Meat technology update

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MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

Effect of hot boning on meat quality

Hot boning of beef and sheep carcases has distinct advantages over cold boning. The warm meat is soft and requires less effort to bone, occupational overuse injuries are less likely to occur, there is potential for improved yield, and expensive chilling of fat and bones is avoided. There are also benefits in terms of certain processing qualities when hot boned meat is used to manufacture meat products.

However there are also perceived disadvantages of hot boning; for instance the potential for the meat to be tough, darker in colour, and for some primals to be different in shape.

In Australia, hot boning usually means boning carcases that have a deep butt temperature of more than 20°C.

It is useful to consider hot boning in two categories—'true' hot boning and warm boning.

True Hot Boning

In true hot boning, carcases or sides are not cooled before they are boned. They are boned within 30 to 45 minutes of slaughter. Plants that perform true hot boning generally use plate freezers to cool the hot meat. Even with plate freezers, it can be difficult to reduce rapidly the temperature of large beef primal cuts. Bulk-packed product at average temperatures of 28-30° can normally be cooled in sufficiently rapid time using plate freezers.

Warm Boning

In warm boning, carcases or sides are boned after a period of pre-chilling. Typically, carcases are pre-chilled for 30 minutes to 6 hours. Short pre-chills are used for mutton and longer periods for beef. Warm boning allows for an increase in throughput on the slaughter floor without having to increase chiller space. After warm boning, primals and manufacturing meat can be cooled quickly enough in air blast or plate freezers to avoid excessive microbial growth. Under some blast chilling circumstances the lids may have to be left off the chilled meat cartons in order to cool primal cuts quickly enough.

Potential improvements in efficiency

The basic concept of hot boning is that slaughtering, boning and packing of the meat is all done within the span of a single working day. An increasing number of plants are hot boning because of the potential for:

- reduced processing time from slaughter to load out;

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- lower chilling space and other capital cost requirements;
- reduced energy consumption and other chiller costs;
- increased boning yield;
- improved productivity;
- elimination of hard fat problems; and
- more rapid product turnover.

Microbiology of hot boned meat

A disadvantage of hot boning is that there is an increased risk that the meat can support the growth of pathogenic bacteria as it cools. In conventional boning, microbial growth on carcases is controlled by a combination of drying and cooling of the carcase surface. When the meat is hot boned and packed, moist meat surfaces may be contaminated and provide an opportunity for microbial growth because they stay moist. The surface temperature of boned meat prepared conventionally in accordance with regulatory requirements is usually less than 15°C for beef and less than 10°C for smallstock. At these temperatures, the growth of pathogenic bacteria is slow and the meat should cool to 7°C within a few hours of boning. At 7°C and below, the growth of pathogenic bacteria is negligible and for this reason, cooling to 7°C or below is regarded as critical for food safety.

In the case of true hot boned meat, the boneless meat surfaces could be 20-35°C at the time of packing. At these temperatures, pathogenic bacteria can adapt to their new environment within an hour or two and begin to grow quickly. Therefore, the meat must be cooled quickly to below 7°C after it is boned in order to control the growth of pathogenic bacteria. (Quick cooling has other meat quality implications and these are addressed in this Newsletter.)

The cooling rate is affected by three main factors:

1. carton size and style;
2. freezer type;
3. air temperature and velocity (in blast freezers or chillers).

Because of the potential for growth of pathogenic bacteria, performance criteria are set out by export and domestic regulatory authorities. A trial (see AQIS Notice Meat 00/06) is being conducted in export plants whereby establishments that are hot boning to produce manufacturing meat are required to show that the cooling rates of boneless meat are sufficient to limit the growth of *E. coli* to prescribed levels.

Meat quality

Removing muscles from the carcase soon after slaughter changes their normal state. Some muscles are normally stretched on the carcase and become free to shorten when released from their attachments to bones. Others which usually cool slowly because they are enclosed by other muscles may be cooled much faster. These differences will affect tenderness development and can cause muscles that are tender when cold boned (e.g. tenderloin) to be toughened.

With true hot boning, meat is still in the prerigor state at the time of boning even if electrical stunning, electrical immobilisation and/or electrical stimulation has been used. This makes muscles susceptible to adverse temperature/pH combinations. Shortening is particularly likely.

With warm boning, many muscles from carcases subjected to electrical inputs are at least partly in rigor at the time of boning. In this case muscles are less likely to be affected by adverse post-boning temperature/pH combinations.

With cold boning, skeletal restraint minimises the risk of the meat being affected by adverse temperature/pH combinations during carcase chilling.

Irrespective of whether meat is boned hot, warm or cold, changes to muscle occur post slaughter. The main differences are due to the effects of degree of skeletal restraint and rate of temperature reduction.

When hot boning is properly carried out, microbiological quality of hot boned frozen or chilled meat is comparable with that of conventionally boned meat. Studies have also demonstrated that hot boned meat can reach the same level of tenderness and manufacturing functional properties as that of conventionally prepared cold boned meat.

