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Hot Boning of Beef for Primal Cuts

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1. Introduction

A series of research projects was commissioned by the Meat Research Corporation (MRC) to study and review aspects of hot boning of beef primal cuts. These projects have recently been completed and this report summarises the major findings and recommendations of these investigations. The final reports on these projects are referenced throughout this Meat Research Report and references to them are listed at the end of the report. Copies of the full reports are held by the MRC.

2. Electrical Stimulation

Electrical stimulation was studied by CSIRO (Project CS221), Friotec AB and CSIRO (Project CS248), and MIRINZ (Project M412).

Muscles that are exposed to low temperatures before they are in rigor will undergo cold shortening, i.e. they will contract along their length. A 'rule of thumb' to avoid cold shortening in beef is to prevent the muscles from cooling below 10°C within 10 hours of slaughter or before the pH has fallen below a value of 6. Cold-shortened muscles are likely to be tough and, in cases of severe cold shortening, ageing the meat will not overcome toughness.

After removal from the skeletal restraint, hot boned muscles are free to contract and can cold shorten when exposed to low temperatures before they are in rigor. Toughening of hot boned muscles is a very real possibility.

Electrical stimulation (ES) hastens the onset of rigor (a pH value of 6 is reached after about one hour instead of the usual 12 to 20 hours). Muscles from carcases which have been effectively electrically stimulated are unlikely to cold shorten even if exposed to low temperatures soon after the animal has been slaughtered. An effective electrical stimulation system is therefore essential if primal cuts of reliable table quality are to be produced.

Two stimulation techniques are applicable – extra low voltage (ELV) stimulation which is applied to the whole carcase in the bleeding area, and high voltage stimulation which is normally applied after the hide is removed. The time between slaughter and hot boning will influence the selection of the type of stimulator. ELV stimulation has the advantage of allowing more time between stimulation and boning and may be the more appropriate system if carcases are to be boned immediately after slaughter. Detailed information on electrical stimulation of beef is available in 'Effective Electrical Stimulation of Beef Carcases and Sides – Industry Guidelines Update (1985)'.

Because ES is such an important aspect in the production of a quality product, consideration should be given to the installation of automatic monitors for manually applied ELV stimulation. The monitor will sound an alarm and record any incidence of ineffective electrical stimulation.

3. Early Detection of Dark-cutting Beef

The early detection of dark-cutting beef was studied by Friotec AB and CSIRO (Project CS248).

The ultimate pH of meat will have an important influence on its colour and microbiological status. As they will produce dark-cutting meat, it is important to detect, at an early stage, those carcases whose muscles will have a high ultimate pH (≥6.0) so that they can be excluded from table meat production.

When meat is hot boned four hours or more after slaughter, pH measurement can be used to detect dark-cutters provided the carcase was electrically stimulated. In this case, a four-hour pH is likely to be close to the ultimate pH.

A new rapid (5 minutes) method of measuring of the ultimate pH has developed under an MRC-funded project. When commercially available, this technique will allow dark-cutters to be detected on the slaughter floor.

4. Boning

Time constraints, Occupational Health & Safety (OH&S) issues, trimming of cuts and yield aspects of hot boning were studied by Friotec AB and CSIRO (Project CS248); Occupational Health and Safety was studied by MIRINZ (Project M412); and time constraints were studied by Australian Meat Technology (Component of Industry Services Project AMT.001).

Time Constraints

The AQIS guidelines specify that hot boned meat must be subjected to further refrigeration (active chiller or freezer) or processing, not more than 60 minutes after removal from the bone. This time may be extended under an alternative time/temperature protocol. Once a carton is closed it should be placed under active refrigeration within 30 minutes.

Occupational Health & Safety

Hot boning is generally considered to be easier than cold boning but care needs to be taken when handling cuts as they may be slippery. A major OH&S advantage with hot boning is that the problem of hard fat is not encountered.

Trimming

Difficulty can be encountered in trimming fat from primal cuts. This can result in a fat thickness that is not to specification and a less attractive cut.

Yield

It has been reported that a yield improvement of 1.5% to 2.0% is achievable with hot boning compared with conventional boning. This increased yield is a combination of reduced evaporation losses and more efficient removal of meat from the bones. It can take some time for boners to become fully competent with hot boning so yield advantages may not be immediately obvious.

