# The Preparation and Transportation of Meat Products with Particular Emphasis on Chilled Meat Shipments

presented by John Bowater at the Intermodal Conference 1996

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The shipment of meat products from the southern hemisphere started in commercial terms in the 1890s. At that time, all meat products were frozen prior to shipment and held at $-10^0$C, or below, during the voyage. In the 1930s, a trade in beef quarters from Argentina was started to benefit from the superior prices obtainable from chilled products - the quarters being held at $-1^0$ to $-2^0$C during a fifteen day voyage. In the 1950s, a similar trade developed from Australia to Europe, but using controlled atmospheres in gas-tight tween decks for the longer journey. The 1960s saw the development of the trade to vacuum packed cuts, whereby the deboning and product preparation was undertaken before shipment.

We now have a trade in vacuum packed and controlled atmosphere packs throughout the world. The evolution of this trade has relied most significantly upon the improved processing methods in the meat works prior to shipment. This paper concentrates more upon these slaughterhouse and meat preparation technologies that have made this trade possible, rather than the actual shipments themselves.

## Objectives

The main parameters for a successful trade in meat products rest on four requirements, as follows:-

i) Shelf-life
ii) Tenderness
iii) Taste
iv) Appearance

### (i) Shelf Life

Frozen products have sufficient shelf-life to hold no barriers for shipment of meat products throughout the world. Chilled products, however, must be so prepared as to ensure there is at least some 15-20 days shelf-life left on entering the country of destination to allow time for reprocessing for retail display and final consumption. Thus the factors for extending shelf-life for chilled products are of exceptional importance and, because of this, primal cuts are the usual products for shipment - retail packs, even with the latest technology, cannot achieve the necessary shelf-life.

### (ii) Tenderness

The most important eating requirement for meat products is tenderness. The factors of particular importance in achieving this are the processing techniques within the meat works and, in particular, hygiene, effective refrigeration and the elimination of cold shortening together with good stock selection.

### (iii) Taste

A good tasting meat product relies upon stock selection and factory processing. Good taste is essential for a successful product.

### (iv) Appearance

An appealing appearance is essential for successful sales. Vacuum packing and controlled atmosphere products for shipment extend shelf-life but do not always enhance the product's appearance. This is a further reason for the necessity of reprocessing for retail display.

## The Processing And Transport Chain

Figure (1) provides a general outline of the usual procedures and transport arrangements for chilled export meat products where the transport time is a period of several weeks, particularly relevant to products coming from the Southern Hemisphere.

The various important elements in this chain are discussed below, but the important point to understand is that the chilled primal cut must be reprocessed in the country of consumption to form the final retail pack, which has limited shelf life, despite the latest techniques and, therefore, cannot be prepared at the export meat works, unless air transport and its increased costs are acceptable. This paper highlights the relevant and important processing procedures within this chain.

