



PPI

Processing & Product Innovation

Vacuum Packaging Primal Cuts 2000

The Australian meat industry has been successfully vacuum packaging chilled primal cuts for over 30 years. Vacuum packaging is a proven technology that is well accepted by meat processors and packers, meat wholesalers, food service customers, supermarkets and, to a limited extent, by retail butchers. This method of packaging improves the stability of meat during chilled storage by reducing rancidity of fats and eliminating aerobic spoilage by excluding oxygen from the meat surface. Vacuum packaging of primal cuts offers extended shelf life thus allowing chilled sea freight and controlled ageing for enhanced eating quality. In some applications it also offers improved visual presentation.

To achieve these advantages it is essential that three process factors are effectively managed.

These are:

- product hygiene;
- temperature control;
- correct application of vacuum-packaging procedures.

Before considering the application of vacuum-packaging technology it is important that procedures are in place to manage hygiene and temperatures. The technology is rendered less effective if product hygiene and temperature control are neglected.

Product hygiene

There is a mixed population of micro-organisms on the surface of fresh meat before it is vacuum packed. Inside the vacuum pack, only the organisms that are suited to the conditions of very low oxygen level, pH in the range 5.4-5.9 and temperatures of around 0°C can flourish and grow. The other organisms from the initial population will not grow and will slowly die. The optimum effectiveness of vacuum packaging relies on the numbers of micro-organisms being low at the time of packaging. This reduces the potential range of micro-organisms that

might be able to grow in a vacuum pack. It also extends the time taken for the maximum population of organisms in the pack to be reached.

The safety of vacuum-packed product relies on the micro-organisms present being predominantly of non-food-poisoning types. The environment in the vacuum pack favours the growth of lactic acid bacteria. If lactic acid bacteria grow quickly they will outgrow the food-poisoning bacteria and effectively suppress them.

Vacuum packaging requires a strong hygiene program that addresses plant, product and personal hygiene throughout slaughter, dressing, boning and packing. Verification of all aspects of the hygiene program by meat contact and carcass surface sampling is normally adequate, although verification of product hygiene at the point of packaging is useful. Microbiological testing of product after vacuum packaging and storage is of little value as a guide to the remaining shelf life of the product.

The microbial population could be high but it is likely to be made up of non-aerobic spoilage and non-pathogenic bacteria.

Temperature control

Good temperature control of the meat from slaughter to distribution is essential and the meat must be fresh.

The development of the correct micro-flora during storage of vacuum-packed meat relies on rapid chilling of the product to the correct temperature and maintenance of this temperature throughout storage and delivery. Two important factors should be considered. Firstly, the lower the meat temperature, the slower the growth of the overall population, the longer the time taken for spoilage organisms to reach critical numbers and the longer the shelf life of the product. Secondly, almost all food poisoning organisms will not grow at temperatures below 7°C; therefore maintaining temperatures below 5°C will minimise any food safety risk. For maximum shelf life of product and minimal food safety risk, product should be held just marginally above the freezing point of the meat.



MEAT & LIVESTOCK
AUSTRALIA

Vacuum-packaged meat starts to freeze at approximately -2°C . The target storage, load out and transport temperature should be $0 \pm 1.5^{\circ}\text{C}$ (ideally, -1.5°C to 0°C).

It is important to recognise that the temperature of boned primal cuts, beef in particular, can be significantly higher than that planned for storage and load out at the time of packing. Deep muscle temperatures of 10°C – 15°C at the time of boning are not uncommon for beef, so it is essential that this temperature is reduced as quickly as possible. Lower temperatures, e.g. 7°C , are desirable. The vacuum bag and the outer carton both provide insulation, as do any air spaces between the cuts, so the product will cool slowly after final packaging. Consideration should be given to improving the cooling rate by one or more of the following means:

- leaving lids off until the product is adequately chilled;
- using cartons with 'hand holes' in the ends;
- cooling in a sub-zero blast chiller;
- loading in the chiller on stillages with adequate spacing (at least 20 mm) to allow adequate air flow over every carton;
- loading in the chiller on pallets with 'egg crate' or other suitable dunnage to allow air flow over every carton.

Never attempt to cool product while block stacked or to obstruct the air flow across carton surfaces while cooling. The contacting surfaces of primal cuts at the centre of all cartons should be reduced to the target temperature ideally within 24 hours – for beef within no more than 40 to 45 hours – from packing. Exceeding these periods may reduce shelf life and increase weep.

