Results for today; Ideas for tomorrow

Meat Technology Update

Newsletter 02/3 June 2002

Spray chilling of carcases and sides

Spray chilling is commonly practised in North American meatworks. The procedure involves intermittently spraying carcases with chilled water during the first few hours of primary carcase chilling. For example, carcases might be sprayed for 90 seconds at 30-minute intervals and this spray cycle may continue for the first six hours of chilling. The main purpose of spray chilling is to reduce carcase weight loss but there could be other advantages – more rapid chilling and softer fat at the time of boning are sometimes claimed as advantages of spray chilling.

While weight loss is an issue in Australia there has been little use of spray chilling at Australian abattoirs. One reason for its limited adoption has been the concern that the celebrated keeping quality of Australian vacuum-packaged beef and lamb may be compromised.

Figure 1. Water lines and spray nozzles positioned above carcases in chiller.

There have been several investigations of the microbiological quality of spray-chilled carcases and there appears to be little difference between conventionally chilled and spray-chilled carcases.

This newsletter discusses some of the issues associated with spray chilling and provides results of some of the investigations into it.

The process

In a typical spray-chilling process, chilled water is circulated around a ring main to spray lines in the chillers. The spray lines are located between the chiller rails, slightly below rail height. Spray nozzles are located on the spray lines at intervals designed to give coverage over all sides hanging in the chiller. Chilled water is pumped from a reservoir through a heat exchanger and around the ring main. The water temperature is maintained at about 1-5°C.

Spray-chilling systems are normally controlled by a programmable controller (PLC), or adjustable timers to give the required spray duration and interval. Investigators have used a range of spray conditions for beef, lamb and pig carcases. Some of these conditions are summarised in Table 1.

Descriptions of various spray-chilling systems include specifications for water temperature of 1 to 12°C, and delivery of water from sprays at rates of 430 to 875 mL per side per minute with droplet sizes of 30 to 300 μm. There should be complete coverage of the spray over the sides while creating minimum run–off and avoiding over-spray to the walls. The spray nozzles and water pressure must be selected to give the appropriate droplet size. Droplet size is critical. If the spray droplets are too large, there is a risk of water

FOOD SCIENCE AUSTRALIA
A JOINT VENTURE OF CSIRO AND AF
CSIRO Afisc Australian Food Industry Science Centre
MEAT & LIVESTOCK AUSTRALIA
AMPC

running down the carcase surface. This can produce bleached streaks on the carcases. If the spray droplets are too fine, too much spray water is drawn into the evaporators.

Table 1: Examples of spray chill conditions for beef, lamb and pig carcases.

Species	Interval between sprays (minutes)	Duration of spray (seconds)	Chilling time during which spray cycle is used (hours)
Beef	30	90	6
	15	60	8
	15	60	4
	15	90	8
	10	60	3.6
Lamb	20	-*	2.6
Pig	15	60	10

* 250 mL per carcase

Each spray head should be fitted with a check valve to ensure that the sprays cease abruptly when the flow is stopped. The check valves ensure that the sprays do not continue to drip after spraying, which can cause spotting or streaking on the carcases.

Regulations

The Australian Standard for Hygienic Production of Meat for Human Consumption does not make any reference to spray chilling. There appears to be no impediment to spray chilling at domestic abattoirs, however normal hygiene requirements such as preventing condensation and ensuring adequate drainage must be met. In addition, a spray chilling process is unlikely to be acceptable if it results in carcase weight gain.

In export abattoirs spray-chilling processes must be approved by AQIS according to Order 10 of the Export Meat Orders as prescribed in the Export Meat Manual (EMM). Applications for the approval of spray chilling must include the performance specifications of the system, and methods of monitoring. The order specifies that only potable water may be used and that the water must not be hyperchlorinated. Spray chilling must not result in condensation, deterioration of chiller structures, product weight gain or unsatisfactory microbial status of treated product. The order, last amended in 1991, also states that the effectiveness of the treatment to control microbial growth must be assessed using test bacteria applied to test carcases. It is not clear if AQIS would still require such an assessment. Any export establishment contemplating the installation of a spray-chilling system should discuss the current requirements for approval with AQIS.

AQIS requirements were based on requirements of the USDA Food Safety and Inspection Service (FSIS), which were principally focussed on measuring hot and cold carcase weights to demonstrate no weight gain during chilling. AQIS has similar requirements but also requires microbiological verification. The FSIS has not required microbiological verification of spray chilling since 1987.

Microbiological considerations

One of the concerns about spray chilling has been that it may not provide the same degree of microbial control as conventional chilling. In conventional chilling, evaporative weight loss from the carcase surface causes a partial dehydration at the surface. This dehydration quickly reduces the water availability to levels that are too low to support the growth of many bacteria. In the early stages of chilling it is both the reduced water availability at the carcase surface and the reduced temperature that inhibit growth of bacteria. In spray chilling, there is sufficient water available for microbial growth. This is counteracted to some extent by the more rapid surface cooling that can be achieved with spray chilling using chilled water. Microbial models can be used to predict potential growth on surfaces of spray-chilled carcases.

