final report

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Evaluation of the effect of spray chilling in preventing chiller yield loss and improving boning room yield in sheepmeat processing

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Abstract

JBS Australia Pty Limited has successfully implemented spray chilling of beef carcases in most of its Australian plants and it was felt that similar benefits could be achieved with sheep and lambs. A section of a chiller at the Brooklyn plant in Victoria was fitted with a system that intermittently sprayed ambient-temperature (18°C) water for the first 8 hours of the chilling cycle.

Spray chilling reduced average carcase weight loss during overnight chilling from nearly 3% to about 0.6%. A yield trial comparing sprayed and non-sprayed carcases from the same chiller indicated that spray chilling resulted in an extra 2.3% of saleable meat.

A shelf-life trial during which bone-in and boneless vacuum-packed lamb cuts were assessed regularly over a 13-week storage period, showed that spray chilling had no effect on shelf life.

It is recommended that extended monitoring be conducted to confirm shrink reductions and yield improvements and prove customer acceptance.

Executive summary

JBS Australia Pty Limited has successfully implemented spray chilling in beef chillers in many of its processing plants. This has resulted in a reduction in evaporative weight loss and improvements in yield without loss of shelf life of vacuum-packaged product. The Company considered that these benefits should also be achievable with sheep and lambs. One zone of a lamb chiller at the Brooklyn, Victoria plant was fitted with equipment to spray carcases with ambient-temperature (18°C) water during the first 8 hours of the chilling cycle. The carcases were sprayed for 20 s every 20 minutes. A trial was then conducted to demonstrate that:

1. Spray chilling lamb carcases will significantly prevent dehydration (shrink) during conventional 24-hour carcase chilling.

2. As a result of spray chilling lamb carcases, the yield of primal and sub-primals and overall yield can be improved when compared to those from conventionally chilled lambs.

3. There is no detriment to the shelf life of chilled Cryovac lamb compared to conventionally chilled lamb. Demonstrate that the appearance, smell, touch and colour of the meat & fat is not compromised and that the amount of purge (weep) is not significantly increased over the 13-week testing period. Also show that there are no signs of variation in the eating characteristics such as taste, texture and tenderness that would greatly distinguish palatability between the samples from the spray chilled and conventionally chilled lamb.

The results showed that spray chilling reduced evaporative weight loss during normal overnight chilling from close to 3% to about 0.6%. Most of this saving was transferred to the carton as indicated by an increase of 2.3% in saleable meat from spray-chilled carcases compared with conventional chilling.

The cuts from the spray-chilled carcases had a very similar appearance to those from conventional chilling and there was no increase in weep in vacuum packs. Assessment of vacuum packs of bone-in leg, rack and boneless shoulder indicated that cuts from both treatments were similar and acceptable throughout the 13 weeks. However due to the test product being mistakenly frozen for nearly 2 weeks, it may be prudent to assume a confirmed shelf life of 11 weeks.

The initial level of microbiological contamination on the lamb cuts was higher than normally experienced with beef and by others for lamb and bacterial levels increased during storage. However the vast majority were lactic acid bacteria that do not produce unpleasant odours or flavour until spoilage levels are reached.

It is recommended that:

1. The spray chilling system in Chiller 2 at Brooklyn be operated over an extended period to allow:

    a. Assessment of improvement in weight loss and yield on a larger number and range of carcases;

    b. Detection of any operational issues;

    c. Evaluation of market acceptance of product from spray-chilled carcases.

2. When the operation has been proven at Brooklyn, extend spray chilling to other sheep processing facilities in the JBS Australia group.

Table of Contents

Abstract 3
Executive summary 4
Background 7
Project objectives 7
Methodology 8
Weight loss 8
Yield 8
Shelf life 8
Results 10
Weight loss 10
Yield 10
Shelf life 11
Assessment of intact packs 11
Odour on opening 12
Weep in vacuum packs 13
Microbiological assessment 14
Conclusions and recommendations 17
References 18
Appendix A: Photographs 19
Appendix B: Growth of lactac acid bacteria 21

Background

JBS Australia Pty Limited has successfully implemented spray chilling in most of its beef processing establishments. As spray chilling has provided proven improvements in yield of saleable meat without any reduction in shelf life of vacuum-packaged chilled meat, it was decided to investigate the extension of this technology to the sheep processing plants.

