Food Centre
Dunsinea, Castleknock, Dublin 15, IRELAND

Keywords: fish; chilling; freezing; quality; freshness, chill chain; temperature abuse; distribution; retailing

Date: February 1996

SUMMARY

Fish quality and freshness is influenced by many factors of which time-temperature-tolerance (ITT) is probably the most important. Chilled foods are much more easily temperature abused than frozen and hence special attention must be focused on the distribution of chilled fish. The application of hazard analysis of critical control point (HACCP) to the chill chain for fish is recommended in order to pinpoint potential black spots. It is essential to monitor chill fish temperatures during distribution by air, sea or road and also during retailing. In the case of live shellfish, some companies are locating holding tanks close to international airports to reduce ‘out-of-water’ time during the shipment of live shellfish. A range of quality tests for measuring fish freshness is cited.

Fish quality

Fish is highly perishable and its quality is influenced by many factors. The high quality shelf life of cod in ice is only about six days (1). Loss of fish quality and freshness is due to physical and chemical changes, and to the growth of microorganisms (1,2). The catching method, the condition of the fish, the presence
or absence of residues/contaminants, the killing method, and other factors, all influence the quality of the fish as it comes on board the trawler or fish farm platform. Post catching, fish quality is influenced by handling and gutting procedures, by the PPP (product, process, package) and TTT (time, temperature, tolerance) factors (3), by the presence or absence of contaminants, and by other factors. The TTT factors are largely the determinants of high quality shelf life.

Hurdles

The concept of hurdles (4) is that of placing barriers or hurdles (as in a race) in the 'way' of microorganisms with the confidence that all pathogenic bacteria will 'fall' before the end of the race, i.e. the product will be microbiologically safe. Common hurdles include heat, cold, salt, sugar, acid and preservatives with the height of the hurdles depending on the temperature (in the case of heat or cold) and the concentration (in the case of salt, sugar, acid and preservatives). Some hurdles for fish quality and safety are listed in Table 1 and it is evident that temperature, and especially chill temperatures, predominate for the various types of fresh and processed fish. For this reason emphasis is placed in this article on temperature abuse as the major problem in fish distribution and delivery. Obviously, other hurdles also have a major influence (5) on shelf life and quality but the over-riding hurdle is likely to be temperature.

Temperature control

A lowering of temperature by 10°C halves the rate of chemical change and also slows bacterial growth. However, there is a large difference between chilled and deep frozen food, including fish. For example, the amount of heat required to raise the temperatures of 1 kg of beef from -5°C to 0°C is 195 kJ whereas only 16 kJ are required to raise the temperature from 0° to +5°C, i.e. chilled foods are very easily
temperature abused and hence great care must be taken to maintain chill temperatures (6). In frozen foods (including fish) the ice serves as a major safety factor because of its latent heat requirements. In commercial practice, therefore, more problems are likely to be encountered with chilled rather than with frozen fish. The future trend, therefore, is likely to be lower chilled food distribution temperatures and, perhaps, crust freezing. The Agreement on the International Carriage of Perishable Foodstuffs (ATP-Agreement; ratified by 25 countries including most EU countries) specifies a maximum of 2°C for the transport of fish. Systems for recording chill food temperatures during distribution include Grant Squirrel equipment, the Temptimem data logger (Woodley Electronics, UK), the ‘Cool Cat’ (tamper proof; for trucks), the Testostar, hand held probes, and sachet or stick-on monitors which change colour when abuse occurs. The sachet-stick-on monitors include those made by I-Point (Sweden) and by Thermindex Chemicals and Coatings Ltd. (UK); the above systems are just a few of many that are on the market. Temperatures for chill foods are not defined in the EU General Hygiene Directive 93/43 but provision is made for appropriate temperatures to be ‘drawn up’. An overview of this directive is published in the September 1994 issue of ‘Keynote’; however, this publication is only available to members of the UK Institute of Food Science and Technology. National legislation often requires more stringent temperature control then does EU regulations and shippers of chilled foods should examine the requirements on a country by country basis.

