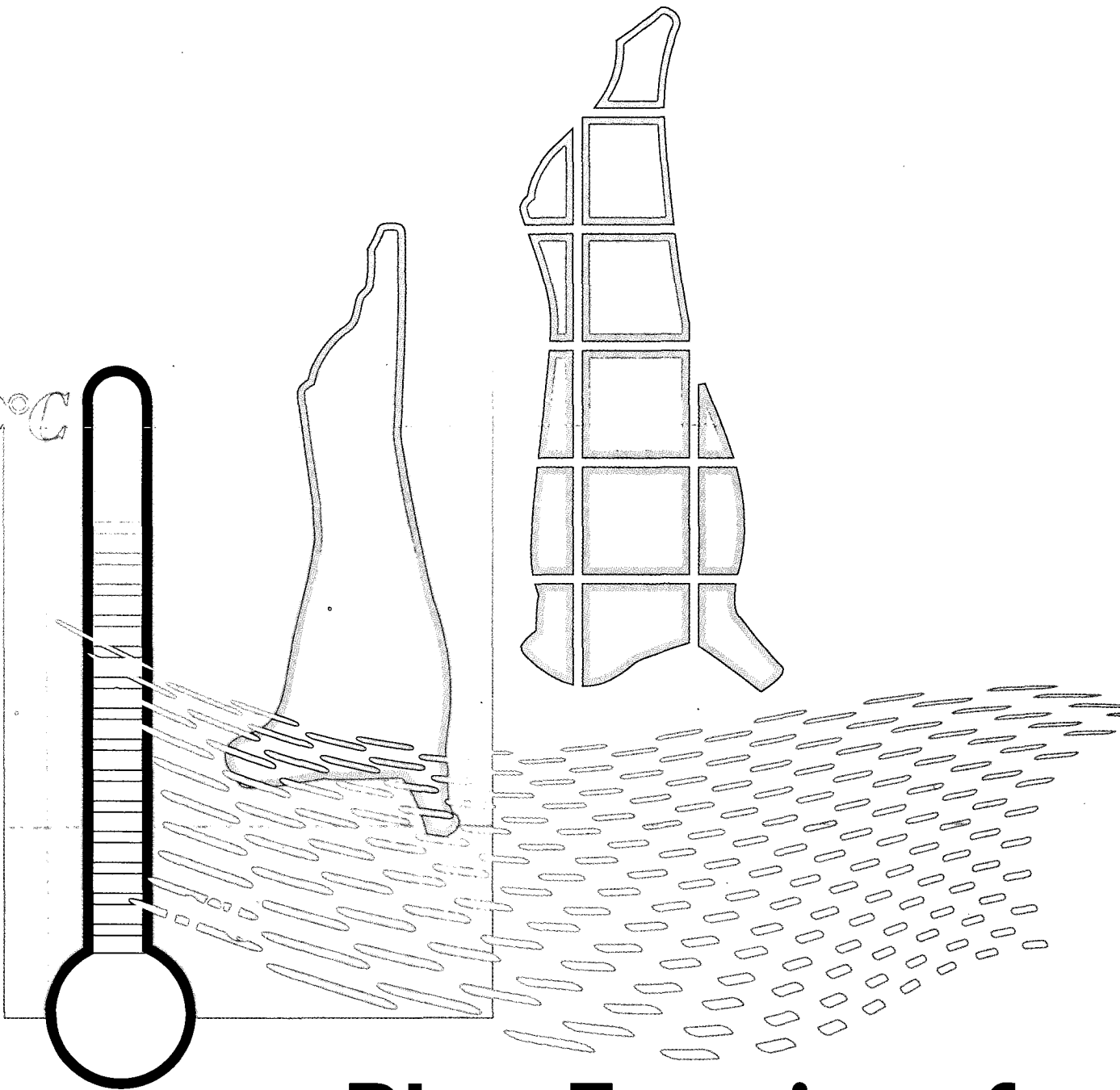


100°C



# Blast Freezing of Carcasses and Quarters

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Meat  
Research  
Corporation



AUSTRALIAN MEAT TECHNOLOGY

**F**reezing has played a crucial role in presenting beef quarters and lamb and mutton carcasses to the market in an attractive state since the inception of Australia's export meat trade to Britain in the latter part of the 19th Century. Until the commencement of the trade in chilled quarters in the 1930s and the cartoned meat trade in the 1960s, freezing was the only method of preservation used to service Australia's distant markets. Today, there is still a significant trade in frozen carcasses and quarters.