A section of a lamb carcase chiller at the Brooklyn, Victoria plant was fitted with spray chilling and trials were undertaken to assess the effect on chiller weight loss (shrink), carcase quality, yield and shelf life of vacuum packed primal cuts when compared with conventional carcase chilling.

Project objectives

The objectives of the project were to demonstrate that:

1. Spray chilling lamb carcases will significantly prevent dehydration (shrink) during conventional 24-hour carcase chilling.

2. As a result of spray chilling lamb carcases, the yield of primal and sub-primals and overall yield can be improved when compared to those from conventionally chilled lambs.

3. There is no detriment to the shelf life of chilled Cryovac lamb compared to conventionally chilled lamb. Demonstrate that the appearance, smell, touch and colour of the meat & fat is not compromised and that the amount of purge (weep) is not significantly increased over the 13-week testing period. Also show that there are no signs of variation in the eating characteristics such as taste, texture and tenderness that would greatly distinguish palatability between the samples from the spray chilled and conventionally chilled lamb.

Methodology

Lamb Chiller 2 at the JBS Australia plant at Brooklyn, Victoria was fitted with a single bank of spray pipes and nozzles in Zone 1. This area represented 1/11th of the total area of the chiller spanning all 10 rails and had a capacity of 130 lambs.

Initial trials were conducted to establish the optimum spraying regime. A spraying cycle with ambient-temperature water of one 20-second spray every 20 minutes for a total of 24 sprays over 8 hours was found to be suitable. The water serving the spray distribution pipes located in the chiller was at a temperature of 18°C.

Weight loss

Lamb carcases from the same lot were loaded into Zone 1 and the similar but unsprayed adjacent Zone 2 of Chiller 2 and chilled overnight using the normal chilling regime with an air set point temperature of 2°C. The spray-chilled carcases from Zone 1 and the conventionally chilled carcases from Zone 2 were weighed cold the next day after the same duration of chilling on calibrated scales to calculate the weight loss (shrink).

Yield

A preliminary yield trial was undertaken by selecting six lambs from a spray chilled group and six from the same lot from a conventionally chilled group. They were weighed prior to boning and each carcase was dissected using the same personnel, cutting lines and trim specification. The primals, sub-primals, trim fat and bone from each carcase were accurately weighed and recorded.

Shelf life

To obtain cuts for the shelf-life trial, 35 lambs were randomly selected from the spray chill zone and another 35 from the same lot from the conventional chill zone. Each group of 35 was divided in to seven lots of five carcases from which were collected 5 femur bone-in legs, 5 cap-on racks and 5 boneless shoulders. The cuts were vacuum packaged, and packed in to cartons which were labelled as spray or conventionally chilled and with sampling times of 3, 5, 7, 9, 11 and 13 weeks. The final set (week 0) were sampled for microbiological analysis in the boning room on the day of packing.

All cartons were chilled overnight and consigned to the Bremer River Cold Store at JBS head office site at Dinmore in Queensland where they were stored at -0.5 to 0°C until removed for assessment.

On each assessment day, five legs, racks and shoulders each from spray and conventionally chilled carcases were removed from storage. A panel of four people assessed each cut for quality of vacuum, visual appearance and odour on opening. They recorded their score on a nine-point scale of 0 to 8 with 8 being very good vacuum, no discolouration or fresh odour accordingly.

Staff from the JBS Dinmore meatworks NATA-accredited laboratory collected samples from each cut for microbiological analysis. Two x 10 cm^2 core samples approximately 2 mm deep were collected from the surface of each cut using a sterile borer. The samples were placed in sterile stomacher bags, chilled and transported to the laboratory for analysis of:

- Total viable count;
- Lactic acid bacteria
- Coliforms and *E. coli*;
- *Brochothrix thermosphacta*

Serial dilutions were inoculated onto Petrifilm according to manufacturer's instructions. Results were recorded as CFU/cm^2.

A further 25 g sample was also collected from the surface of each cut for determination of the presence of *Salmonella* using the Australian Standard method.