The fish chain

A likely chain for fish is given in Fig. 1 and indicates many sections, even in the case of processed fish. Trawling methods and net lifting techniques together with speed of handling on deck have a major influence on fish freshness at the start of the chain. Immediate chilling in ice, refrigerated sea water, or chilled sea water is essential (1); handling procedures and speed of handling at time of unloading are also critical in maintaining chill temperatures. The chain (Fig 1) splits into processing and fresh
routes but TTT factors are evident throughout, including the transport of the fish from the retailer to the home by the consumer, and also temperature of storage in the home refrigerator. It is evident with such a long chain that hazard analysis of critical control point procedures (HACCP) must be in place in order to ensure non-failure of the chill chain and to safeguard product quality. In this context a HACCP user guide (7) has been produced in a number of languages as one of the outputs from the EU FLAIR (Food Linked Agro Industrial Research) programme.

**Potential black spots**

The transport part of the chill chain is laden with potential black spots and misconceptions, and these include:

- inadequate prior cooling of transport vehicles
- the assumed and actual product temperatures are often different
- inadequate temperature control during transport by air, road or sea
- temperature abuse at product transfer points, e.g., truck to store; store to home
- temperature abuse during retailing.

Some practical examples/case histories are as follows:

**Aircraft hold temperatures**: Seafoods shipped by air are normally transported in the cargo holds of commercial passenger aircraft. The holds are not chilled and the temperatures prevailing during the flight relate to those on the ground at time of loading the aircraft (8). The data (Table 2) show that temperatures are not conducive for the transport of seafood products and hence particular care must be taken to ensure that the seafood is adequately precooled/crust frozen and packaged for its journey.

**Transport of smoked salmon**: The data (Table 3) show that deep freezing was necessary to ensure that commercial consignments of smoked salmon packed in polystyrene boxes arrived suitably chilled after an air journey from Dublin to New
York. The journey time from smokehouse to consignee took 50 hours including a holding time at Dublin airport. This illustrates the potential problems (due to holding times or delays) that have to be guarded against. Data from a test on the commercial shipment of smoked salmon sides from a smokehouse in Dublin to a consignee in Luxembourg showed the following temperatures:

- ex smokehouse (Dublin) = -4°C
- on arrival (Luxembourg) = +6°C
- mean for 28 hr journey = +2°C
- holding time at London Heathrow = 14 hr
- flight durations = 2 hr

The temperature print-out indicated that the product was held in a chill store at circa 2°C (as it should have been) at Heathrow airport. These are just three of many studies in the area of smoked salmon distribution (9).

**Transport of smoked salmon gift sides:** Individual sides of smoked salmon are frequently distributed worldwide in gift boxes (usually polystyrene) as a mail order business. The safety of this procedure is questionable and the data (Table 4) show that deep freezing is essential prior to dispatch. Packing of a deep frozen (-20°C) smoked salmon side in a polystyrene box with solid CO₂ held the side at 0°C or under for only 24 hours, and after 30 hours the side temperature was 15°C; this was the best of the treatments tested (Table 4). Exporters of smoked salmon gift sides must, therefore, thoroughly research the transport/delivery points between product shipment and destination.

**Distribution by road:** Tests on the distribution of chilled foods by road (8) often indicate temperatures above desirable limits. For example, products (quiche, yoghurt, paté) in a distribution truck were above 5°C for over 40 hours of the 100 hour journey; these temperatures would have been too high for fish and indicate the
importance of shipping fish on its own because of its low temperature requirements, i.e. chilled fish does not lend itself to mixed chill distribution with other products. Care must also be exercised by consumers when transporting fish from the supermarket to the home as temperatures of food products in a car can be in excess of 20°C on a warm day; journey times, therefore, should be kept to a minimum.

Temperatures at retail and in the home refrigerator: The wet fish counter is making a major comeback in many supermarkets (10). Fortunately, standards of icing and display of the fresh fish are generally high in supermarkets but there is no room for complacency. Smaller shops selling fish, and also some specialised fish shops, often have lower standards and less-fresh fish, this may be linked to the volume of sales which is generally lower in these shops than in supermarkets. Careful temperature monitoring is required for packaged chilled fish fillets retailed from chill cabinets as surveys (11) have shown chill product temperatures above 5°C for lengths of time ranging from 1% to 57% of the 48 hr test period.

A survey (11) on the mean temperatures over a 24 hr period in six household fridges showed values ranging from 3.8 to 6.2°C; again these values are on the high side for the storage of chilled fish. Other surveys on the temperatures prevailing in household refrigerators have given similar results (12).

