CHILLING AND HOLDING CARTONED MEAT

Neil G. McPhail, Ian McNeil, David Macfarlane

The optimum storage temperature for chilled meat is the lowest possible temperature at which no freezing occurs. As meat commences to freeze at -1.5°C, we should be aiming to reduce the meat temperature to -1 to 0°C as soon as possible after packaging.

There are several advantages to be obtained in reducing meat temperature quickly. These are:

- bacterial growth is restricted, therefore enhancing storage life;
- weep is reduced;
- the product is available for dispatch earlier. (The meat temperature should be at or below 0°C at the time of loading).

Some options available to reduce the meat temperature are:

- chill in holding chiller;
- chill in blast chiller; or
- chill uncartoned.

1. Holding Chiller

This is the least cost, but of course the least effective method. The cost savings are obtained through having all product in one room, therefore minimising refrigeration costs and handling.

On the debit side, it can take over 3 days for cartons of heavy cuts to reach 0°C. Figure 1 shows the cooling rate measured in the centre carton of a pallet. This slow cooling was mainly due to the difficulty of attaining sufficient air velocity over the carton. Even with gaps of 20-30 mm between the cartons, there was very little air movement and the air temperature in the centre of the pallet between cartons was 5°C higher than around the outside.

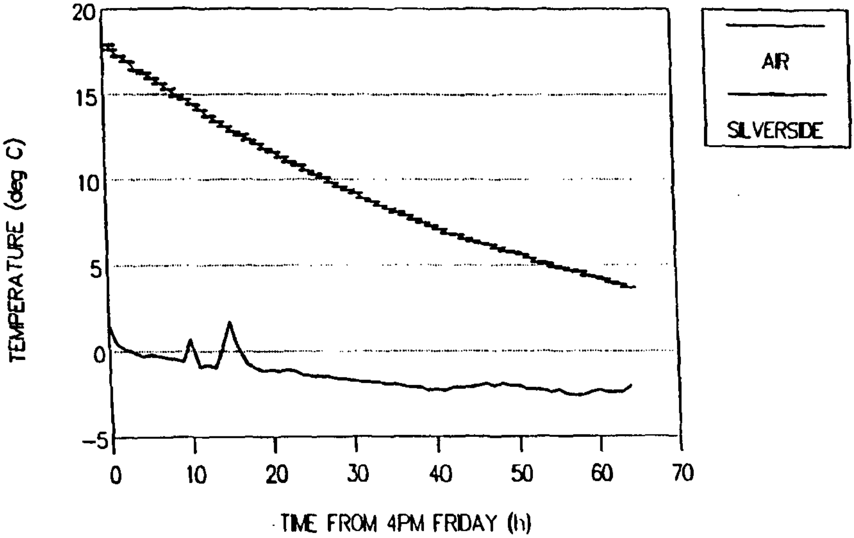

Figure 1 Cooling rate in centre of carton of vacuum-packed cuts on a pallet

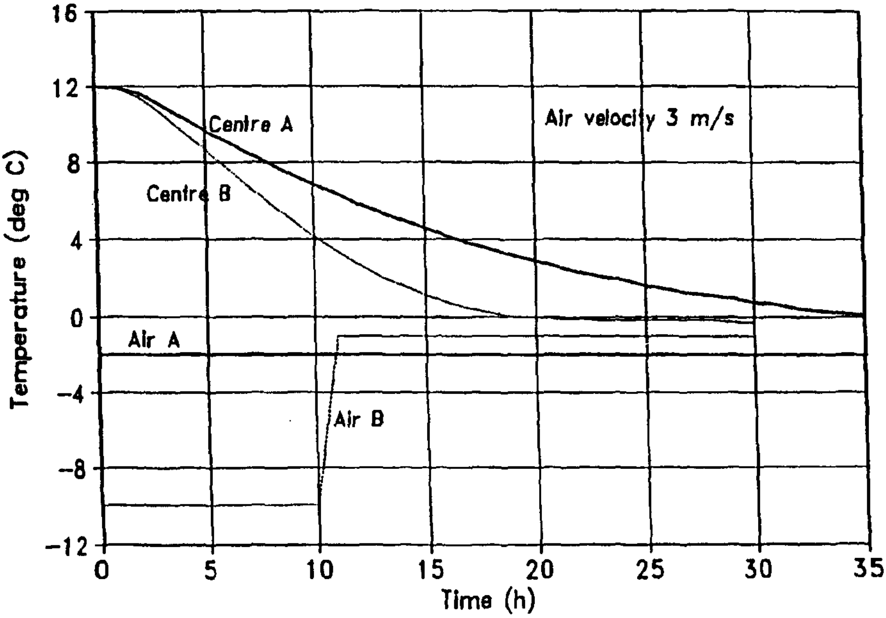

Figure 2 Computer prediction of carton cooling rate

If this is the only facility available for chilling, then the system should be given every chance by:

- chilling carcasses well before boning (deep butt temperature below 15°C and preferably close to 10°).
- allowing sufficient air gaps between cartons and placing dunnage or spacers between layers.

2. Blast Chilling

Blast chilling involves placing the cartons on racks or stillages in a room with high air velocity similar to a blast freezer (3 to 5 m s^{-1}). In some instances batch blast freezers have been converted to carton chillers. Figure 2 - Plot A shows predicted chilling rates achieved in a room with an air velocity of 3 ms^{-1} over the carton and an air temperature of -2°C. Even in this case it took 35 hours for the centre temperature to reach 0°C.

In batch rooms more sophisticated air temperature control can be employed, such as using sub-freezing air temperatures of -10 to -5°C for the initial portion of the cycle, then, as the meat surface temperature approaches freezing, raising the air temperature to -1°C. This will facilitate more rapid chilling without surface freezing. Such a cooling regime (Figure 2 - Plot B) shows that 0°C can be achieved in under 20 hours.

The main disadvantage of this system is the higher cost due to additional handling, and the requirement for additional refrigeration capacity, both in the chiller and the engine room. This should be balanced by the assurance that product temperature criteria are being met.

For optimum performance the air velocity over the cartons should be in excess of 2 ms^{-1}. Arrangement of the fans and orientation of cartons and racking should be such that even air distribution is attained by eliminating large voids and restrictions which promote preferential air flows. The long axis of the cartons should be aligned with the direction of air flow to enhance the surface heat transfer through the top, bottom and sides.