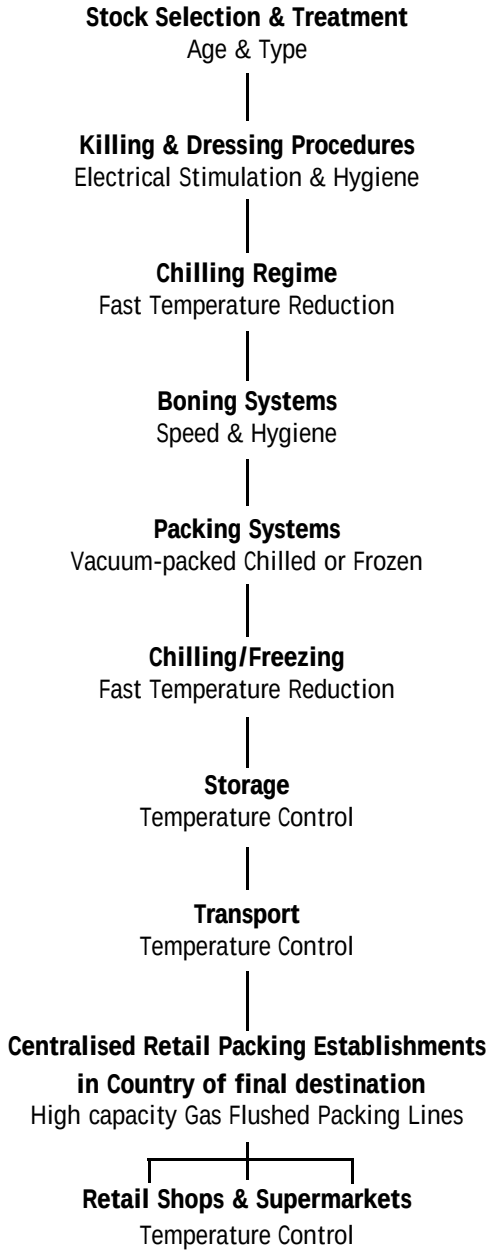


*Figure 1. The process and transportation chain*

## Transport Requirements

Modern meat products which are for the most part packed in 27.5 kg cartons, whether frozen or chilled, are easy to transport by refrigerated container. Meat, unlike fruit products, does not give off heat once reduced to carrying temperatures and thus bulk stows with effective air circulation provision around the stow of some 110 air changes per hour should be all that is required. There is no necessity for the provision of air passageways around the individual cartons, although some shippers still use a form of battening for chilled products to guarantee air flow past the cartons, to ensure that product not down to temperature at loading will be cooled during the voyage - see Figure (2). Frozen meat products are best

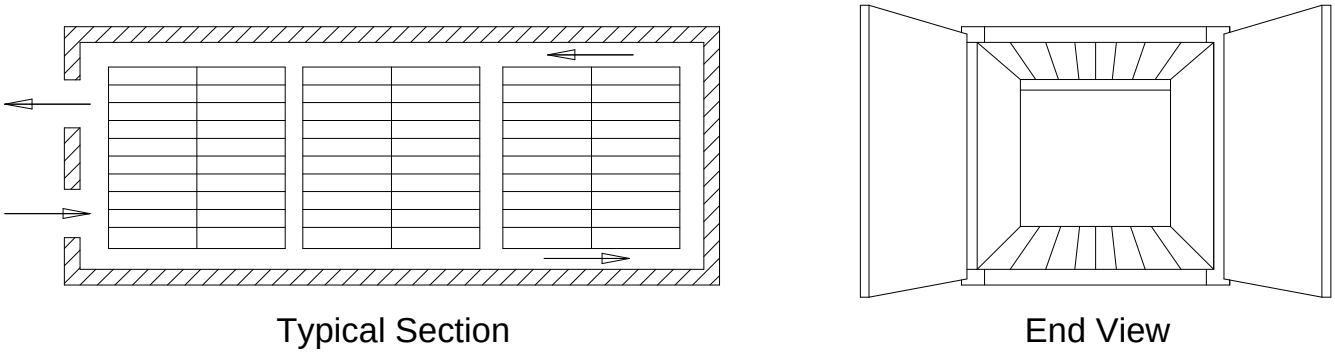


*Figure 2. - Typical port hole type refrigerated container and air flow requirements*

carried below -18$^0$C and chilled products as close to -1$^0$C as possible. The carriage of carcasses or beef quarters for export shipment are a thing of the past, although shipments of whole lamb carcasses encased in controlled $C0_2$ boxes are being carried out for special markets. The most difficult consideration concerning the transport stage is temperature control. Too low a temperature will freeze the meat fat, while higher temperatures of -1$^0$C significantly reduce shelf-life.

## Processing Requirements

Transport of modern meat products is relatively simple, provided the product is loaded at the correct temperature and the temperature control system on the container is effective. However, the successful shipment and the ultimate quality of the product is very much dependent upon the processing of the product prior to shipment.

### i) Cut Selection

Figure (3) shows a beef side and the various cuts obtainable from the different areas of the carcass. The carriage of chilled meat is only relevant to the high priced cuts from the carcass. There is no commercial benefit in carrying low quality chilled cuts - such cuts are better frozen for long shelf-life and commodity trading.

