Results for today; Ideas for tomorrow

Meat Technology Update

Newsletter 4/04 *August 2004*

Validation of critical limits during chilling

The objective in chilling carcase meat is to cool the meat fast enough to control bacterial growth. In some cases chilling may also result in a reduction in the numbers of harmful bacteria. This newsletter is designed to assist in the validation of the critical limits that relate to the microbiological status of meat during chilling.

Most HACCP plans for chilled carcase and cartoned-meat production nominate chilling as a critical control point (CCP). Critical limits must give assurance that the control intended at the CCP is being exercised reliably. If the intended control is exercised, the hazard will be controlled, eliminated or reduced to an acceptable level.

To select and then validate a critical limit, it is important to be clear about what hazard is involved and what is meant by reducing the hazard to an acceptable level. The hazard(s) should be clearly identified in the hazard analysis. They are likely to include the enteric pathogens most frequently associated with cattle, sheep and goats i.e. *Salmonella* and pathogenic *E. coli*. But what does reducing these hazards to an acceptable level mean in practice? This is a difficult question but should relate to the risk-assessment step of the hazard analysis and the preliminary steps that define the consumers and uses of the product, and the method of distribution. In most cases the preliminary steps will identify:

- that the meat is intended for further processing e.g. cooking; and
- that the meat will be distributed at less than 7°C and for export product, normally at, or below, 0°C.

In these circumstances it can be argued that it is not necessary to eliminate the nominated hazards. Also, there are no CCPs available that can be relied upon during processing of carcases and fresh meat to eliminate the hazard. Chilling may result in a reduction in microbial hazards on carcases in some circumstances; but, for now, it is better to interpret the requirement (for the CCP to control, eliminate or reduce hazards to an acceptable level) to mean that chilling is being used to prevent any increase in the hazards.

Selecting critical limits

All processors of meat must comply with the Australia New Zealand Food Standards Code and the Australian Standard for the Hygienic Production and Transporatation of Meat and Meat Products for Human Consumption (AS4696–2002). In addition, all export-registered establishments must comply with the Australian Government's Export Meat Orders. AS4696 requires that plants ensure that either:

- within 24 hours of slaughter the surface temperature of carcases, sides, quarters or bone-in major separated cuts must fall to 7°C or below; and, for other carcase parts, the temperature at the 'site of microbiological

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concern' must be no warmer than 5°C; or

- alternative temperature conditions that have been validated and approved by regulators have been achieved.

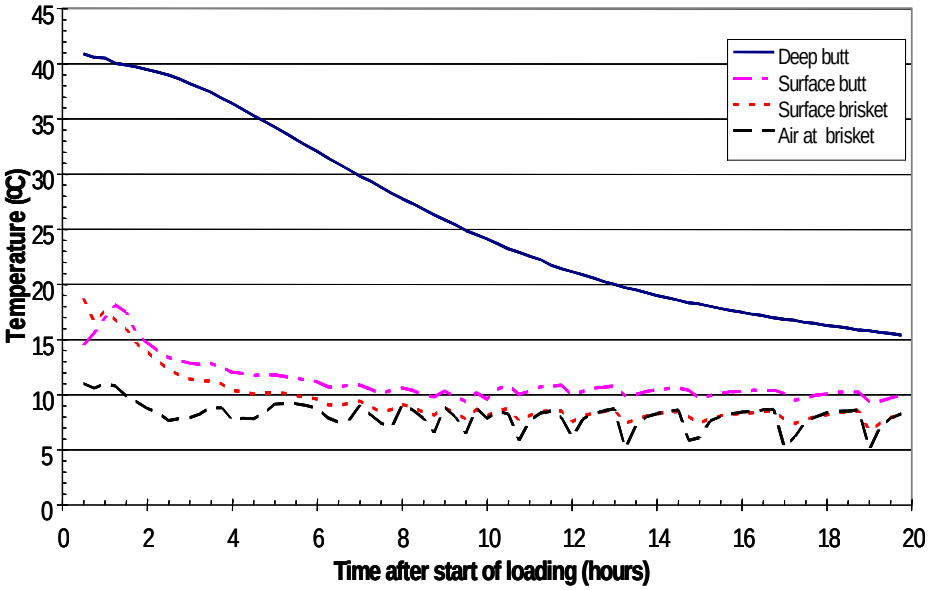

Figure 1. Temperature of beef carcase during overnight chilling.

