HOLDING CHILLERS AND TRANSPORT OF CHILLED CARCASSES

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1. Holding at the Works

By definition a holding chiller does just that, i.e., holds the meat at the temperature at which it is loaded. In practice the meat is usually placed in a holding chiller the day after active chilling commences, or earlier if active chiller capacity is a constraint. The design of the holding chiller's refrigeration capacity should take this into account.

The optimum temperature for holding meat after active chilling, whether it be sides, quarters, carcasses or vacuum packaged cuts, is the lowest at which no freezing occurs. In practice this is -1°C to 0°C as freezing can commence below -1°C. As was mentioned in the paper on chilling cycles, in the case of domestic carcass meat there is not much point in achieving such a low storage temperature unless the meat is to be held at the works for more than a few hours and/or the refrigeration conditions once the meat is loaded out are equally stringent.

For longer storage at a works the meat will maintain better subsequent shelf life if held at the lower temperature. The temperature must be maintained below 8°C, however, in order to control the growth of bacteria of public health significance, so a deep butt and chiller temperature of no higher than 7°C should be the goal.

The benefits of a lower and non-fluctuating holding temperature are:

- inhibition of the growth of bacteria;
- better meat and fat colour;
- less weep;
- reduced enzymic deterioration of the meat.

The holding chiller should be capable of reducing the temperature of a capacity load of meat from about 20°C to 0°C in 48 hours and then holding it at this temperature with minimum fluctuation. In the holding mode the conditions should be the same as for an active chiller holding over, i.e., an air velocity of ca. 0.5 m s^{-1}, an approach temperature of ca. 2°C, and a $t\Delta$ of < 2°C.

There are advocates of using ozone generated by ultraviolet lamps and the like to control bacterial growth. However, the level of ozone necessary to produce any significant decrease in bacterial numbers is so high that it increases the rate of oxidation of fat and thus the extent of rancidity. It may also constitute a hazard to persons working in close proximity.

2. Load-out and Transportation to Shipping Terminal or Domestic Destination

Ideally load-out to container, road transport vehicle or rail should be enclosed and refrigerated so a dust-free and controlled temperature environment can be maintained. In practice not many works have such a facility so much greater attention must be given to a speedy transfer from holding chiller to transport if meat quality is not to suffer. Carcasses and quarters should be kept in the closed holding chiller as long as possible and then loaded without delay. Any inspection, ticketing, bagging and the like should be carried out in the chiller.

Works should satisfy themselves that the transport vehicle or container is clean and the insulated body is in good condition. The refrigeration equipment must be capable of maintaining the meat at the specified temperature under the ambient conditions which will prevail during the journey, and the container or truck body must have a temperature recorder in full working order with adequate available chart capacity for the journey, including contingency time. Sample deep meat temperatures should be recorded and any meat which does not meet the minimum load-out temperature requirement rejected from the shipment. Pre-cooling of the container can result in condensation on the overhead metal structure during loading and should not be necessary provided the on-board refrigeration is adequate. Carcasses are loaded tightly into containers and truck bodies and it is not feasible to carry out any uniform temperature reduction during the journey to make up for inadequate chilling at the works. The load out temperature of the meat should therefore be no higher than the desired discharge temperature at the destination. On arrival at a domestic destination the same procedures should apply as for loading, i.e., the truck body or container doors should not be opened until the un-loading personnel are assembled ready to work. Again inspection, recording and the like should preferably be performed after the meat is in a refrigerated environment. Temperature checks should be carried out on carcasses or quarters and identified as to their location in the transport vehicle. By this means potential meat quality problems can be predicted and appropriate action taken.

When porthole containers without clip-on units are used from works to container terminal a trip time under Australian summer conditions of over 4 hours will result in unacceptable meat temperature rise. CO2 snow (dry ice) in sublimation boxes stowed under the carcasses could be used but integral or clip-on refrigeration equipment is much preferred. It is cheaper, and provides insurance against unforeseen delays in transit. Snow-shooting as used for frozen meat transport is unacceptable as the surface of meat which comes in contact with the snow will freeze.