Results

Weight loss

Conventional chilling of lamb carcases resulted in an average weight loss (shrink) of 2.96% compared with 0.59% for the spray-chilled carcases. Figure 1 shows the variation in weight loss for each group of carcases. The majority of conventionally chilled carcases lost between 3 and 4 percent but a few only lost less than 1%, whereas the majority of spray-chilled carcases lost less than 1%.

The appearance of the spray-chilled carcases did not differ greatly to that of the normally chilled ones except that the thin flap area was noticeably moister.

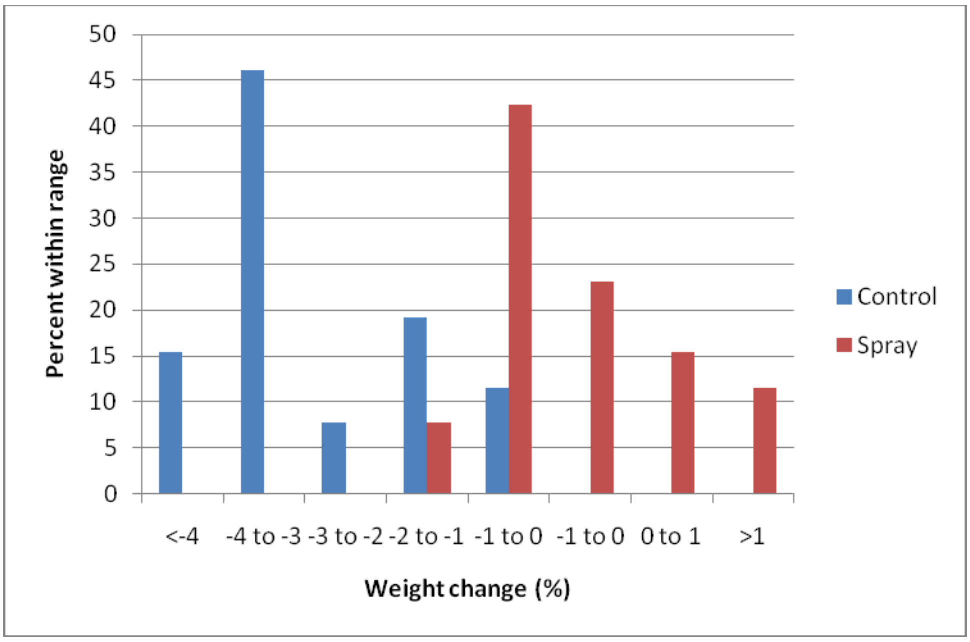

Figure 1: Weight loss during conventional and spray chilling of lamb carcases

Yield

The yield of saleable meat from the spray-chilled lamb carcases was 87.6% on a hot weight basis which was significantly greater (P <0.05) than the yield of 85.3% from the conventionally chilled group. The average hot carcase weight of the spray-chilled group was 21.0 kg and the control group 23.2 kg.

The yield of individual cuts, trim, fat and bone is presented in Table 1. There was a tendency for the yield of most cuts and bone to be higher for the spray chilled carcases but the difference was only statistically significant for the bone-in square cut shoulder. With only six carcases in each group, statistical significance is difficult to achieve but the trial is a guide to the improvement in yield that spray chilling may provide. Based on these results and a daily throughput of 5,000 sheep and lambs per day, an increase in yield of 2.3% could equate to an extra 2,760 kg of saleable meat per day based on an average 24 kg carcase weight.

Table 1: Yield (%) of primal cuts, trimmings, fat and bone from conventional and spray-chilled lamb carcases

Primal cut (HAM* No.)	Yield (percent of hot carcase weight)		Statistical significance
	Conventional chill	Spray chill	
Leg – femur bone (4802)	20.92	21.94	NS**
Shank (5031)	3.58	3.50	NS
Rib flap (5011)	6.80	7.04	NS
Flap (5009)	5.69	5.49	NS
Breast (5010)	2.35	1.97	NS
Neck (5020)	2.23	2.13	NS
Sq cut shoulder (4992)	22.36	24.06	P <0.05
Fore shank (5030)	3.40	3.57	NS
Rack (4932)	10.07	9.82	NS
Shortloin pair (4883)	6.36	6.35	NS
Trimmings (5270)	1.55	1.71	NS
Fat	3.89	3.69	NS
Bone	6.45	6.89	NS
Total saleable meat	85.30	87.58	P <0.05