5. Packaging

Vacuum Packaging

Vacuum packing of hot boned meat was studied by Friotec AB and CSIRO (Project CS248), and MIRINZ (Project M412).

Hot boned cuts can be vacuum packaged using similar techniques to those used for conventionally boned meat. However, special care is needed in the following areas.

- Insertion of cuts into bags. It is easy to smear the inside of the bag with sticky fat, which is likely to cause poor seals and 'leakers'. It is advisable to use bag loading fingers.
- Bag shape. Some cuts (such as striploin and cube roll) require a square end. The normal bags can deform the cut resulting in wastage by the end user. This may be reduced by using bags with a square bottom seal.
- Vacuum machine adjustment. Hot boned meat can be more difficult to vacuum pack due to the higher temperature. The surface moisture can boil under low pressure resulting in an increased load on the pump.
- Roller conveyors. Cuts may be caught between the rollers of conveyors in shrink tunnels, due to the flexibility of warm meat.

6. Cartoning

The cartoning of hot boned meat, including carton style, use of air spacers and shape of cuts was studied by Friotec AB and CSIRO (Project CS248), and the shape of cuts was further studied by CSIRO (Project CS221) and Warringah Consulting (Project M570).

Carton Style

The cooling rate of vacuum packaged primals can be affected by the type of cartons into which they are packed. Cooling can be enhanced by using:

- perforated cartons;
- open cartons.

Perforated cartons are designed such that holes in the sides are open during chilling to allow air circulation and closed by turning the lid around after chilling. In some cases the lid will need to be left off during chilling in order to achieve satisfactory cooling rates. In both these cases strapping will need to be done after chilling. This technique has the advantage of permitting easy reinspection of all cuts prior to despatch.

Air Spacers

The contact surfaces between large primal cuts near the centre of the carton are the slowest to cool. The rate of cooling at this point is the critical rate for meeting the AQIS time/ temperature requirements. Cooling at this point can be facilitated by inserting fibreboard or plastic spacers between the cuts. The spacers could be removed prior to lidding and reused.

Shape of Cuts

The final shape of the primal cut depends to an extent on how it is packed in the carton. The shape of some cuts can be improved by using dividers between each cut or by inserting formers to keep the end of a cut square. The use of such dividers or packing can usually only be justified for higher value product. There is potential with some cuts for the shape to be altered to meet the particular needs of a customer by means of a mould in the carton.

7. Chilling of Primal Cuts

Options for the chilling of primal cuts, including effect of pre-chilling sides was studied by Friotec AB and CSIRO (Project CS248), and Australian Meat Technology (Component of Industry Services Project AMT.001). Chilling of cartoned cuts was studied by the above, plus CSIRO (Project CS221) and MIRINZ (Project M412). Chilling of individual cuts was studied by CSIRO (Project CS221), Friotec and CSIRO (Project CS248) and MIRINZ (Project 412).

Effect of Pre-Chilling the Sides

The AQIS hot boning regulations specify the time to reach 7°C for initial temperatures in the range 20–40°C. In the case of cartoned primal cuts, this temperature is measured between contact surfaces of cuts near the thermal centre of the carton.

This initial temperature depends primarily on how long the sides have been subjected to any pre-chilling. Other factors which affect this temperature are carcase size and chiller conditions. As a guide, the following initial temperatures are normally encountered with large cuts (e.g. silversides, topsides).

Boning Time (hours after slaughter)	Initial temperatures
Less than 1 hour	35 – 38°C
Approx. 1 hour	30 – 35°C
Approx. 2 hours	25 – 30°C
Approx. 4 hours	20 – 25°C

Chilling Cartoned Cuts

When hot boned vacuum packed cuts are cartoned prior to chilling, it can be extremely difficult to meet the AQIS time/temperature requirements. It is important that there should be no surface freezing of vacuum packed cuts. Meat begins to freeze at –1.8°C; therefore, extremely low temperatures should not be used for long periods. Two alternative chilling procedures are recommended:

- one-stage chilling where the cartons remain in a chamber at a set temperature of –1°C during the entire chilling cycle;
- two-stage chilling using a low temperature rapid chilling zone (–20°C to –30°C air at a velocity of 3 to 5 m/s) for the first three to six hours followed by equilibration at –1°C.

One-stage chilling will normally only be satisfactory for cuts from carcases which have been pre-chilled such that the initial temperature of the cuts is below 25°C. Two-stage chilling will be necessary for product from carcases boned immediately after slaughter or cuts with an initial temperature above 25°C. Further details of the recommendations are outlined in the Hot Boning Process Guide.