Holding, loadout and transportation quality assurance should not be left to chance. There should be a Total Quality Management (TQM) plan, based on HACCP principles in operation and help in compiling one which suits the needs of individual works is readily available.

3. Container Terminal

The important factor for an off-refrigeration container is the elapsed time from arrival at the terminal to hooking up to a tower unit. Tower units cater for up to 4 containers by means of inlet and outlet refrigerated air ducts connected to a refrigeration unit. Unfortunately, in most tower units the return air temperature that is monitored is that of the combined air streams of the 4 containers and inadequate air supply to one container can be masked by the recording of an average temperature of all of them.

4. Ocean Transport

Refrigeration to containers on board ship is supplied in a number of ways:

- by inlet and outlet air ducts from the ship's cargo refrigeration system (porthole system);
- by integral refrigeration units which are permanently attached to the container and plugged in to the ship's power supply;

- by clip-on refrigeration units plugged in to the ship's power supply.

In all cases continuous temperature recordings are maintained, either by the ship's instrumentation or by recorders attached to the containers. These recordings are available in case of problems or dispute as to carriage temperatures.

5. Chilled Transport in CO_2 Atmosphere

Shipments of chilled, 300 day grain fed quarter beef averaging 210 kg side weight have been made to Japan in a nominal 40% CO_2 atmosphere. The sides are chilled for 3 days and a deep butt temperature of ca. 3°C was attained prior to quartering. The quarters were stockingetted and hessian bagged prior to shipment in containers fitted with integral refrigeration units. These special containers are fitted with an internal rail hanging structure and were tested for gas tightness using the pressure decay method. The container is pressurised and the time for the internal pressure to decay from 4" to 2" water gauge (WG) is measured. The results of a test on four containers is given in Table 1. During loading, two polystyrene foam sublimation boxes filled with 18 kg blocks of dry ice were placed below the raits and jammed between the hanging quarters. A further 18 kg of dry ice was strewn on the floor of each container prior to the doors being sealed. Heat for sublimination passes from the 0°C container space through the polystyrene insulation at a rate calculated to maintain the CO_2 atmosphere at ca. 40% for the length of the voyage. In conjunction with the Transport Studies Group of the CSIRO Food Research Laboratory (now re-named the Food Science and Technology Laboratory) we were permitted to record the temperatures of 4 containers of this type of shipment from slaughter through to the establishment in Japan where the quarters were boned and vacuum packed for distribution.

The following graphs were compiled from the data:

Figure 1: Plot of the % carbon dioxide samplings

Figure 2: Plot of container air-temperature recordings

Figure 3: Plot of quarter-beef surface, butt and deep-butt temperature recordings.

A comparison of the pressure decay times in Table 1 with the graph of CO_2 concentration readings in Figure 1 shows that the container with the fastest decay time (No.2) was not the one which had a low level of CO_2 during shipment.

Due to the sensitivities of the Japanese importer it was not possible for us to correlate the meat quality factors of microbiology, colour and shelf life of the meat from the various containers.

We expect to publish a more detailed report on this shipment shortly.