*HAM AUS-MEAT Handbook of Australian Meat

**NS Not statistically significant (P > 0.05)

Shelf life

Assessment of intact packs

The cartons of vacuum-packed primals were stored in a chiller at a temperature of -0.5 to 0°C except for a period over Christmas and New Year when they were mistakenly placed in to a freezer at -18°C between sampling weeks 9 and 11. Prior to each assessment, the cartons were removed from the chiller and appearance scored by three to five people. There was very little difference in scores between the conventionally and spray-chilled samples as the appeared quite similar as shown by the photo of shoulders after 13 weeks (Figure 2). Additional photographs are shown in Appendix A.

The lamb racks appeared excellent throughout the storage period with maximum scores of 8 only reducing slightly to 7.5 at week 13. The shoulders and legs were also excellent but appearance scores dropped from eights to sevens at the week 11 assessment. Only one primal cut – a spray-chilled leg – showed obvious signs of deterioration such as poor meat and weep colour but the pack had a poor vacuum while not considered to be a leaker.

The vacuum of the majority of packs was considered to be good and was maintained throughout the storage period. Only three obvious leakers were detected from 180 packs and these were excluded from the analysis.

Figure 2: Spray-chilled (S) and conventionally chilled (C) square-cut lamb shoulders after 13 weeks storage

Odour on opening

There was very little odour from the packs, other than a slight meaty odour during the early weeks of storage. A higher level of odour was detected in most packs from week 9 when there was a significant reduction (P <0.05) in scores to below 7 for most cuts compared with Week 3. However the odour was not considered unpleasant except in the case of two packs of legs at week 11. Again the racks with week 13 scores of about 7 (Figure 3) were scored more highly than the shoulders and legs (Figure 4). The average scores for all cuts at the end of the storage period were above 4 which would be defined as the level of acceptability.

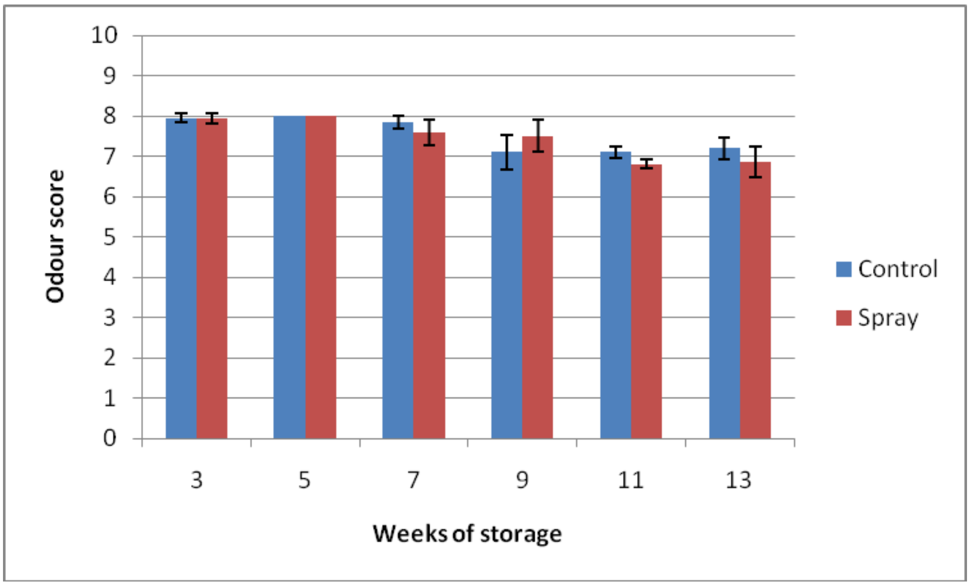

Figure 3: Odour scores for bone-in lamb racks (8: no odour, 0: strong off odour, error bars show standard deviation)