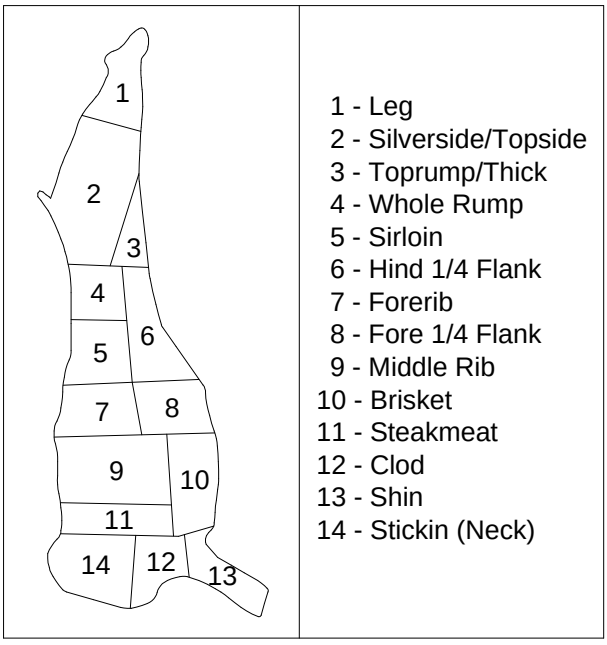


*Figure 3. – Beef Cuts*

| Cut | %Useable of Carcass | Export Disposal |
|---|---|---|
| Rump<br>Striploin<br>Tenderloin<br>Cube Roll | 16% | Chilled<br>Vacuumed<br>Cuts |
| Topside<br>Silverside | 16% | Frozen<br>Cuts |
| Leg<br>Hind Flank<br>Fore Flank<br>Middle Rib<br>Brisket<br>Steakmeat<br>Clod<br>Shin<br>Neck | 68% | Frozen<br>Bulk<br>Packs |

*Table (1) - Beef Carcass Cut Disposals*

Table 1 schedules the major cuts and shows a typical percentage break-up of the beef carcass. The high quality cuts which benefit from chill transport are limited to the rump, striploin, tenderloin and cube roll. As can be seen, these only represent 16% of the total useable meat carcass disposal. Thus the major transport requirement in volume terms is always likely to continue to remain with frozen product. Similar percentage figures are relevant to pig and sheep carcasses

Thus specialised preparation for the high quality cuts is necessary for chilled transport with acceptable shelf-life, while more straightforward processing is applicable for the bulk of production scheduled for freezing.

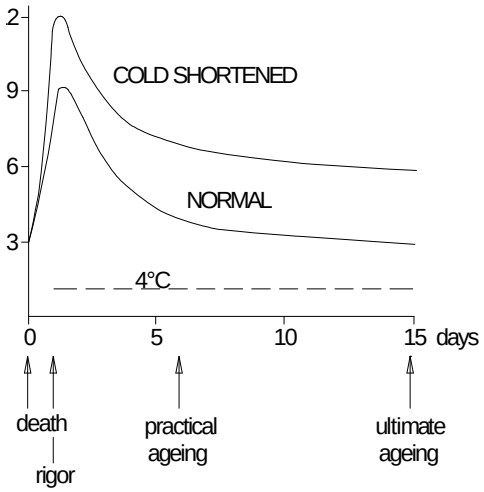


*Figure (4) - Changes in the toughness of meat after cooking during processing*

## (ii) Dressing Floor Requirements

### a) Stock Resting and Quality

To benefit the quality of chilled or frozen meat products, it is essential that all stock are rested prior to slaughter. Highly stressed stock will result in high pH meat, which reduces shelf life and produces poor colour and is particularly disadvantageous for chilled vacuum packed product for shipment. Thus following transport, the stock must be rested for at least eight hours. The age and type of stock, as to whether it be grass or lot fed, is also relevant.

### b) Electrical Stimulation

Following stunning and sticking and during the bleeding period, low voltage stimulation is essential for beef and sheep meat, while beneficial for pork. This process, which was developed in the early 1980s, provides a pulsating current at low voltage through the carcass which accelerates rigor mortis and ensures the carcass pH drops to 6 or lower, before entry to the carcass chillers. If fast chilling takes place before the pH drops to 6, a phenomenon known as cold shortening sets into the carcass and contracts the muscles, which produces tough meat, and cold shortening is irreversible.

Good quality meat can be produced as it used to be many years ago by slow chilling, but slow chilling is unacceptable nowadays as it allows surface bacteria to grow which in turn reduces shelf-life considerably for chilled export products. Also slow chilling requires more chillers, resulting in more capital cost and increased working capital.