The effect of spray chilling on microbial growth on carcases must be judged in company with other chilling parameters such as chiller air temperature and air velocity. In one set of experiments conducted by CSIRO Meat Research Laboratory, there were small increases in the total viable counts and coliform counts on spray-chilled carcases held overnight. When they were held over a weekend there was a greater than 10-fold increase in total counts on test carcases. In these experiments spray chilling was not directly compared with conventional chilling but the results indicated that to maintain microbiological control, spray chilling must be combined with adequate chilling and holding procedures, particularly over weekends.

In another series of experiments there was a small reduction in total counts on spray-chilled carcases during an overnight chill. There was very little change in total counts on conventionally chilled carcases tested at the same time. In these experiments the air temperature used in the spray-chilling process was about 1-2^{o}C lower than used in the conventional chilling process. The lower air temperature was used when it was found that spray-chilled carcases could be chilled at lower air temperatures than used in conventional chilling without causing hard fat problems. When the spray-chilled carcases were held over a weekend there was a small average increase in total counts but the increase was less than on conventionally chilled carcases.

Most of the assessments of spray chilling have been done by examining the natural contamination on beef sides; however some have been conducted using inoculated carcases. In one experiment patches of carcase surface were inoculated with the organism *Klebsiella oxytoca*. This organism has very similar growth characteristics to *E. coli*, is non-pathogenic and can be

distinguished from *E. coli* during routine testing. During overnight chilling the numbers of the test organism did not increase on either spray-chilled or conventionally chilled carcases. During a weekend chill, the numbers of the test organism increased by 0.4 $\log_{10}$ units on the spray-chilled carcases and by a little over 2 $\log_{10}$ units on conventionally chilled carcases. As expected, holding carcases at lower temperatures during a weekend chill reduced the growth of the test organism.

In the tests with inoculated carcases, the growth of the test organism on both spray-chilled and conventionally chilled carcases was very similar to the growth predicted from the temperature profile at the carcase surface. This indicates that the microbial safety of the spray-chilling process can be effectively assessed from the temperature data.

As an illustration: for a weekend chill, carcases could be sprayed for 6 hours, and the surface temperature reduced to 10°C after 7 hours and 5°C after 10 hours. If the carcases are held at 7°C for 25 hours and then allowed to increase to 9°C during the remainder of the chill, the microbiological control is satisfactory. Predictions indicate that other spray regimes and carcase cooling rates are also satisfactory and may be preferable, depending on the type of carcases and the abattoir's operation.

Effects on vacuum-packed meat

There have been suggestions from industry that vacuum-packed chilled meat from spray-chilled carcases may have a reduced shelf life; however, the effects of spray chilling must be considered in conjunction other influences such as chiller air temperature and meat temperature at boning. If spray chilling is combined with lower chiller-air temperatures to achieve more rapid cooling rates, the microbiological condition of the spray-chilled carcases will be as good as conventionally chilled carcases and there should be no reason to expect a shorter shelf life of the boneless meat. In addition, if spray-chilled carcases can be boned at slightly lower temperatures than conventionally chilled carcases without incurring hard-fat problems, there should be an advantage to the shelf life of the packaged meat.

In US and Canadian experiments done in the 1980s and 1990s, spray chilling had no effect on the keeping quality of meat on retail display after periods of vacuum packing up to 44 days.

There are conflicting reports about whether spray chilling causes additional weep in vacuum packs. A US study indicates that weep from vacuum-packed cuts from spray-chilled carcases is slightly greater than weep from cuts from conventionally chilled carcases. A similar Canadian study indicates there is no difference.

In the case of both weep and shelf life of vacuum-packed meat then, available information indicates that spray chilling can be combined with other chilling, boning and packing conditions so that there is no loss of quality compared with conventionally chilled product. However, meat packers may have to conduct some fine tuning of their total processing procedures to make sure that conditions are combined to prevent loss of shelf life or increased weep.

Weight loss

The main point of spray chilling is to reduce weight loss. There is no doubt that it can reduce weight loss from carcases. Research reports indicate carcase weight losses of less than 0.4% from spray-chilled carcases compared with losses of about 1.5% from conventionally chilled ones. In practice, spray chilling can produce zero weight loss and even weight gain. The determining factor is how long the spray chilling cycle is applied relative to the total chilling time. For example, if carcases are sprayed for 90 seconds at 30-minute intervals throughout a 20-hour chill, it is likely the carcases would gain weight. If the spray regime is continued for only the first 6–10 hours of a 20-hour chill, the average weight loss should be between 0 and 0.5%. Canadian researchers reported a relationship between spray-chill duration and weight loss/gain from which it can be calculated that the duration could be as long as 10 hours before weight gain is experienced.