The Export Meat Orders (EMOs) are currently being reviewed and the new orders will refer, where appropriate, to AS4696. Many of the time and temperature values that are specified in the current EMOs will not appear in the new orders. Even if you continue to chill and freeze in accordance with the conditions in the current EMOs, it will be necessary for you to validate the critical limits that you specify in your HACCP plans. In many cases, values that are prescribed in the current EMOs are not appropriate as critical limits. For instance, there is no valid reason related to food safety for the holding temperature specified for fat ovine carcases (12°C) being different from that for other ovine and bovine carcases (10°C); rather, it appears to have been specified because of the practical difficulty of boning mutton carcases with a heavy fat cover.

AS 4696 states that the carcase surface is to reach a temperature no warmer than 7°C within 24 hours, but processors of heavy beef usually achieve a temperature much lower than this—sometimes near 0°C—after just a few hours. They must do so—not to control growth of surface pathogens—but to prevent the onset of bone taint. Bone taint is typified by putrid and sour odours in the deep parts of the meat near the bone. It may also be evident in the bone marrow. In order to minimise bone taint, the deep butt temperature should be reduced to below 30°C within 10 hours of slaughter, and should continue to fall to 20°C or below within 20 h. To achieve this reduction in meat temperature for beef sides that weigh 150 kg or more, it is necessary to employ chilling conditions that result in the surface temperature falling below 7°C within as little as 5 h. To decide whether it is appropriate to nominate 7°C within 5 h as the critical limit, we should consider what the required outcome of chilling is.

As stated in AS 4696, the outcome required is that chilling and freezing does not jeopardise the wholesomeness of the meat. In practice, this means that chilling must quickly produce conditions that are unfavourable for the growth of most meat-borne pathogens and prevent excessive increases in the numbers of spoilage bacteria. Reaching 7°C within 5 h is much faster than necessary to control bacterial growth on the carcase surface, although it may be appropriate, in relation to assuring wholesomeness, to ensure bone taint will be avoided. However, a more appropriate limit for ensuring absence of bone taint, is to specify a deep butt temperature to be achieved within a specified time—say 20°C with 20 h.

As they stand, neither the current EMOs nor the Australian Standard provide appropriate guidelines for the validation of chilling. The new EMOs may offer some guidance in this area, but in the mean time, how should you set a critical limit? A logical approach is to set the limit based on a chilling rate that is currently achievable in practice at your plant. For example, the critical limit could be defined as 'outside neck surface temperature cooled to 7°C in 12 hours'. While this may seem like a tough critical limit relative to AS 4696, it is sensible because the validation will relate to what happens in practice in your chillers.

Ways to validate your chilling program

To validate, there are several options that may or may not be used in combination, and validations should be conducted for the worst-case situation e.g. mid-summer or heaviest bodies. The advantages and disadvantages for each are discussed below.

1. Published literature

Laboratory studies have shown that some strains of *E. coli*, *Salmonella* and other pathogens can grow on meat at temperatures as low as 8°C. Published literature is available to validate that 8°C is the minimum temperature for growth of *E. coli* and *Salmonella* on meat, and that cooling meat to, and storing it at, 7°C or below will assure no growth on the chilled meat. There is some information that can be used to support the use of conditions that include a temperature higher than 7°C, but it doesn't adequately cover the many variations of chilling patterns that are possible.