Figure (4) shows the toughness of meat on a time basis from slaughter. Meat cooked immediately after slaughter is tender - it might be given an arbitrary rating of 3 toughness units. If handled normally and cooked in rigor (after 24 hours), it is excessively tough (say 9 toughness units); after the resolution of rigor (2 - 3 days), the toughness will decrease rapidly to about 6 units and from then it will disappear slowly during ageing until, at about 14 to 20 days, it returns to the original value of 3.

The same profile of immediate increase in toughness for cold shortened meat, which comes about from fast chilling is shown, and the toughness also reduces during the ageing process, as before, but the final aged product ends up with double the toughness factor of normal non cold-shortened product. This difference is unfortunately irreversible and the product is damaged for good.

Thus, for today's chilled product transport requirements, electrical stimulation is essential.

### c) Hygiene and Weasand Tying

To achieve good shelf life, good dressing floor hygiene is essential. Contaminated material and poor dressing procedures will result in high carcass surface bacteria counts, which will result in faster deterioration of the product and thus shorter shelf life. One of the most important requirements is to prevent the internal stomach material of each carcass being spread and put in contact with the meat cuts of the carcass. To prevent such contamination of

the head meat and, more importantly, general contamination during evisceration of the carcass, weasand tying is essential. This procedure involves opening up the neck of the carcass immediately following stunning and before bleeding and pushing a weasand clip down the weasand and clipping the weasand at the point of entry to the stomach. In this way, stomach material contamination is reduced or eliminated. The weasand is the connection pipe between the mouth and stomach of the carcass. This is a most important requirement to reduce bacteria and increase shelf life, particularly for chilled export products that need to maximise shelf life.

### (iii) Chilling Regime

After the dressing floor procedures, the next important stage in the carcass processing is chilling. The carcass temperatures after dressing are still at around body heat of 38 - 40$^0$C. To maximise shelf life for export chilled products, it is important to chill the carcasses as rapidly as possible as bacteria multiplication increases dramatically at higher temperatures. Below 7$^0$C this multiplication falls off significantly.

Fast reduction in carcass temperatures is easy for lambs, but much more difficult for pig carcasses and particularly beef carcasses, where the distances from the internal parts of the best cuts to the outside of the carcass is much greater. Normal beef carcasses can be effectively reduced to an internal deep leg temperature of 7$^0$C within 24 hours by refrigerating in an air stream of-3$^0$C and 1 metre per second, dependent upon carcass weight and fat cover. This then allows deboning the carcass the following day with meat temperatures below 7$^0$C. See Figure (5).

Such a chilling regime, as shown in Figure (5), which is more rapid than normal practice, will result in all lamb carcasses being cold shortened, with most of the best beef cuts being likewise affected. The cold shortening problem occurs for beef and lamb to any part of the carcass which drops below 0$^0$C within 10 hours of slaughter. This is because the pH of the carcass is generally above 6 during the 10 hour period. Low voltage electrical stimulation can reduce the pH to 6 within 1 hour of slaughter. Thus the chilling regime in Figure (5) is allowable without the disastrous toughening effects demonstrated in Figure (4). Thus electrical stimulation for lamb and beef carcasses is essential in order to produce tender products, while allowing rapid chilling to extend shelf life. Pork carcasses are not so dramatically affected, as pork carcass pH drops faster than lamb or beef carcasses, but it is advisable to electrically stimulate pork as well.