Sea freight and air freight shipping containers, and refrigerated trucks are designed to hold product temperatures. They are not designed to cool product. It can take up to 45 hours to cool beef from the temperature at packing to the storage temperature; therefore, if the product is loaded out within 48 hours from packing, routine temperature checks should be made to ensure that product is at the carriage temperature (usually -1°C to 0°C) before load out.

Vacuum-packaging procedures

Once these important quality management procedures are in place, the application of best practice to vacuum-packaging procedures will ensure a successful outcome. For best practice the following issues should be considered and addressed:

Selection of product

Ageing of meat through vacuum packaging allows for the natural enzymic activity to break down the meat fibres in the absence of microbial spoilage, resulting in tenderisation of the meat. This enzymic activity will not break down collagen fibres; therefore sinewy meat from older animals or from cuts high in connective tissue will not show the same tenderising effect during ageing.

It is important to select suitable cuts for vacuum packaging from non-stressed animals only. Stressed animals produce meat with high pH levels (greater than 6.0) and are identified as 'dark cutters'. Some types of bacteria grow more prolifically on high pH meat resulting in premature discolouration (greening), a rotten egg smell and a shelf life of as short as four weeks. Ideally, vacuum-packaged meat should be in the pH range of 5.4–5.9.

Prompt processing

Natural respiration of the meat occurs for some two days after the animal is slaughtered. This respiration uses up oxygen and releases carbon dioxide. Any small amount of oxygen remaining after vacuum packaging can be converted to carbon dioxide if the natural respiration is still occurring. Vacuum-packaged meat from carcasses/sides that have had an overnight chill is still in the natural respiration state and produces more stable product than meat from carcasses/sides that have been chilled and held for long periods prior to boning. Meat from carcasses that have been chilled over a weekend can be successfully vacuum packed but there is no point in vacuum packaging meat that is already a couple of weeks old and expecting the vacuum pack to provide an extended shelf life.

It is also important to pack the meat without delay after it has been boned and sliced. When the meat surface is cut it begins to absorb oxygen. This causes the purple pigment myoglobin to change colour to bright red at the surface of the meat. Underneath the layer of red oxymyoglobin, a thin layer of brown metmyoglobin can form and, in extreme cases, may be irreversible. The longer the meat is left exposed before packing, the more metmyoglobin will form. If metmyoglobin forms before packing because of delays between slicing and packing, the display life after the pack is opened may be reduced.

After vacuum-packed meat is aged and the pack opened, the meat blooms to a bright red colour but it has a shorter display life than fresh meat. This is because the aged meat absorbs oxygen more readily than fresh meat and the enzymes that convert metmyoglobin back to myoglobin are not as active. As the exposed meat absorbs oxygen, a layer of metmyoglobin can form quickly under the surface of the meat and, as the layer grows, the brown colour becomes visible from the surface. Aged meat on display in air permeable film should be kept as cold as possible (at less than 4°C) to delay the appearance of brown discolouration.

Minimal product handling

The more product is handled, the greater the risk of bacterial contamination with potential loss in shelf life. Also excess handling releases the natural juices from the meat's fibrous structure, resulting in excess weep or purge. The use of conveyors, bagging chutes or loading fingers and gentle manual handling all assist in producing quality vacuum-packed product with maximum storage life.

When manually handling meat that has been placed in vacuum bags, always lift it with hands under the bag. Never pick it up by the bag itself and never throw or drop the product. There is a serious risk of damaging the bag film or end seal through poor handling, resulting in leakage. Any leakage will mean at best, a repack and at worst, a loss of product. Both can result in significant cost.

Smooth product flows without delays

Meat should spend as little time as possible in the boning room between the carcass/side chiller and the carton chiller. Product pile-ups can occur at the boning/slicing table, bagging station, vacuum-packaging machine and in the carton loading area. Eliminating handling, delays or stacked product at these locations effectively minimises bacterial contamination and growth, weep or purge, and colour deterioration.

Minimising all these issues assists in producing product with optimum presentation and maximum shelf life.

Film permeability

As the purpose of vacuum packaging is generally to exclude oxygen from the pack, thus preventing aerobic spoilage and acidity, it is important that the film used is not permeable to oxygen. The permeability of a film is the rate at which oxygen can pass through the film. It is expressed as cubic centimetres of oxygen per square metre of film per 24 hours at 25°C, 760-mm mercury air pressure and 75% relative humidity. Good commercially available films have a permeability of 20-30 units in an unshrunk condition and when shrunk this can be as low as 12-15 units. The permeability is very temperature dependent and films that have a permeability of 20 units at 25°C can have a permeability as low as 1 unit at 0°C.