Transporting live shellfish

There is increasing demand for live shellfish which are displayed in tanks in restaurants, and a wide range of tanks is now available (13). However, the shellfish must be distributed live for this purpose, and this presents certain difficulties even for a short-haul journey. In this context, an insulated container stacking system (the Traystor system) has been developed in Canada which maximises holding capacity and reduces stress for a wide variety of shellfish (14) such as crabs, oysters, mussels and lobsters. The system comprises an 850 litre tank which holds 8 x 50 litre trays each
holding 25 kg of lobsters or other shellfish. However, increasingly the live shellfish are sent by air to distant markets, and some companies have built holding tanks for lobsters and other shellfish close to international airports (15) to ensure the shortest possible out-of-water time for the shellfish. Special air cartons have been designed which minimise delivery and crushing problems (15). A Queensland packaging supplier has developed an ‘insul-box’ (16) which is made of double corrugated board with in-built insulating materials. Tests with the system using 15 tonnes of seafood being sent from Australia to Japan, Jamaica and Saudi Arabia, indicated that the product temperature was 6°C on arrival and that the mortality level for the live shellfish after four days was only 10%. With blue swimmer crabs, the insul-box reduced mortality from 60 - 100% to less than 5% compared with iced polystyrene containers.

Drip from live mussels is a major problem during distribution and results in loss of weight (thus requiring an ‘overfill’) and also a wet pack. Tight packaging systems are being designed (17) which are helping to overcome this problem.

**SOME TRANSPORT POINTERS ......**

These include the following for chilled fish:

- ensure adequate product chilling and/or crust freezing
- use ice or carbon dioxide snow
- ensure adequate insulation of the chilled product
- thoroughly research the transport system
- ensure adequate training of transport staff
- monitor temperature throughout the journey
- maintain a product temperature of 0 to -2°C
- use a HACCP system
Malpractices at retail level or by the consumer reflect on the product and so it is important to ensure that the product is receiving proper attention at retail level and by the consumer. Some pointers relating to chill fish include:

- monitor handling practices and product temperatures at retail level
- ensure that retailers understand the requirements of the product
- provide information leaflets on the product for consumers thus indicating potential hazards of 'long times in the car boot' and of too high home refrigerator temperatures for fish.

**Measuring fish freshness**

Good testing procedures are essential for measuring fish freshness at various points in the fish chain. A number of these have been reviewed (1) and include total volatile bases nitrogen (TVBN), trimethylamine nitrogen (TMA), K value, free amino acids, total viable count (TVC) and Torrymeter readings; newer techniques include the Aroma Scan (AromaScan plc, UK). The fact that there are so many tests suggests that none is totally successful for measuring fish freshness in comparison with sensory evaluation; this has been shown time and time again. In the context of sensory testing, attention is drawn to the multilingual guide to EC freshness grades for fishery products (18).
TABLES AND FIGURE

TABLE 1: Some hurdles for fish quality/safety

<table>
<thead>
<tr>
<th>Fish Type</th>
<th>Fresh</th>
<th>Frozen</th>
<th>Heat processed</th>
<th>Fermented</th>
<th>Smoked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cold (C or DC)</td>
<td>Cold (F)</td>
<td>Heat (aw)</td>
<td>Acid</td>
<td>Salt (aw)</td>
</tr>
<tr>
<td>Package</td>
<td>Package</td>
<td>Salt (aw)</td>
<td>Sugar (aw)</td>
<td>Drying (aw)</td>
<td>Smoke</td>
</tr>
<tr>
<td>Gases</td>
<td>Package</td>
<td>Cold (C)</td>
<td>Package</td>
<td>Package</td>
<td>Cold (C or DC)</td>
</tr>
</tbody>
</table>

± preservatives  
Cold = chill (C); deep chill (DC); frozen (F)  
Package = ambient, vacuum, gas (MAP)
FIGURE 1: 'FISH CHAIN'

In the net (trawling; lifting)
↓
On-deck (handling; speed)
↓
In-hold (chilling; stacking; TTT)
↓
Unloading (handling; speed)
↓
Transport [truck; sea; air (TTT)]
↓
Factory → processing → storage (TTT)
↓
Packhouse (TTT)  Transport
↓
Market/retailer (TTT)
↓
(car journey)
↓
Household fridge (TTT)
↓
Consumption
TABLE 2: In-flight air temperature in the cargo holds of passenger aircraft