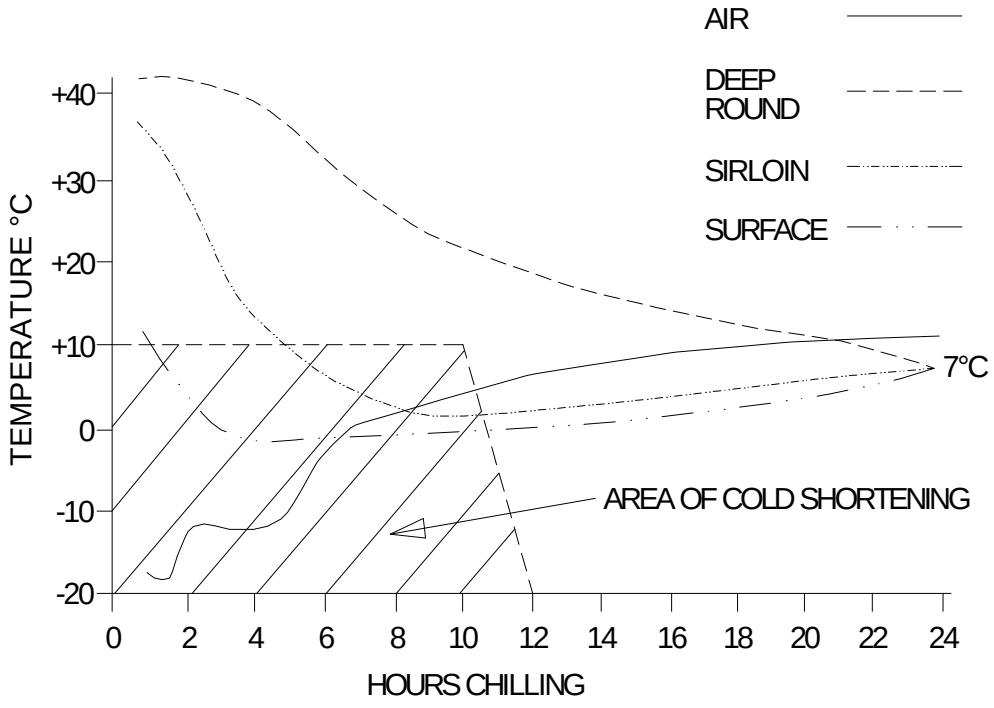


*Figure (5) – Temperatures recorded during rapid beef carcass chill tests*

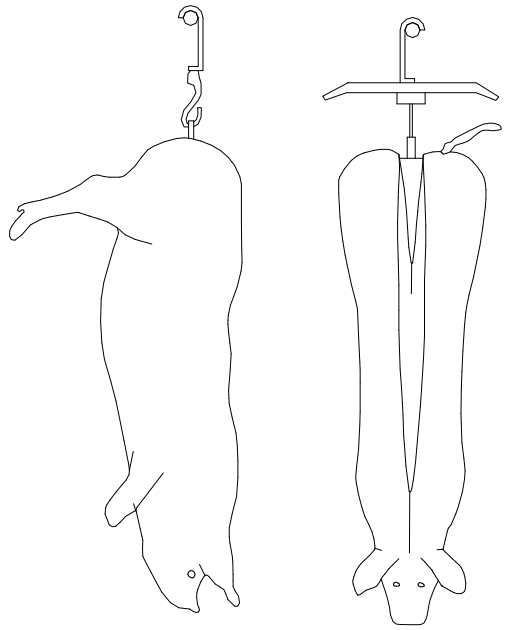

*Figure (6) - Aitchbone hanging for pork carcasses*

During the chilling process, tenderisation is further enhanced by hanging carcasses by the Aitchbone rather than the leg, which is the conventional requirement. - See Figure 6. This prevents muscle contraction in the leg and loin, which are the most valuable parts of the carcass and which causes toughening.

### (iv) Ageing

Ageing the best cuts of a carcass is essential for achieving tender product (see Figure 4). Some retailers insist on hanging the carcasses for two days prior to deboning and preparing primal cuts with a further day's hanging of the hind quarter.

For export chilled products, this procedure is expensive and unnecessary. Firstly, it is only necessary to age the best cuts - there is no advantage in ageing meat destined for manufacturing products, such as burgers or sausages [see Figure (2) and Table 1]. To build carcass chillers for two days' chilling and hold product longer than necessary is uneconomic. Export cuts should be vacuum packed after boning, and ageing can be achieved during the transport period. Ageing longer than 15 days produces marginal improvements in tenderness, and seven days with electrical stimulation is generally the minimum for acceptable quality.

### (v) Freezing after Boning

Frozen product for shipment is either prepared as special cuts in a similar way to chilled cuts, usually for topsides or silversides (see Table 1), but wrapped rather than vacuum packed. Forequarter meat is usually frozen in bulk for export prior to sale to manufacturing operations. Shelf life is extended almost indefinitely by freezing, but the best cuts achieve lower sales values compared to chilled cuts. Freezing is carried out in a similar way to carton chilling (see Figure 7), but using low air temperatures down to -35$^0$C for 24 hours turnaround, or -26$^0$C for two day freezing, as shown.

### (vi) Chilling after Boning

Chilled vacuum packed meat products must be held as close to -1$^0$C as possible to increase shelf-life, while not freezing the product.