Vacuum-packaging films are usually multi-layered to provide all the attributes that are required. The inner layer is a sealing layer that fuses under heat to create a seal. Other layers give oxygen impermeability and abuse resistance to give the bag strength. The outer layer is an abrasion-resistant layer to prevent the inner layers being damaged by scratching or puncturing during handling. The oxygen-impermeable layer is the most expensive layer, so it is important not to over-specify permeability, as this will add cost to the bag. A permeability of 20 units at 25°C is adequate for commercial meat processing applications.

Occasionally vacuum packaging is used for other purposes, such as enhancing the presentation of frozen products. For example, shrink vacuum packaging lamb cuts before freezing eliminates freezer burn and frosting, producing a pack with excellent visual appearance. As the product is frozen there is no need to eliminate oxygen. In fact, oxygen should be present to maintain bloom. In this situation a less expensive non-barrier film with high oxygen permeability is used.

Bag sizing and loading

For vacuum packaging to be cost effective, it is sensible to use the smallest amount of film possible for each meat cut. Vacuum-packaging plants generally carry a range of bag sizes to give efficient use of packaging film. Most plants use pre-formed vacuum bags. A major packaging supply company has advised that the correct size of bag to use is determined by the following formulae:

$$\text{bag width} = \frac{\text{meat cut circumference}}{2} + 50 \text{ mm}$$

$$\text{bag length} = \frac{\text{meat cut circumference}}{2} + 150 \text{ mm}$$

For example:

1. When packaging a knuckle that is roughly a cube shape of say 250 mm x 250 mm x 250 mm, the circumference over each of the long and short axes will be 1000 mm. In this case the bag selected should be $(1000 \div 2) + 50 = 550$ mm wide by $(1000 \div 2) + 150 = 650$ mm long.

When packaging a striploin that is roughly a flat box shape of say 450 mm x 200 mm x 50 mm, the circumference over the long axis will be 1000 mm and the circumference over the short axis will be 500 mm. In this case the bag selected should be $(500 \div 2) + 50 = 300$ mm wide by $(1000 \div 2) + 150 = 650$ mm long.

To minimise the risk of bag damage when bagging, use of packing chutes or loading fingers is recommended as follows:

Place the meat piece on the chute or fingers with the fat side down and so that the thickest part of the piece is at the bottom of the bag, thus improving air evacuation. Place any required bone protection material smoothly over any unprotected bone that may puncture the film. Slide the bag over the meat leaving the recommended amount (usually approximately 50 mm) of tail of bag below the meat. Slide the bagged cut off the chute or loading fingers and lower it gently onto the packing conveyor, fat down, for transportation to the vacuum machine.

Bagging operations can be assisted by using automatic units that open and present the bags ready for packing, using an air jet system. A supply of bags on perforated roll stock can also aid bagging by keeping unused bags clean and tidy. Handling large numbers of loose bags at the packing point can often lead to bags being dropped or damaged.

Not all packaging operations use pre-formed bags. An alternative is the use of continuous tube stock that is formed to the correct bag length at the point of use by a unit that heat seals and then cuts.

Vacuum-packaging machine

Most packaging operations use equipment that will automatically evacuate and seal the bag. Smaller operations or plants packaging corned beef, where the brine can corrode equipment, use snorkel machines that are clip sealed.

All machines should be regularly maintained to ensure that an adequate vacuum can be drawn in the packs. The seal bars should also be regularly checked to ensure that a complete and even seal is formed every time. If clips are used, the clipping mechanism must be checked to ensure that a tight seal is achieved and there are no sharp clips that could puncture the bag.

Place the bagged meat, with fat down for bone-in cuts, fat up for boneless cuts, on the machine's platen ensuring that the tail is retained at the bottom of the bag. Loss of this tail, by pushing the meat to the very bottom, will reduce the effectiveness of the air evacuation and lead to retained air in the bottom of the pack. Gently pull the top of the bag taut over the seal bar ensuring that both films are aligned and fully flat, without wrinkles. Any wrinkle is a potential leakage site in the machine-formed seal. When positioned correctly there should be a length of bag (usually approximately 75 mm) at the top of the bag, between the meat cut and the seal bar. If using a snorkel machine ensure that the bag is evenly distributed around the vacuum tube so that an even seal is obtained on clipping.