Post-slaughter changes in muscle

Immediately post-mortem, there are two related processes that affect eating quality:

- a fall in muscle pH and temperature;
- shortening of the muscle.

The combination of a very rapid fall in pH and slow cooling of the carcase can lead to heat or rigor shortening, whereas a slow fall in pH and rapid cooling can lead to cold shortening. Shortening is undesirable as it can cause moderate to severe toughness. A further important penalty of both cold and heat shortening is a reduction in the ability of the meat to tenderise during ageing. Also, both may adversely affect functional properties of manufacturing meat.

Because of the lack of skeletal restraint, these processes are more important with true hot boning than with warm or cold boning. The aim is to achieve an optimal rate of pH fall during rigor mortis and cooling. However, this is not readily achievable with true hot boning because of the varying cooling rates within a carton on meat.

As mentioned above, a rapid rate of cooling to 7°C is necessary to control bacteria. During this period, the optimal rate of pH fall can be controlled to a certain degree by manipulating electrical inputs.

Electrical inputs

The application of an electrical current to beef or smallstock carcases on the slaughter floor accelerates pH decline. The term electrical inputs refers to all currents applied to the carcase on the slaughter floor and includes:

- electrical stunning;
- immobilisation;
- hide-puller rigidity probes;
- conventional electrical stimulation .

These electrical inputs are additive in terms of their effect on the rate of pH fall and lead to the early onset of rigor mortis. In some abattoirs where extra low voltage stimulation (ELV) and downward hide pullers are used, beef sides have attained close to ultimate pH (5.5-6.0) within 60 minutes of stunning. ‘Overstimulation’ in this instance is undesirable. It can increase the risk of heat shortening, reduce the ageing potential of the product and in warm (and cold) boning can cause denaturation and paleness of slow cooling internal muscles.

Factors that need to be considered in determining the duration and amperage of electrical stimulation (ES) include other electrical inputs applied on the slaughter floor and the chilling rate.

In order to prevent heat shortening, there is some evidence that stimulation is best done as close as practical to the entry of the sides to the chiller or to the boning room in the case of hot boning.

Based on existing knowledge, it is essential that an accelerated rate of pH decline is achieved with hot boning. Appropriate electrical inputs (including ES) applied within about one hour of slaughter are particularly important.

Heat shortening

Measuring muscle pH and temperature as the beef side enters the chiller or just prior to boning will indicate the effect of the combined electrical inputs. As a guide, if the pH is at or below 6.0 while the temperature is at or above 35°C, then the electrical inputs have been excessive and there may be heat shortening. These measurements are best taken in the *Longissimus dorsi* muscle in the carcase.

New Zealand studies indicate that damage to the functional properties of true hot boned frozen manufacturing meat are minimised if the muscles are prevented from going into rigor at high temperatures. This can be achieved by reducing electrical inputs to prevent rapid onset of rigor and/or chilling boneless meat as quickly as possible.

Cold shortening

Measurement of pH and temperature after the carcases or the cartons of hot-boned meat have been cooled will indicate whether cold shortening is a possibility. If at any time the pH is at or above 6.0 when the temperature is at or below 12°C, then it is likely that the combined electrical inputs are insufficient and there may be cold shortening. The pH is taken in a cut that would reach a normal ultimate pH such as a striploin, cube roll or topside.

With tight packing of manufacturing meat in cartons, shortening is largely prevented. Similarly, tight wrapping of hot-boned table meats in stretch or heat shrink type films will restrain the muscles from shortening. Muscles maintain a constant volume throughout contraction. Tight packaging can mimic the skeletal restraint that occurs in the muscles on the carcase during chilling and is recommended with true hot boning.

With true hot boning, it may be difficult to achieve the ideal temperature/pH combinations and plant trials and further research is necessary. For further information about shortening and the optimal rate of pH fall, see Meat Technology Update Newsletters 99/1 and 99/4.

In summary, rigor temperature and rigor status influence the extent of muscle shortening and in consequence, the tenderness and manufacturing functional properties of the meat. Muscle temperatures around 10-15°C are associated with minimal shortening. Also, in this temperature range the adverse effects on the enzymes responsible for ageing are minimal. Below this range, cold shortening occurs; above it, heat shortening occurs.

There is another possible cause of toughening—shortening during thawing.

If a muscle is frozen before it is in early rigor and is then thawed rapidly, it may shorten and toughen considerably.

Other relevant aspects

Hot Boned Table Meats

1. *Carcase Classification Difficulties*

The marbling level is difficult to establish before hot-boned primals are wrapped or packed in cartons for cooling, and colour is not well developed.