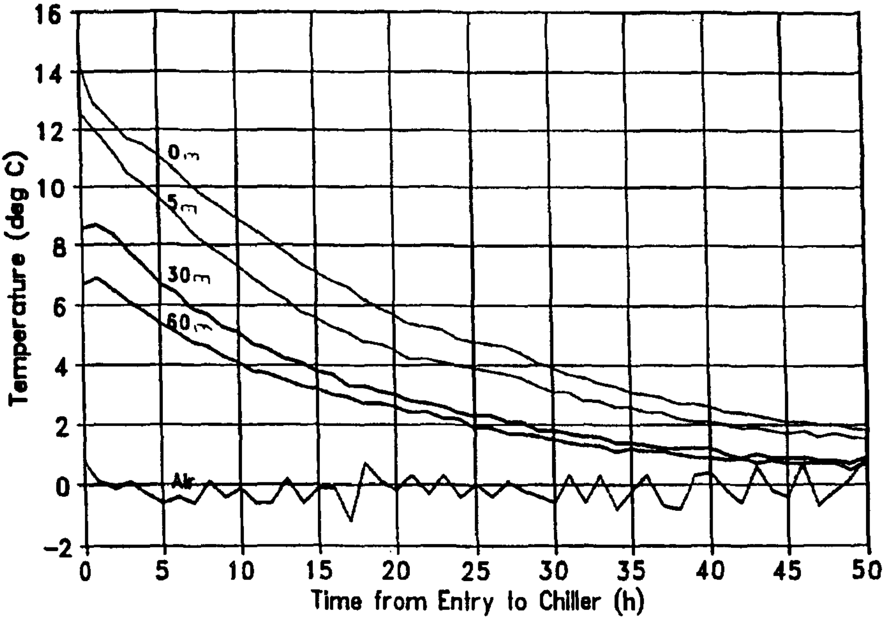

Figure 3 Cooling rate of the surface of cartoned topsides after spray chilling

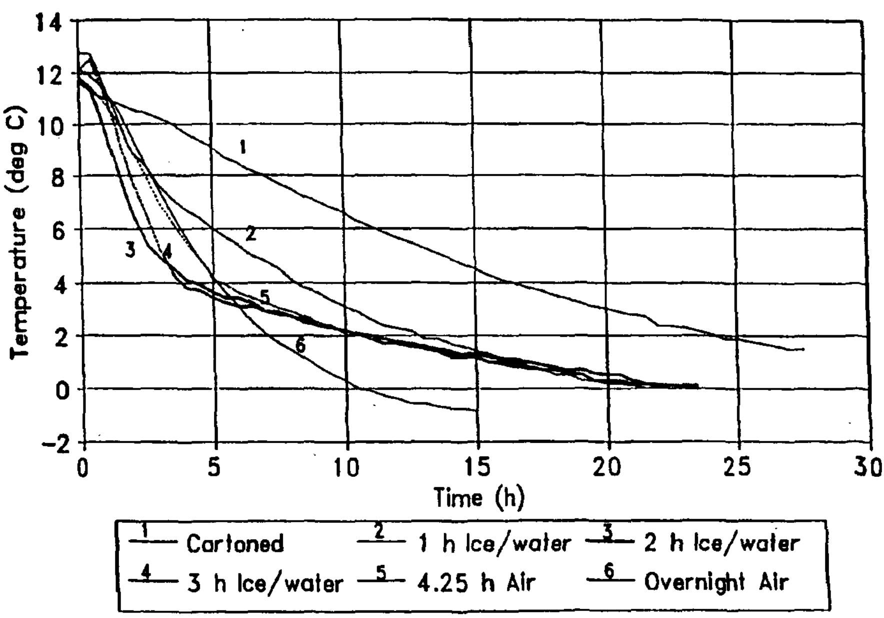

Figure 4 Cooling rates of 7.4 kg vacuum-packed cut

3. Chilling Uncartoned

There is interest in pre-cooling vacuum packed cuts prior to cartoning. Claims have been made that rapid chilling after packaging reduces weep and improves shelf life and meat colour. A research program is about to be undertaken to evaluate these claims. Leaving product quality aside, there are sound practical arguments for chilling cuts individually. These are:

Favourable aspects

- A temperature of below 0°C in even the heaviest cuts is attained within less than 24 hours. This would enable the packed cartons to bypass the holding chiller and be loaded directly into shipping containers.
- Detection of "slow leakers" is enhanced.

Unfavourable aspects

- Cartoning arrangements need to be re-organised.
- Cuts destined for a particular order or to meet a non-standard specification would need to be appropriately identified.
- Depending on the system, there may be a higher capital cost involved.
- Additional handling of bagged cuts may increase the incidence of "leakers" if workers are not adequately trained and supervised.

Vacuum packaged cut chilling can vary from a brief 30 second spray or dip in cold water to counter the heating effect of the shrink tunnel, to more lengthy immersion times of several hours in chilled water, or overnight chilling in air.

We have carried out many experiments to evaluate various chilling regimes. In order to measure the effectiveness of the different chilling methods tested, the following criteria were set:

- the centre temperature of the cut must be below 0°C within 24 hours.
- there should be minimal rise in the surface temperature of the cut when it is cartoned.

In one group of experiments cuts were chilled in a cold water spray tunnel for 0, 5, 30 and 60 minutes. They were then cartoned and chilled in air at 0°C. The cooling rate of the surface in the centre of a cartoned topside sprayed for various times is shown in Figure 3.