At temperatures less than 10°C, when the carcase is dry, the rates of growth and lag times of the bacteria of concern are prolonged and have little or no practical significance during overnight chilling. For *E. coli* and other coliforms on meat that is held moist (e.g. over-wrapped) and at a pH around 6, the lag before any growth commences will be of the order of 24 h at 10°C. After that time they will grow slowly, taking at least 6

to 7 h to double in numbers. Research results from CSIRO and elsewhere support a view that for a chilling program where cooling is fast enough to avoid bone taint (as shown in Figure 1 for example), there will be no detectable increase in numbers of *E. coli* until around 30 h after commencement of chilling.

Much of the published literature reports on laboratory studies where growth was determined in broth or meat slurry systems. The studies have not taken into account surface drying and pH changes that occur as carcases hang in chillers. For that reason the literature may over-estimate the likelihood of growth of pathogens occurring.

Therefore, as an individual processor you can use the published literature to assist in the validation of your cooling procedures, along with temperatures you have logged; but the limitations to this approach mean that it may not be adequate for validating your chilling procedures. An information sheet outlining suitable published reference material is available by contacting Meat Industry Services staff.

2. Microbial counts

You may also consider doing your own microbial counts as part of the validation. The aim is to show that your chilling does not contribute to a food safety risk. The problem with monitoring the microbial load on carcases for validation is that the numbers of *E. coli*, or *Salmonella* naturally present on carcases are very low. In order to accumulate enough data on which to do an analysis that is statistically valid, many tests may be required—perhaps several hundred. Therefore, processors may need to consider inoculating delineated areas of carcases with a suitable test microorganism (e.g. non-virulent strains of *E. coli*) at a much higher level. This has been the approach taken for the validation of alternative procedures at some plants. Taking this approach can reduce the amount of testing and time, but obviously considerable skill and care is necessary.

3. Predictive Microbiology

Another option is to use a predictive microbiology approach. While there are many models available, not all are acceptably accurate. The model developed by researchers at the University of Tasmania, with support from MLA, has proven to be very useful to meat processors. The predictive equation has been used for some years to predict the likely response of *E. coli* to various cooling regimes for both hot-boned and cold-boned meat. The equation can be applied to consider the likely growth of *E. coli* from the slaughter floor until cartons of meat are frozen or chilled to carriage temperature.

One of the disadvantages of the current predictive microbiology programs for carcases is that they do not adequately account for all the concurrent changes that occur at the surface during chilling. They tend to over-estimate the potential growth of pathogens.

As well as the change in temperature, water activity and pH are also known to change during chilling. The Tasmanian predictive equation takes into account the constant change in temperature and a modification may soon mean that the next most significant influence on growth at the surface—changing water activity due to surface drying—can also be taken into account. Water activity is important because the drier a carcase surface is, the less hospitable the conditions are for microbial growth. Different chiller loading configurations, chilling programs etc., will have an effect on the water activity.

A recent Australian study that examined the relative effects of carcase surface temperature, water activity and chilled holding time on the ability of *E. coli* to grow under different chilling regimes, will be discussed in a future newsletter.

Predictive microbiology is likely to be the approach of choice because of its convenience. If you choose to use it, you will need to generate cooling rate data (temperature logs) for your products and then interpret these with an appropriate predictive modelling program. If the rate of cooling is very rapid, no growth of *E. coli* will occur and none will be predicted; however, the predictive model needs to be utilised in conjunction with appropriate criteria to determine compliance.

An example of appropriate criteria is given in AQIS Notice Meat 2001/20 for hot- or warm-boned meat. Specifically, the average hot-boning index (HBI), now referred to as the refrigeration index, should be no more than 1.5; 80% of the HBIs must be no more than 2.0; and there is an upper target of 2.5. These guidelines are for the whole process of hot or warm boning, up until the cartoned product has cooled below 7°C. If applied for conventional chilling and boning of carcases, the refrigeration index needs to be applied across the entire chilling process—carcase chilling plus cooling of cartoned product.