2. *Early Detection of Dark-cutting Beef*

The ultimate pH of meat has an important influence on the colour, microbial status and eating quality. It is important to detect, at an early stage, those carcases whose muscles will have a high ultimate pH and therefore be dark cutting. Some undesirable characteristics of dark-cutting beef include darker 'bloom' colour which is unappealing to consumers, reduced shelf life, and varying toughness.

When meat is hot boned four hours or more after slaughter, pH measurement can be used to detect dark-cutters provided the carcase has been 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 the ultimate pH has been developed under a project funded by the MLA. When commercially available, this technique will allow dark-cutters to be detected reliably on the slaughter floor.

3. *Occupational Health & Safety*

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

4. *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. With care, trimming can be done accurately.

5. *Yield*

It has been reported that a yield improvement of 1.5 to 2.0% is achievable with true 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.

6. *Shape*

Primal cuts with shape and appearance that are acceptable to the domestic market and some export markets 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 Korean and Japanese chilled beef markets when boning immediately after slaughter. If carcases are warm boned, the appearance of most primal cuts is acceptable. However, depending on the duration of carcase chilling, 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 (viz. seam boning), deformation tends to be less severe. If the Korean, Japanese and other overseas chilled meat markets agree to accept cuts in this form, hot boning of this high quality product is likely to be more widely accepted. There is evidence that the shape of true hot boned primal cuts can be improved by tightly wrapping or packaging them in stretch or heat shrink wrap. There is scope for better utilisation of this restraint phenomenon.

7. *Weep*

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

8. *Colour*

The colour of hot boned primal cuts and the subsequent meat on retail display and retail case life is equivalent to that of conventionally boned product. However, in cold boning some of the deeper beef muscles are often paler than the more superficial muscles because of their slower temperature fall and faster pH fall. Hot boning can mean that these cuts are cooled more rapidly leading to less denaturation, avoidance of pale meat and less two toning than in their cold-boned counterparts. Some staining of the fat of primal cuts with blood from superficial blood vessels has been experienced in hot boning.

Hot boned Manufacturing Meat

Meat that is taken form a carcase pre-rigor (i.e. with no electrical inputs) and promptly subjected to further processing has manufacturing advantages such as better fat emulsifying and water holding properties. However under Australian conditions, hot-boned meat is either chilled or frozen before it is used for manufacturing. If hot-boned meat cannot be processed immediately after slaughter, it is possible to preserve its superior manufacturing properties by very rapid (i.e. cryogenic) freezing. The meat must be frozen while it is still in the pre-rigor state and held at storage temperatures close to -18°C. In fresh beef or mutton, freezing must be completed within six hours of slaughter. If the meat is thawed before use, however, biochemical changes take place rapidly, and most of the advantages of pre-rigor meat are lost.

By adding at least 2% salt (sodium chloride) before freezing, or at the time of thawing (e.g. during chopping) the superior qualities of the pre-rigor meat can be retained after thawing. When minced thoroughly with the meat, 2 % salt has been shown to preserve the water binding power of fresh (unfrozen) pre-rigor meat for some days.

Comminuted pre-rigor meat has water holding capacity similar to that of similarly treated post-rigor meat to which polyphosphates have been added. In some countries, the use of phosphates and other non-meat additives to improve water holding capacity and fat emulsifying properties of manufactured meat products is either forbidden or restricted. The addition of salt to pre-rigor boned meat before freezing is acceptable, however, as salt is included in the formulation of sausage meats.

Therefore there is an opportunity to better exploit the superiority of hot-boned meat for processed meat products.

Conclusion

Some shortening will occur during cooling of hot boned meat. The objective is to minimise shortening. However, providing appropriate attention is paid to the application of electrical inputs and cooling regimes, hot boned meats can be equivalent, or even superior to, conventionally cold boned product in meat quality terms.

Some recommendations already exist for electrical inputs that suit different Australian conventional beef side chilling and post-boning cooling regimes, and optimise the acceptability of table meats (in terms of both eating quality and shape) and of manufacturing meats (in terms of suitability for end use). However, further research and development is needed in order to better define the electrical inputs for both beef and smallstock table and manufacturing meats that are hot boned.

Contact us for additional information

Meat Industry Services is supported by the Australian Meat Processor Corporation (AMPC) and Meat & Livestock Australia (MLA).

Brisbane:
Food Science Australia
PO Box 3312
Tingalpa DC QLD 4173

Ian Eustace
T +61 7 3214 2117
F +61 7 3214 2103
M 0414 336 724

Neil McPhail
T +61 7 3214 211
F +61 7 3214 2103
M 0414 336 907

Alison Small
T +61 7 3214 2109
F +61 7 3214 2103
M 0409 819 998

Sydney:
Bill Spooncer
PO Box 181
KURMOND NSW 2757
T +61 2 4567 7952
F +61 2 4567 8952
M 0414 648 387

Adelaide:
Chris Sentance
PO Box 178
FLAGSTAFF HILL SA 5159
T +61 8 370 7466
F +61 8 8370 7566
M 0419 944 022