The aim of freezing is to slow or arrest microbiological, biochemical and other effects that result in spoilage. Although frozen meat has a slightly different appearance from fresh or chilled meat, eating quality after thawing can be the same if the meat is correctly frozen, stored and thawed.

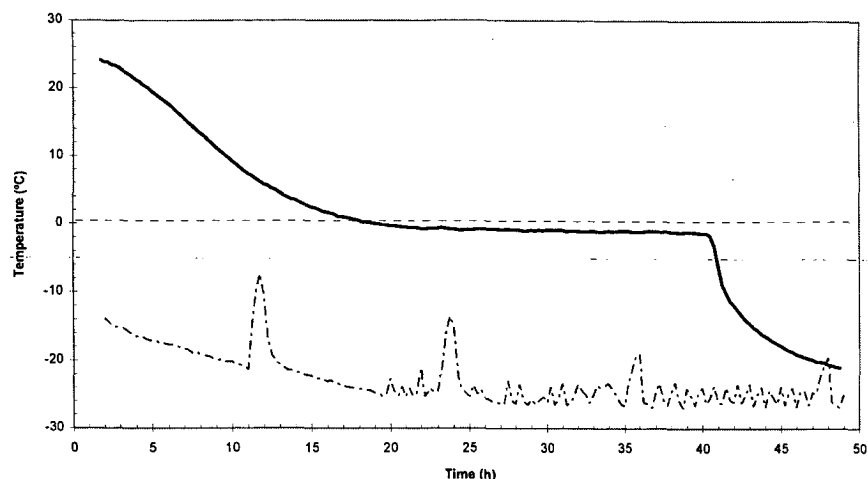
If hot carcasses are frozen or chilled too quickly, the meat will become tough due to cold shortening. In addition, if carcasses are frozen before the meat is set in rigour, the muscles will contract further on thawing and toughen substantially. This toughening during chilling or freezing can be minimised, however, if carcasses are electrically stimulated.

### The Freezing Process

When a liquid such as water changes to a solid, a large amount of heat must be removed. This heat is called the "latent heat of freezing" and is removed at 0°C in pure water.

Meat, on the other hand, acts more like a weak salt solution, and about 10% of the water is so tightly bound to the protein molecules that it is not frozen, even at very low temperatures. Enough water is available, however, to ensure that, as the temperature falls, there is a thermal arrest plateau in the thermal centre at about -1°C. (See Figure 1) At about -5°C, sufficient ice is formed for the meat to be considered hard frozen.

FIGURE 1 Centre temperature of meat during freezing



### Freezing Systems

In high throughput plants in New Zealand, lambs are frozen in automatic air blast freezers. In Australia and most other countries, throughput is lower, and batch blast freezers are used for carcasses and beef quarters.

The air temperature in the blast should be -20°C to -30°C with an air velocity over the carcass surface of 1.5 to 3.0 m/s. While lamb and mutton carcasses are generally frozen directly after slaughter, beef is chilled prior to quartering. Because a chiller is less expensive to operate than a freezer, plants should remove as much heat as possible from the beef while it is in the chiller.

Although quarters and carcasses can be frozen as is, it is normal practice to wrap the quarters and carcasses in polyethylene and stockinette for lamb and mutton and stockinette and hessian for beef quarters.