Chilling Individual Cuts

An alternative is to chill cuts after vacuum packaging and prior to cartoning. This is much more efficient in terms of heat transfer but may not easily fit in with existing product flow.

There are two practical methods of individually chilling cuts:

- air; and
- immersion in water or brine.

Cooling rate requirements can generally be met using either of these methods. The cuts may either be partly chilled then cartoned or completely chilled ready for loadout. The advantage of this option is that all vacuum packs can be checked for leakers prior to cartoning. However, cartoning will lag behind boning by several hours, one shift or even 24 hours.

If a wide range of cuts and grades is produced, care would have to be taken to ensure correct identification and labelling.

8. Meat Quality

Meat quality of hot boned meat was studied in terms of shape by CSIRO (Project CS221) and Friotec AB and CSIRO (Project CS248); in terms of weep, colour and tenderness by CSIRO (Project CS221) and MIRINZ (Project M412).

Shape

Primal cuts with shape and appearance acceptable to the domestic market can be produced from either hot or warm boning. However it is very difficult to produce primal cuts which meet the exacting requirements of the Japanese market when boning immediately after slaughter. If carcases are chilled for several hours, the appearance of many primal cuts is acceptable. However some cuts, such as the cube roll and square cut chuck, may still be unacceptable due to slippage of muscles and fat. This results in inferior shape and wastage due to trimming and slicing losses.

When single muscles are removed, deformation tends to be less severe. If the Japanese market can be persuaded to accept cuts in this form, hot boning of this high quality product will be more acceptable.

The shape of primal cuts can be improved by:

- using suitably sized bags, possibly with a square bottom seal;
- using inserts in the carton to mould the shape of the cut.

Moulds and netting have been suggested but these introduce additional handling and equipment costs and may mark the surface of the cuts.

Weep

There is no difference in weep (drip) in vacuum packs between cuts that have been hot boned and those that have been cold boned.

Colour

The colour of hot boned primal cuts and the subsequent meat on retail display is equivalent to that of conventionally boned product. Some staining of the fat of primal cuts with blood from superficial blood vessels has been experienced.

Tenderness

Provided carcases are effectively electrically stimulated and vacuum packed cuts are aged for at least one week, the tenderness of hot boned meat is equivalent to that of conventionally boned meat.

If very rapid cooling techniques, such as immersion in chilled water, are to be used, then the duration of ELV electrical stimulation should be extended to about 80 seconds or the carcase chilled for at least three hours prior to boning. Unacceptably tough meat may result if the cut is cooled too rapidly before the pH has fallen below a value of 6.0.

9. Hygiene

The hygiene aspects of hot boned meat were studied by Friotec AB and CSIRO (Project M412), and MIRINZ (Project M412).

Hot boned meat provides optimal conditions for the rapid growth of microorganisms. The viability of using hot boning to produce a high quality product will depend upon controlling the extent of initial contamination at the time of production.

The following procedures have been shown to minimise contamination of hot boned meat:

- using stainless steel hooks to move carcases manually on rails;
- boning carcases on the rail;
- using stainless steel hooks to handle cuts;
- cleaning mesh gloves, aprons, hooks and knives thoroughly at each work break.

10. Industry Assistance

AMT can provide ongoing assistance for the hot boning of beef for primal cut production and for hot boning generally.

11. Acknowledgements

The support of the Meat Research Corporation in this project is gratefully acknowledged.

12. References

Meat Research Corporation funded reports

Project No.	Contractor	Report Title
CS221	CSIRO	Experimental Determinations on Hot-boned Meat
CS248	Friotec AB & CSIRO	Hot Boning Process Guide
M412	MIRINZ	Evaluation of Hot Boning Procedures
M517	MIRINZ	Hazard Analysis Critical Point (HACCP) Systems for Manufacture of Hot-Boned Beef
M541	MIRINZ	Modelling of Hot Boning Processes
M570	Warringah Consulting	Warm Boning and Mould Chilling of Cuts
AMT001	AMT	Implementation of Hot Boning

The paper on Implementation of Hot Boning is available from Australian Meat Technology. Copies of the full reports of the other projects are available from the Meat Research Corporation: Phone (02) 380 0666; Fax (02) 380 0699.