<table>
<thead>
<tr>
<th>Journey</th>
<th>Flight duration</th>
<th>Aircraft type</th>
<th>Mean temp</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUB (12) to LHR (15)*</td>
<td>0.9</td>
<td>Boeing 737</td>
<td>12.7</td>
<td>2.4</td>
</tr>
<tr>
<td>DUB (15) to LHR (20)</td>
<td>0.9</td>
<td>&quot;</td>
<td>16.7</td>
<td>0.8</td>
</tr>
<tr>
<td>LHR (16) to DUB (14)</td>
<td>1.0</td>
<td>&quot;</td>
<td>15.6</td>
<td>2.7</td>
</tr>
<tr>
<td>LHR (20) to DUB (13)</td>
<td>1.0</td>
<td>&quot;</td>
<td>16.2</td>
<td>3.4</td>
</tr>
<tr>
<td>SHA (19) to JFK (27)</td>
<td>6.7</td>
<td>Boeing 747</td>
<td>14.6</td>
<td>2.5</td>
</tr>
<tr>
<td>JFK (30) to SHA (17)</td>
<td>5.6</td>
<td>&quot;</td>
<td>21.1</td>
<td>2.9</td>
</tr>
<tr>
<td>SHA (6) to JFK (-5)</td>
<td>6.7</td>
<td>&quot;</td>
<td>6.1</td>
<td>2.1</td>
</tr>
<tr>
<td>JFK (-6) to SHA (1)</td>
<td>5.5</td>
<td>&quot;</td>
<td>5.3</td>
<td>1.1</td>
</tr>
<tr>
<td>DUB (5) to EM (4)</td>
<td>1.0</td>
<td>Shorts 360</td>
<td>2.5</td>
<td>1.2</td>
</tr>
<tr>
<td>EM (4) to DUB (10)</td>
<td>1.2</td>
<td>Shorts 360</td>
<td>4.2</td>
<td>1.1</td>
</tr>
<tr>
<td>DUB (15) to MAN (17)</td>
<td>0.7</td>
<td>BAC 1-11</td>
<td>16.0</td>
<td>0.9</td>
</tr>
<tr>
<td>MAN (17) to HAM (20)</td>
<td>1.5</td>
<td>&quot;</td>
<td>11.7</td>
<td>4.3</td>
</tr>
<tr>
<td>HAM (20) to MAN (18)</td>
<td>1.5</td>
<td>&quot;</td>
<td>16.0</td>
<td>2.7</td>
</tr>
<tr>
<td>MAN (18) to DUB (17)</td>
<td>0.7</td>
<td>&quot;</td>
<td>15.4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*ambient temperatures at the airports at the time of flight departure/arrival
TABLE 3: Smoked salmon temperature during air freighting

<table>
<thead>
<tr>
<th>Test 1: Dublin to New York via Shannon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex smokehouse (DUB)</td>
</tr>
<tr>
<td>On arrival in Downtown NY</td>
</tr>
<tr>
<td>Maximum temperature</td>
</tr>
<tr>
<td>Mean for 50 hr journey</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test 2: Dublin to New York via Shannon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex smokehouse (DUB)</td>
</tr>
<tr>
<td>On arrival in Downtown NY</td>
</tr>
<tr>
<td>Maximum temperature</td>
</tr>
<tr>
<td>Mean for 50 hr journey</td>
</tr>
</tbody>
</table>

Breakdown of 50 hr journey

09.30 hr (Saturday) : Depart smokehouse (DUB)
10.00 hr (Saturday)  - 11.45 (Sunday) : hold at Dublin airport
11.45 hr (Sunday)    - aircraft departs Dublin
20.15 hr (Sunday)    - aircraft arrives New York
04.00 hr (Monday)    - fish cleared by broker in New York
11.45 hr (Monday)    - delivered to consignee

(all hours are Dublin time)
TABLE 4: Warm-up time for individual vacuum-packed smoked salmon sides in a range of packs

<table>
<thead>
<tr>
<th>Packaging</th>
<th>0°C</th>
<th>10°C</th>
<th>15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polystyrene box (PB)</td>
<td>12</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>PB + dry ice</td>
<td>24</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>PB + aluminium foil</td>
<td>14</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>PB + blanket</td>
<td>15</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>Cardboard box</td>
<td>6</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Plastic sleeve</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Vacuum pack only</td>
<td>3</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

1 starting temperature -20°C
2 circa 1 cm thickness
3 Alkreflex 2L-2

REFERENCES