### Estimation of Freezing Times

Meat plant operators should know how long carcasses and quarters will take to freeze as these items should not be stacked in a cold store until the latent heat has been removed. Likewise, engineers who design a plant or process should also be able to predict the freezing time.

Several methods can be used to estimate or calculate freezing times. These methods range from nomograms to slide-rule type calculators, computer programs and laborious hand calculations.

Nomograms are useful as they allow quick estimates to be made and can be used by relatively

untrained personnel. The accuracy of nomograms, however, is limited, and it is difficult to include all variables that are likely to be encountered.

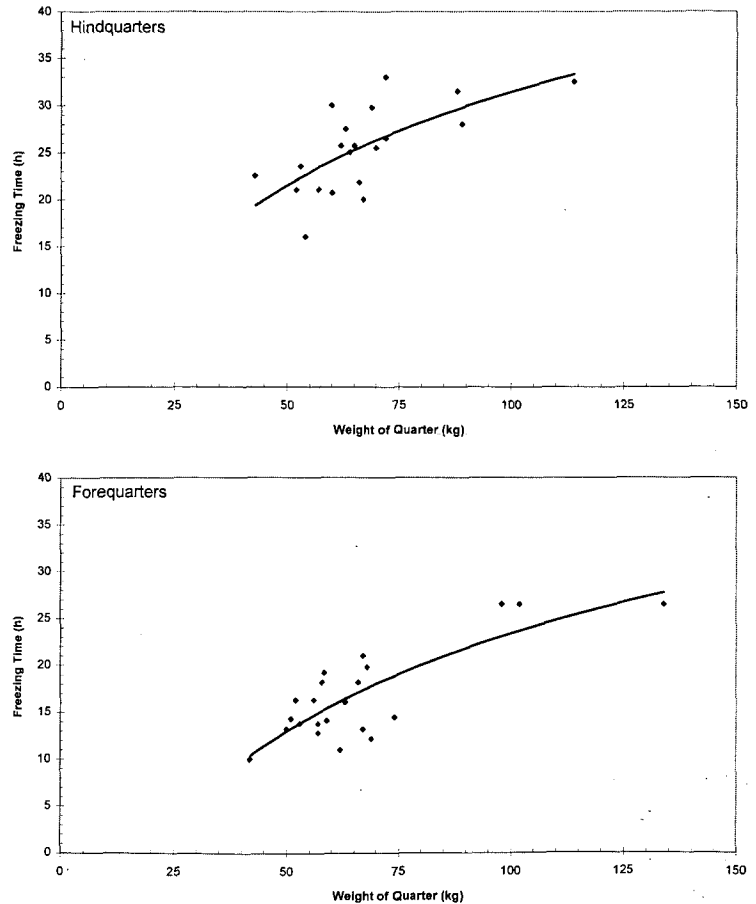
Figure 2 shows a nomogram constructed to predict the freezing times to  $-5^{\circ}\text{C}$  deep leg temperature of mutton and lamb carcasses in stockinette. [Acknowledgement given to the Meat Industry Research Institute of New Zealand (Inc.) (MIRINZ) and extract from paper by A K Fleming of that organisation.]

The freezing rate is more difficult to predict for carcasses in polyethylene bags with a stockinette outer. This is because the rate is dependent on the fit of the wrapping. Freezing times, however, are generally about 60% greater than for lambs in stockinette only.

Work in the United Kingdom on the freezing times of pre-chilled beef quarters at the most commonly used freezing conditions shows the effect of weight of the quarter on the freezing time. The large scatter in the experimental results (Figure 3) suggests that factors other than weight influenced freezing time. These factors included fat cover and carcass conformation as well as the practical problem of accurately locating the thermal centre.

The results showed that most unwrapped pre-chilled forequarters could be frozen in a 24-hour

**FIGURE 3 Freezing times of beef quarters in air at  $-32^{\circ}\text{C}$ , 1.5 m/s velocity**



freezing cycle whereas a 48-hour cycle would be more appropriate for hindquarters. Although it is common practice to freeze hinds and fores together, consideration should be given to freezing hindquarters and forequarters in separate rooms, with the effect of the wrapping taken into account.