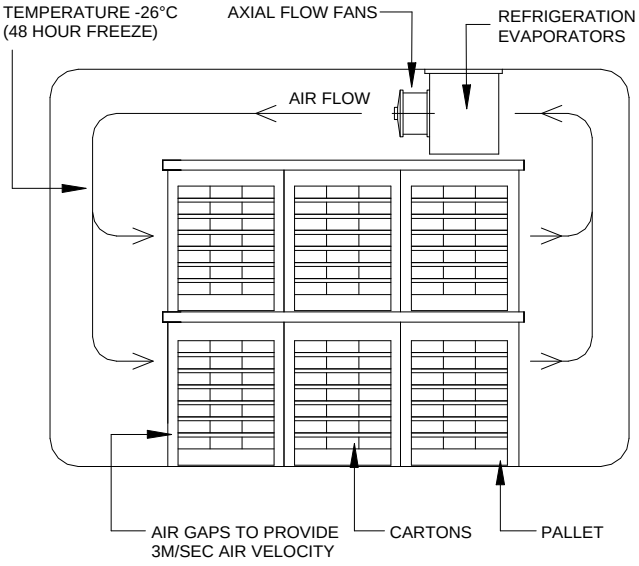


*Figure (7) - 48 hour carton freezing tunnel (Similar configuration for chilling with air down to -5 $^0$C).*

Thus it is important that the meat works incorporates special chill tunnels which are used immediately after packing the vacuumed cuts into cartons to reduce the meat from boning room temperatures of 7$^0$C down to 0$^0$C as rapidly as possible (see Figure (7), with air temperatures no lower than -5$^0$C. It is poor practice to simply hold the product in a cold store at 0$^0$C and wait for temperatures to equalise. It is such practice that has made shippers play safe and incorporate battening when loading containers (see Figure (1)).

## Wholesale Packs

Wholesale packs are used in the transport chain (see Figure 1) before retail packing, which is usually carried out in the country of consumption.

### (i)Frozen Primal Cuts

Once the primal cuts have been prepared in the boning room and following trimming to specification, they are normally wrapped in PVC material and placed in 27.5kg cartons (60 lbs.). This weight of carton is virtually standard to the meat industry for wholesale distribution. Thus each carton holds a significant number of primal cuts, dependent upon the part of the carcass from which each cut is taken. After being placed in cartons, these cartons are then either strapped or glued and then frozen. The product can then be traded as a commodity in a wholesale manner around the world's market and finally sold on to further processors. The retail shop or a further processing factory prepares the product for retail presentation. Shelf-life can extend to a year and longer.

### (ii) Chill Vacuum Packed Primal Cuts

Again, these packs are usually prepared for shipping purposes only. The same general processing procedure is applied to these products as to the frozen primal cuts except that each primal cut is placed into a vacuum pack bag and the air is then evacuated from the pack prior to sealing. The original technology has advanced considerably insofar as evacuation of air takes place inside and outside the bag to ensure that air is not entrapped during the evacuation process. The primal cuts are then placed in 27.5kg cartons and the product can again be traded in a wholesale manner on the world markets, destined eventually to arrive at further processors for portioning and retail preparation.

The vacuum packed primal is the most common chilled transport system used. The extended shelf life depends upon the ageing bacteria consuming oxygen within the pack, while at the same time giving off $C0_2$. This eventually results in an atmosphere within the bag of down to 2% oxygen and up to 30% $CO_2$. As the $C0_2$ builds up, the bacteria diminishes due to lack of oxygen.

To obtain maximum life, the meat pH should lie between 5.4 and 5.6, when being packed, and must not exceed pH 6. Because of this, sealing used to take place 36 hours after slaughter. However, with electrical stimulation, sealing now can be performed immediately after chilling, usually within 24 hours of slaughter. Packing should take place immediately after boning to retain good colour. Transport should be effected at -1$^0$C. Shelf-life for beef can extend up to 90 days and 70 days for lamb.

### (iii) Gas Flushed Primal Cuts

A more recent advance for chilled primal cut transportation has developed by gas flushing primals with 100% $CO_2$.

This system requires firm individual containers, and the packing machines flush out the air and replace it with $C0_2$ before sealing. Shelf life can be extended by some 30% over normal vacuum packing, but stowage is less economical than vacuum packing and the process is more expensive.