As mentioned earlier, the current models are likely to over-estimate the potential growth of pathogens during carcase chilling. If the criteria above are exceeded, it may be necessary to resort to a program of bacterial testing to validate an alternate set of criteria.

In practice, when carcases are boned after chilling overnight, the component of the overall index attributable to cooling cartoned meat is small and relatively constant. In most instances, it will be possible to attribute a maximum value (probably 0.4 units or less) to the carton-cooling component of the index for cold-boned meat, meaning that the likely target for the carcase-chilling component will be 1.0 to 1.2 units; however, individual plants must validate their chilling practices to determine the critical limits appropriate for their operation.

Examples of chilling validations

An investigation of a modified chilling regime was undertaken in 1998. The trials at an export-registered abattoir indicated that both overnight and weekend chill regimes resulted in good control of microbial growth. The approach taken to determine if the modified regime provided at least equivalent control to standard chilling, was to:

- compare the microbial counts of naturally occurring bacteria on sides before and after chilling under both the modified regime and the conventional chilling; and

- inoculate test carcases with a non-pathogenic test microorganism (*Klebsiella oxytoca*) and compare counts before and after chilling using both regimes.

The pattern of cooling that was observed during a typical overnight chill program is shown in Figure 1. The carcase deep butt temperature fell to 20°C in less than 14 hours. Neither the normal bacterial contaminants nor the test organism increased in numbers overnight. Although there were increases in total counts during the weekend chills with both regimes, this did not affect the wholesomeness of the product.

In a recent survey of several abattoirs in South-East Queensland, surface temperatures of beef sides were closely monitored during overnight chilling. The chillers selected for the survey represented a range of designs and chilling conditions encountered in Australia. While all chillers easily complied with AS 4696, the ability to cool quickly varied considerably between chillers. One chiller reduced the surface brisket temperature to 7°C in less than 4 hours, whereas another took nearly 12 hours to reach the same temperature. The surface over the butt was slower to cool than the brisket, but was consistently drier—an observation made on previous occasions. In previous trials, growth on the neck and brisket most closely agreed to the predicted growth. This is the reason why the point-end brisket or outside neck locations are recommended for surface-temperature measurement.

Predictions of refrigeration indices from the temperature histories that were recorded showed that all easily met the criteria given in AQIS Notice Meat 2001/20; however the chilling patterns used in several of the chillers were unsatisfactory in that they resulted in excessive cooling of the subcutaneous fat. 'Hard fat' is an important OH&S issue in some plants and many beef sides needed to be rewarmed before the fat became soft enough for boning.

To avoid rewarming, it is conceivable that processors use a chilling pattern that rapidly reduces the temperature for the first several hours, but then holds the surfaces warmer than 7°C. Predictions from the study, of the surface temperatures for the latter part of the overnight chills, indicated they could be raised to as high as 10°C without jeopardising the wholesomeness of the meat. Other regimes may be suitable for weekend chilling.

Conclusion

Existing scientific literature can be used to validate programs in some chillers but this approach is limited by the rather small amount of specific data available. Microbiological testing can also be used but considerable skill and care is needed—both for the testing and for statistical analysis of the results. Predictive microbiology promises to be a more user-friendly approach. It will make possible the validation of a range of specific chilling patterns, including ones where some rewarming may be necessary to overcome the OH&S problems associated with boning carcases with excessively hard fat.

Further reading

Information package: Literature for chiller validations, August 2004 – Contact MIS staff.

Ross, T (1999) Predictive microbiology for the meat industry. Meat and Livestock Australia.

Sumner, J., Krist, K. (2002) The use of predictive microbiology by the Australian meat industry. Journal of Food Protection 73: 363-366.

For more information, contact one of the Meat Industry Services staff listed below.

Food Science Australia Meat Industry Services Section

The Meat Industry Services (MIS) section of Food Science Australia is an initiative supported by Meat and Livestock Australia (MLA) and the Australian Meat Processor Corporation (AMPC) to facilitate market access for, and support world-class practices in, Australia's meat industry.

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