Table of Container Pressure Decay Times

Container Number	Decay Time(s)
1	120
2	55
3	65
4	60

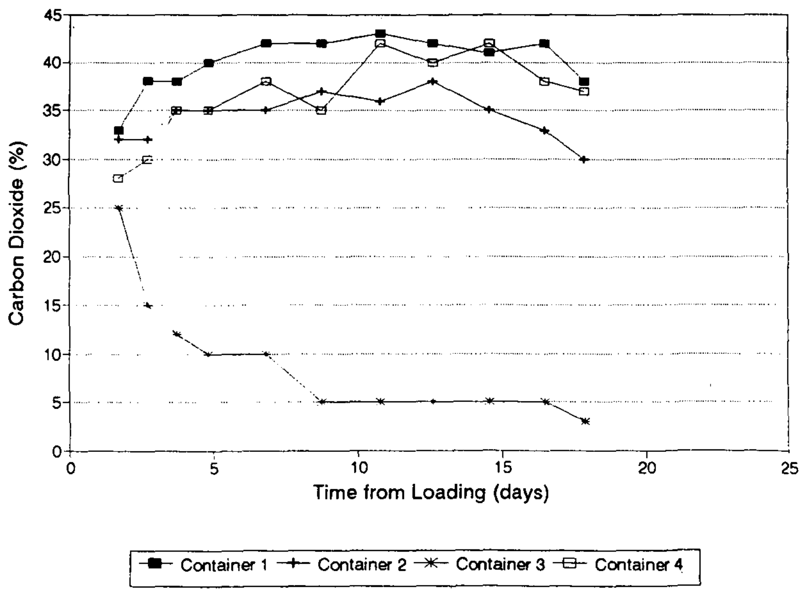

Figure 1: *Chilled quarter-beef shipment to Japan*
Carbon dioxide readings

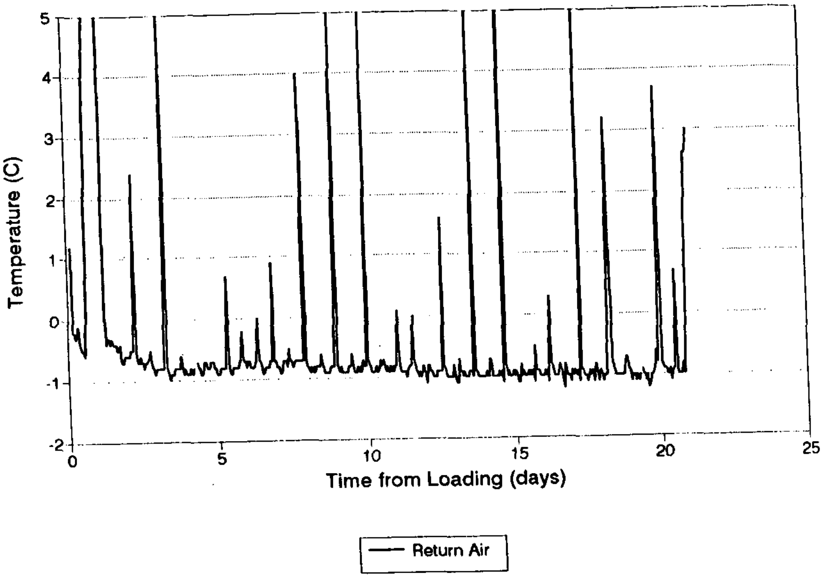

Figure 2: *Chilled quarter-beef shipment to Japan*
Air temperature

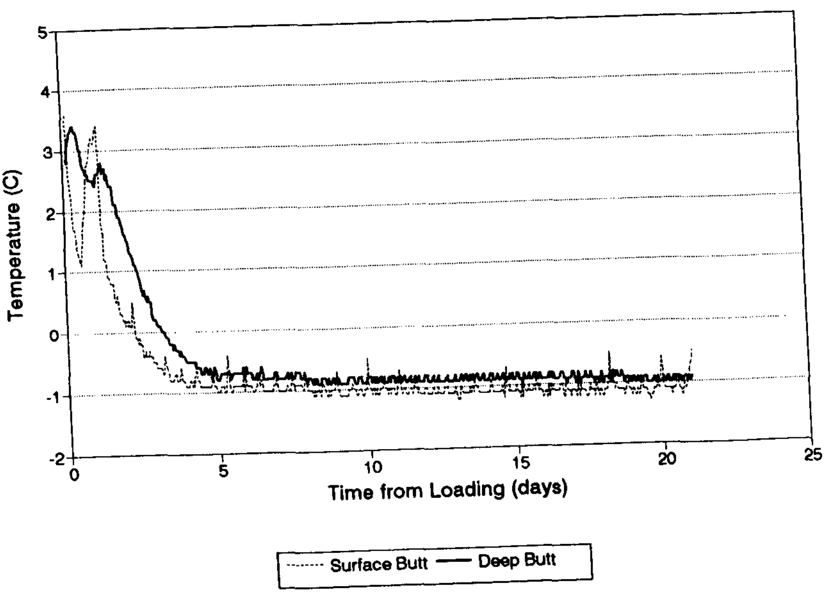

Figure 3: *Chilled quarter-beef shipment to Japan*
Meat temperatures