Since then further work has been undertaken in which topsides were immersed in an agitated ice/water bath for periods of 1, 2 and 3 hours, then cartoned and chilled in air at -1.5°C. The cuts were also cooled on trays in -1.5°C air for 4 hours and overnight. In all cases the centre temperature was reduced to 0°C or below in 24 hours (Fig. 4). The effect on the surface temperature is shown in Figure 5.

These results indicate that chilling in air for only slightly longer than in ice/water is just as effective except that the initial surface temperature fall is not as rapid. This is because the surface heat transfer co-efficient in ice/water is about 10 times that in air but the thermal conductivity of the product is fixed, which means that for large cuts the advantages of immersion chilling over air chilling are reduced.

The problem which now arises is how to cool the cuts individually without incurring unacceptable handling and capital costs.

A continuous conveyorised chilling tunnel in the shape of a spiral or some other configuration which either returns the cuts to the boning room or transfers them to a separate cartoning area would be possible solutions.

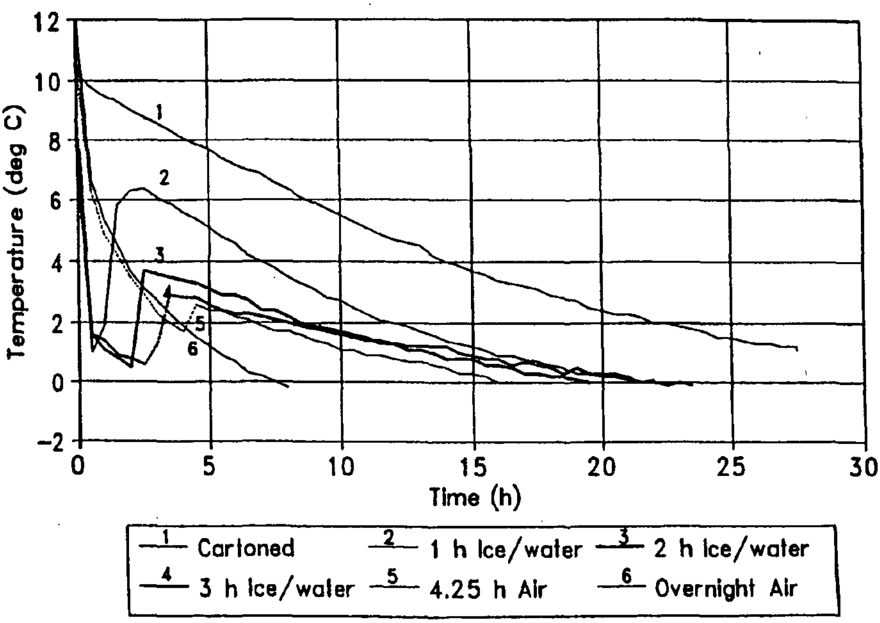

Figure 5 Cooling rate of surface of 7.4 kg of vacuum-packed cut

Some design parameters for such a system are:

1. Air temperature -1.5°C(lower temperatures could be tolerated in the initial stages);
2. Air velocity 2 to 3 ms^{-1}(higher air velocities may be advantageous initially);
3. Time in tunnel 4 h to overnight;
4. Support cuts on solid trays to avoid marking meat;
5. Avoid rough handling.

Cartoning of cuts at the exit from a high intensity chiller could be carried out by a later shift or, provided above freezing temperatures are used, the cuts could remain overnight in the chiller and be packed next day by day labour.

4. Holding Chillers

In most cases it is advantageous to dispatch chilled meat as soon as possible.At times, especially if local trade is involved, there may be extended holding periods. Assuming it is not to be used as an active chiller, the following are some of the design parameters for this type of room:

1. Air temperature -1± 0.5°C;
2. Air velocity 0.5 ms^{-1} or less to provide air distribution;
3. If possible avoid doors opening directly to outside to reduce ingress of ambient air;
4. Maintain a constant temperature as fluctuations in meat temperature promote weep.