Mathematical formulae have been developed to calculate freezing times of various foodstuffs. Many of these are a modification of Plank's equation developed in 1941 and can predict freezing times of standard shapes, such as rectangles and cylinders, to an accuracy of  $\pm 15\%$  or better. The application of one of these equations is described in MIRINZ Bulletin No. 37.

The Meat Industry Research Institute of New Zealand (MIRINZ) has developed a computer program that allows rapid calculation of cooling and freezing times of

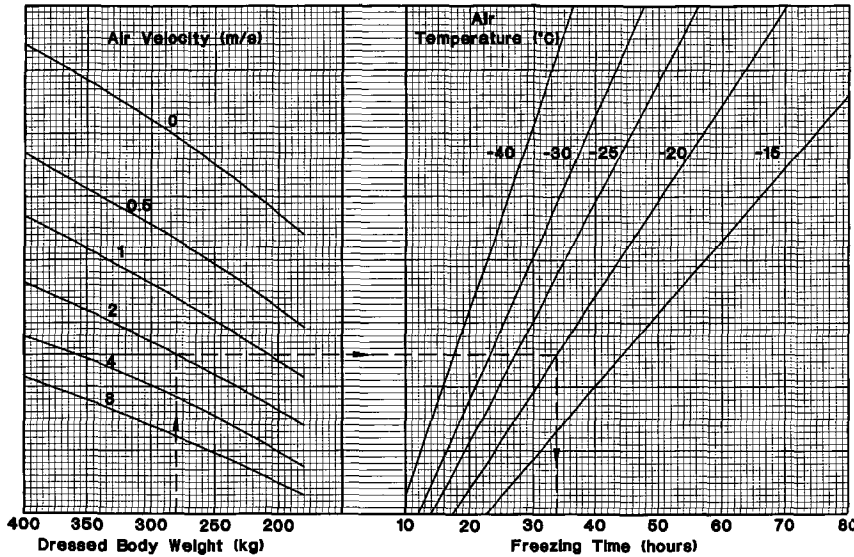
**FIGURE 2 Lamb carcass freezing nomogram**



*Example: A 15kg lamb carcass wrapped in stockinette with an initial temperature of  $15^{\circ}\text{C}$  would take 10 1/2 hours to freeze in a transverse air blast of 1 m/s and an air temperature of  $-20^{\circ}\text{C}$ .*

a variety of meat products including carcasses and quarters. The freezing times can be quickly calculated knowing carcass weight and wrapping, air temperature and air velocity. A nomogram for beef hindquarters in stockinette has been constructed based on this program.

**Figure 4 Beef hindquarter freezing nomogram**



**Additional information**

More detailed information on this subject is provided in the following:

*17th International Congress of Refrigeration Proceedings, "The Freezing of Beef Quarters"*

*MIRINZ Bulletin No. 37, "Calculation of Freezing Times"*

*Workshop Proceedings, A C Cleland and D J Cleland Massey University, NZ, 1992, "Cost-Effective Refrigeration"*

*ASHRAE Guide and Data Book, "Applications" Volume*

*43rd ICOMST 1997 Congress Proceedings, "Modelling Meat Processing Operations"*

**Additional information**

Additional help and advice are available from Food Science Australia, Meat Industry Services Section:

	Phone	Fax
Ian Eustace	(07) 3214 2117	(07) 3214 2103
Neil McPhail	(07) 3214 2119	(07) 3214 2103
Bill Spooner	(02) 4567 7952	(02) 4567 8952
Chris Sentence	(08) 8370 7466	(08) 8370 7566

**Or contact:**

**Processing and Product Innovation  
Meat & Livestock Australia**

**Tel: (02) 9463 9166  
Fax: (02) 9463 9182**

**Email: [ppi@mla.com.au](mailto:ppi@mla.com.au)**