In each application, trials should be conducted to determine which spray regime and duration gives the minimum weight loss. The principle from the regulatory point of view is that no carcase should gain weight. Bearing in mind the variations in weight loss between individual carcases, it is necessary to aim for an average weight loss above zero to ensure that no individual carcase gains weight. For example it might be necessary to accept an average weight loss of about 0.2–0 .4% to ensure this.

Weight loss from carcases is relatively easy to control in a spray-chilling process and it can be readily monitored by measurement of carcase weight before and after chilling.

It is more difficult to assess whether reduced carcase weight loss translates to increased yield of boneless meat. No studies of the yield of boneless meat from spray-chilled carcases are publicly available; however, there is a study of the yield of boneless meat from hot-boned beef carcases. Hot boning is analogous to spray chilling in that either will prevent the evaporative weight loss that occurs during conventional chilling.

The hot boning study shows that the yield of saleable meat from hot-boned carcases depends on the type of carcase and the specification of the boneless meat. The yield of boneless manufacturing meat from hot-boned cow carcases was 1.4% higher than the yield from equivalent cold-boned carcases. In the case of trade steers (0 to 2 tooth 233 kg carcases) there was no difference between the yield of boneless meat from hot-boned and cold-boned carcases. The trade steers were boned and packed as primal cuts with 6–1 2 mm fat cover and manufacturing meat.

Differences in yields from hot-boned and cold-boned carcases are affected by the amount of meat that can be recovered from the bones in addition to the moisture retained by the carcase. In the trials with hot-boned cows, the yield of fat and bone was slightly higher from the cold-boned than the hot-boned carcases –

indicating that slightly more meat may have been removed from the bones of the hot-boned carcases. Even if the increased weight of fat and bone from cold-boned carcases is added to the yield of boneless meat, a 1.1% advantage in the yield of boneless meat from hot-boned carcases can be demonstrated.

The observations with hot-boned meat are backed up by anecdotal evidence from boning operations using spray-chilled carcases. Boning rooms have reported that the yield of boneless meat from spray-chilled carcases is greater than from conventionally chilled carcases if the carcases are lean, packed for manufacturing meat and the meat receives minimal trimming in the boning room.

If the carcases are fatter, and primal cuts derived from the carcases are trimmed to a specified fat depth, the yield from spray-chilled carcases may not be different from the yield from conventionally chilled carcases.

The yield advantage of spray-chilled carcases is probably due to moisture retained in the surface tissue of the carcases. If these tissues are trimmed in the boning room and are not included in the boneless meat it can be expected that the overall yield of boneless meat from spray-chilled carcase should be no different of the yield from conventionally chilled carcases.

Other advantages of spray chilling

Spray chilling may not always result in increased yields of boneless meat but other advantages have been claimed. There are some suggestions that the fat on spray-chilled carcases is softer and lighter coloured than the fat on conventionally chilled carcases at the same temperature. If it is softer, boning of spray-chilled carcases at lower temperatures than used for conventionally chilled carcases is possible. This in turn would be likely to lead to improvements in the hygiene and keeping quality of meat from spray-chilled carcases; however, further studies are required to confirm that spray-chilled carcases are less prone to hard fat and associated boning difficulties than conventionally chilled carcases.

More rapid surface chilling, which should result in more rapid chilling of deep muscle tissue, can be achieved with spray chilling compared with conventional chilling. There are claims that this results in more uniform meat colour in spray-chilled carcases. It is possible that spray chilling can reduce heat ring and pale discolouration of deep meat tissues – conditions caused by slow chilling.

Another advantage of spray chilling is that chiller floors are kept cleaner and less time is spent on cleaning chillers between loads.

Further reading

Greer, G. G., Jones, S. D. M. (1997) Quality and bacteriological consequences of beef carcass spray-chilling: Effects of spray duration and boxed beef storage temperature. Meat Science, **45:** 61-67.

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.

Need additional information help, information or advice?
Contact any of the following

BRISBANE
Food Science Australia
PO Box 3312
TINGALPA DC QLD 4173

Ian Eustace
Ph. 07 3214 2117
Fax. 07 3214 2103
Mob. 0414 336 724

Neil McPhail
Ph. 07 3214 2119
Fax. 07 3214 2103
Mob. 0414 336 907

Jocelyn Midgley
Ph. 07 3214 2109
Fax. 07 3214 2103
Mob. 0414 647 231

Cheryl Masson
Ph. 07 3214 2117
Fax. 07 3214 2101
Mob. 0416 198 403

SYDNEY
Food Science Australia
PO Box 181
KURMOND NSW 2757

Bill Spooncer
Ph. 02 4567 7952
Fax. 02 4567 8952
Mob. 0414 648 387

ADELAIDE
PO Box 178
FLAGSTAFF HILL
SA 5159

Chris Sentance
Ph. 08 8370 7466
Fax. 08 8370 7566
Mob. 0419 944 022

Past issues are available at: www.meatupdate.csiro.au