Cold Chain Technology and the Meat Industry
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The term 'cold chain' implies the use of temperature control continuously from point of production to point of sale. It can be applied to frozen meat or meat products, and to chilled meat or products held at a temperature close to but above freezing point. The object of the chain is to maintain product quality and thus enable both producer and retailer to obtain satisfactory profits from the sale of quality goods.

Frozen meat is generally stored and transported at -18°C or below. As meat is not damaged by lower temperatures, and as microbial activity ceases below about -8°C to -10°C, this temperature is not as critical as some legislators may believe. This is no excuse for any lack care, but it does allow some tolerance for short periods without refrigeration, for example when unloading bulk frozen meat from ships' h

Chilled meat is much more critical. One specification has called for a meat temperature of -1 ± 0.5°C throughout a cargo, throughout a voyage, with rejection if the temperature exceeds 0°C anywhere for more than 24 hours or if it ever falls to -1.9°C. The upper limit is likely rates of microbiological deterioration. The lower limit is seen as the boundary between "chilled" and "frozen".

The freezing point of meat is not well defined, but the difference in value between frozen and chilled is very clear; sometimes the temperature at which "chilled" becomes "frozen" seems to have more to do with market conditions than with meat science!

As with any chain, the cold chain is only as good as its weakest link. Whilst there may be a little slack in the chain, all those involved regard this as a margin for the inadvertent errors of others. If everyone has the view that the slack is for their benefit, then failure is certain.

The first link in the chain is product quality. No amount of care in cooling and transport can overcome deficiencies in initial meat quality meat works handling. The next link is the cooling or freezing prior to storage and transport. For chilled meat which is likely to be vacuum packed or in bags containing a CO_2 atmosphere, temperature both before and after packaging may be relevant to how fast the me be cooled throughout to its storage temperature of, typically, -1°C.

It cannot be emphasised too strongly that refrigerated transport equipment is designed to maintain the temperature of goods, not to p cooling. For chilled meat, even one degree of excess temperature can take many days to recover during transport. It follows, for examp for proper shipment of chilled meat, a pre-shipment store using a chilled water system at +0.5°C is not suitable. A combination of ex temperature control, and adequate time is necessary. Needless to say, this requires both good equipment and good logistic control proce

For loading into refrigerated containers for overseas markets, there has been much discussion as to the merits of precooling the co before loading. If the loading is to be from a controlled temperature loading bay with proper door seals between the bay and the co then precooling is recommended. However, if loading is from an ambient temperature bay, precooling the container will have two eff first, the container will become wet and slippery making handling difficult, and secondly, once the doors are closed, all the condensed mo in the container will form frost on the evaporator leading to an early defrost operation and no immediate refrigeration, which is not help good temperature control.

For frozen meat, as there is no effective lower temperature limit, freezing can be carried out with limited temperature control. The proble be avoided here are excessive moisture loss (dependent on packaging in some cases), and inadequate time for full-depth freezing. Meat is transported at too high a temperature may adversely affect other consignments, in the case of insulated "porthole" container transport.

The storage and transport lifetime of frozen meat is long compared with any normal journey times, and is not likely to be a contentious For chilled, lifetime is dependent on carcass quality, handling, packaging method, and temperature. Beef has a longer life than lamb things being equal), and chilled pork has a relatively short life.

For transport by air, which is too expensive for all but special consignments, it is important to know that the cold chain effectively do exist. The need for temperature control is replaced by speed, and this is compromised if there are unscheduled delays.

For land transport by road, the typical refrigerated semi-trailer (shown schematically in figure 1) is well equipped to carry frozen Frequently, for carcass meat, rails and hooks will be fitted. Refrigeration is adequate to maintain temperature as long as there a appreciable periods without power. Generally temperature is controlled by the temperature of air returning to the cooler. Such a system suitable for close temperature control of chilled meat, and more modern equipment with delivery air temperature control is avai However, in most of the world, most road vehicles have difficulty in maintaining chilled temperatures close to freezing without ac freezing the load.

For long distance transport by sea, for frozen meat there is a choice between a door-to-door containerised system and a port-to refrigerated cargo ship served by road and rail transport at each end of the journey. The choice is dictated by the total journey logistics a costs, and will need to be considered specifically for any particular trade. Clearly, cargo ships are best suited to consignments of hundre thousands of tons port-to-port, whereas containers can be used for consignments of either comparable or much smaller sizes. For pro frozen meat, refrigerated cargo ship holds provide excellent temperature control, and modern palletised handling systems can lead to rapid handling.

Temperature controlled transport in intermodal 'ISO' containers has been well established for a quarter of a century. There are two systems available.