After operating the machine check that a complete flat seal has been made. Any doubtful seals or leakers must be put aside for repackaging.

The removal of oxygen during vacuum packaging leads to changes in the colour of meat. Inside a vacuum-package, residual oxygen is consumed and carbon dioxide is produced as a result of metabolism by the muscle tissue and microbial growth. The atmosphere that usually results contains less than 0.3 per cent oxygen, some 20-40 per cent carbon dioxide, and the remainder nitrogen.

The bright red (oxymyoglobin) colour of fresh meat disappears in the vacuum as the pigment reverts to its purplish-red form. This is the normal and desirable colour of vacuum-packed meat. Within minutes of the packs being opened, the surface purple myoglobin changes to bright red oxymyoglobin – it ‘blooms’ to a bright red colour.

Shrinking

Not all vacuum-packaging films are designed to shrink. Some processors use vacuum pouches that are non-shrinkable for domestic product. These are less expensive than shrink bags and are adequate when a shorter shelf life is required.

Shrinking improves the vacuum package by:

- creating an attractive ‘second skin’ effect;
- eliminating folds and capillaries that can trap air;
- thickening the film and reducing oxygen permeability;
- strengthening the seal;
- reducing purge/weep.

To obtain a good, even shrink it is important to maintain the correct water level and temperature in dip tanks and the correct water temperature and even spray pattern in spray tanks. High temperatures and water levels can result in product browning while low temperatures and water levels can result in incomplete shrinkage. Manufacturers of vacuum-packaging film give recommendations as to the best shrink temperatures to use with their bags and these should be observed. After shrinking the film, the pack can be put through a cold water dip to remove the heat added in the shrink tank.

Drying

Air blowers are used to remove any excess water from the vacuum-packed meat. The surface should be as dry as possible before cartoning to ensure that the integrity of the carton is maintained. Unless there is an appropriate fibreboard lining, the presence of moisture will soften the fibreboard, thereby reducing the strength of the carton. Vacuum packs are usually packed in cartons with polyethylene liners to prevent damage to the fibreboard from water on the packs.

Cartoning

To prevent stressing the vacuum-packaging film, ensure that, when cartoning, the packs are deposited gently into the correct size and type of cartons. Never overfill the cartons. The carton, not the product, should be allowed to bear any stacking weight. Using the vacuum-packed product to bear the weight of stacked cartons will stress the film and seal, risking leakage and excessive weep.

Cartons are normally packed with the fat up for boneless product to prevent staining of the fat by weep, except for cuts such as striploins, which are normally packed on their sides. Bone-in products are packed with the fat down to minimise the risk of bone puncture.

Storage and container loading

When stacking product on pallets, or for storage or shipping, ensure that the cartons are aligned so that the carton itself takes the load. Minimising the load on the vacuum-packed product minimises the risk of leakers.

Placing the load on the carton is best achieved by column stacking rather than cross stacking. Column stacking ensures that the corrugated fibreboard making up the carton sides and ends is always aligned. This gives maximum strength.

Managing quality

Vacuum packaging of primal beef and sheep cuts to gain extended shelf life has been a major success in the Australian chilled meat industry. This has only been as a result of considerable effort on behalf of packers to control all aspects of the vacuum-packaging process.

Consistent process performance and product quality does not happen by accident. A strong HACCP-based quality assurance program from farm to customer is essential to ensure the on-going successful use of vacuum-packaging technology.

Further reading

Meat Research Corporation and Australian Meat Technology Information Brochure ‘Refrigerated Transport of Cartoned Meat in Containers’ 1997.

Meat Research Corporation and Australian Meat Technology Information Brochure ‘Chilling Vacuum-packed Product’ 1997.

CSIRO Division of Food Processing, Meat Research Laboratory ‘Production of Chilled Meat for Export – Workshop Proceedings, 1991.

Additional information

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

Ian Eustace – Phone: (07) 3214 2117 Fax: (07) 3214 2103

Bill Spooncer – Phone: (02) 4567 7952 Fax: (02) 4567 8952

Chris Sentance – Phone: (08) 8370 7466 Fax: (08) 8370 7566

Contact

Processing and Product Innovation
Meat & Livestock Australia

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

Email: ppi@mla.com.au



165 Walker Street, North Sydney NSW 2060

Tel: (02) 9463 9333 Fax: (02) 9463 9393 www.mla.com.au

Published August 2000

ISBN: 1 74036 696 4

© Meat & Livestock Australia