### (iv) Gas Flushed Carcasses

An even more recent development has devised a lamb carcass bag which is $C0_2$ filled and then placed into a transport box. This system is expensive and wasteful on container space. However, for certain markets, such as the Middle East where buyers do not like frozen products, there is a market.

## Retail Packs

Once the primal cuts or carcasses described above reach the country of consumption, further processing is then carried out to prepare the final retail packs as follows (see Figure 1):-

### (i) Tray Wrap

Tray wrapped portions are almost always made up by means of slicing and trimming chilled primal cuts, after removal from their bags, at the rear of the supermarket or butchers shop for display in that shop. For practical purposes, the shelf life will not be longer than two days; usually all such packs are sold on that particular day. The wrapping system may not be sophisticated and is often carried out by hand, as the volume required is normally limited. However, there are volume automatic shrink wrapping systems available.

### (ii) Vacuum Packed Portions

The raw material used will again be chilled primal cuts, and packaging is often carried out at the rear of the

supermarket or butchers' shop. Instead of using trays, small vacuum packing units are used, and the benefit of proceeding in this way is that an extended day shelf life should be possible. This gives more flexibility on the part of the retailer to sell his product. However, vacuum pack produce does not usually display good colouring and thus such packs are not common. Shelf-life in the pack of some 15 – 20 days can be achieved.

### (iii) Gas Flushed Portions

Gas flushing is a process which grew up in the 1980s and is still the most popular display pack. The product is again prepared from chilled primal cuts but, because gas flushing can expand the practical shelf life up to 11 days compared with the tray wrapped product, it is now possible to prepare these portions in a centralised processing factory, removed from the retail outlet, and thus economies in volume production can be achieved. The process usually involves setting up high volume production lines starting with a slicing machine, continuing with conveyor packing stations and high capacity gas flushing machines which expel the air and substitute it with a selection of gases. There has been considerable research into the best gas combination and it is usual for a mixture of carbon dioxide, nitrogen and oxygen to be used. Due to the complete eradication of the normal air mix and the substitution of this specially prepared gas mix, the bacteria multiplication is significantly reduced and the shelf life is extended, compared with the tray wrapped product, while good colour is retained, which is impossible with vacuum packed portions.

Some retailers do not believe, however, that the gas flushed pack is as attractive to the customer as tray wrapped product, and certainly gas flushed product requires a significant increase in capital investment because the machinery is expensive. Packs are most often removed from shelves early, if unsold, and the meat can then be frozen and further processed rather than be lost.

### (iv) Frozen Portions

Frozen portions are produced from either vacuum pack primals or frozen primal cuts. The primal cuts are purchased either by further processing operations or supermarkets and, in the case of the frozen primals, the portions are then cut from the primals using a band saw and are usually then vacuum packed prior to being displayed in frozen cabinets in supermarkets and butchers' shops. This processing can either be carried out in a centralised factory or at the rear of the supermarket or butchers' shop. This low quality pack, introduced in the 1970s, is becoming less popular as time proceeds. Shelf-life can extend to several months. The effectiveness of vacuum packaging of primal cuts for shelf-life cannot be over-stressed. Shelf life is increased threefold over the shipment of normal carcasses.

What is of particular relevance nowadays is that the final retail pack which the consumer requires cannot be prepared in an export meat works. The product must be shipped in primal form for reprocessing into retail packs, if so required in the country of consumption. All the above retail packs have sufficient shelf life for central processing and preparation other than the tray wrapped product which must be prepared at the retail site. The retail outlet must have display cabinets that hold the chilled product temperatures close to $0^0$C to retain these shelf lives.

## Conclusion/Summary

The successful shipment of quality meat products depends principally upon scientific preparation at the export meat works.

The fundamental objective is to achieve long shelf-lives for chilled product, while maintaining tenderness, taste and appearance. The actual transporting requirements are relatively simple and only require constant temperatures and acceptable air circulation, provided the meat works preparation is good. The process prior to shipment requires good livestock selection and treatment, scientific and hygienic dressing floor processing, electrical stimulation, efficient cooling systems and well managed boning and packing systems, and this processing is complicated and needs attention to detail to achieve high quality products.

The final retail pack is usually prepared in the country of consumption. But the successful use of quality imported meat rests principally with the exporting country, and the individual meat works' scientific management of all the required processing details. This paper highlights some of the most important processing requirements.