The insulated (or 'porthole', or 'Conair') container, as its name suggests, is not endowed with refrigeration equipment. It is designed to be used with either a central air handling unit in a ship's hold or at a port terminal, or to be fitted with a clip-on mechanical refrigeration unit run from a power supply. Typically, a trailer mounted generator set will power such a unit from meat works to port.

The refrigerated container (or 'integral', or 'reefer box'), shown schematically in figure 2, has inbuilt refrigeration suitable for all purposes. Temperature control for frozen goods is regulated by return air temperature, but for chilled is automatically switched to delivery air temperature control. Frequently, air circulation rates of up to two per minute are available for chilled goods, and a reduced rate (to save energy) for frozen. The capabilities of this equipment have been fully detailed elsewhere (references 1,2,3).

Proper control of the cold chain requires temperature monitoring. Traditionally, circular chart recorders have been used to record return air temperature, but these are gradually being displaced by electronic systems integrated into temperature controllers. In Europe, following the QFF (Quick Frozen Foodstuffs) directive, a standard for temperature recorders has been developed (reference 4). The recording equipment on the vehicle or container is often supplemented by shipper's recorders within the load, and several types are available. Simple recorders using bimetallic strips may be adequate for identifying gross abuse of frozen cargo, but modern electronic recorders accurate to a quarter of a degree are necessary for meaningful monitoring of chilled meat. Many such are available, and Cambridge Refrigeration Technology has used these regularly to monitor shipments of meat.

At the end of the cold chain, success can be assessed by the quality of the product. It can also be checked by measuring temperature with hand-held equipment. The EU QFF directive (reference 5) lays down requirements for such equipment. It is important to appreciate the need for regular calibration checks, and also to be aware that temperature gradients within the equipment can affect accuracy (reference 6). A meter kept in a warm office and taken into a cold store can be appreciably in error until temperatures stabilise. This problem is not universal, but it represents an area needing consideration.

The cold chain technology available to the meat industry has been developed over about 120 years, and if properly used and understood, produces excellent results. Co-operation between partners in the chain, rather than confrontation if things are not quite perfect, is the way forward. The technology of refrigeration, including the cold chain, faces great challenges from the need to avoid ozone depletion and the growing importance of minimising climate change by reducing energy use. The cold chain represents one of the greatest benefits of refrigeration to mankind, and these benefits must be remembered and valued if they are to be maintained against disproportionate environmental and political pressures in the years ahead.

Abstract

The term 'cold chain' applies to both frozen and chilled goods. Technology needs for chilled meat are the more critical. Temperature and other requirements for successful transport of meat and meat products are identified. Road and marine transport equipment are described, with reference to temperature control and monitoring.

References

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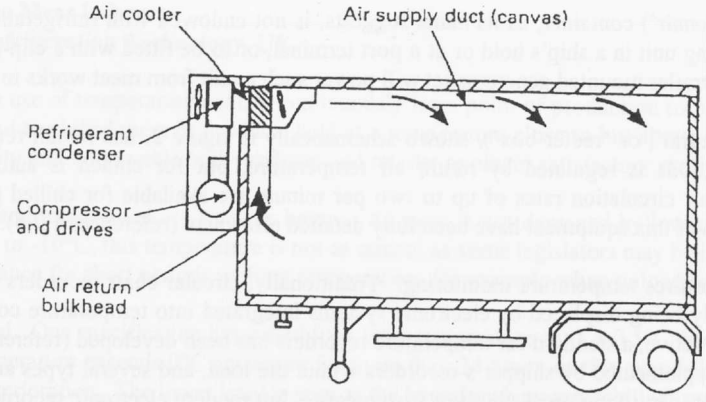

Fig. 1. Schematic arrangement of refrigerated semi-trailer.

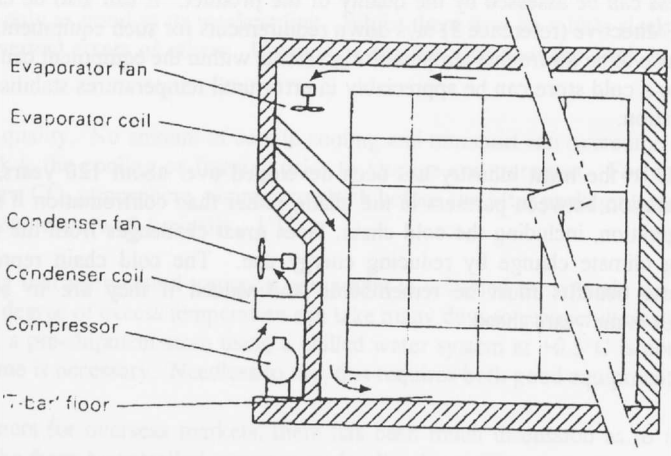

Fig. 2. Schematic arrangement of refrigerated container.

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