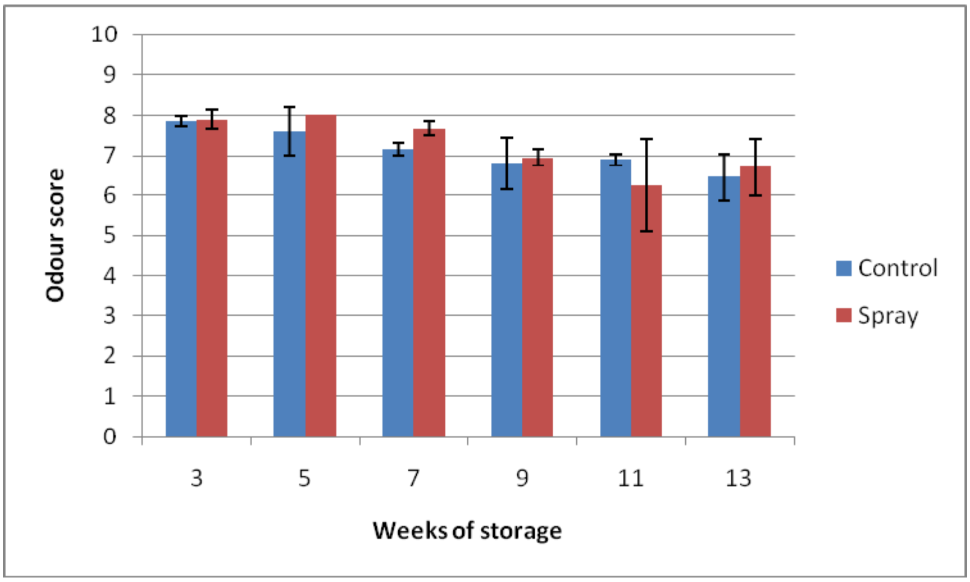

Figure 4: Odour scores for bone-in lamb legs (8: no odour, 0: strong off odour, error bars show standard deviation)

Weep in vacuum packs

There was little effect of treatment on weep in vacuum packs but there were large differences between legs, racks and shoulders. The amount of weep increased with storage time and there were large variations between individual cuts within each cut type. There was negligible weep in the rack packs for the entire storage period, even after they had been frozen after week 9. Legs had the greatest amount of weep (1.5 to 2% at 13 weeks) and shoulders 0.8 to 0.9% but there was no evidence that spray chilling had any effect.

The amount of weep at each assessment for legs and shoulders is shown in Figures 5 and 6 respectively.

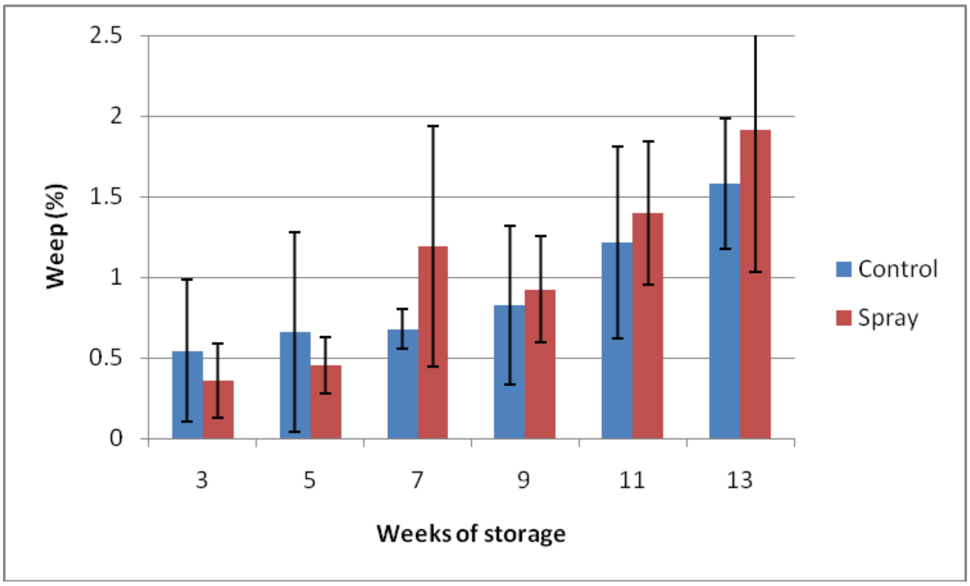

Figure 5: Weep from vacuum-packed legs (error bars show standard deviation)

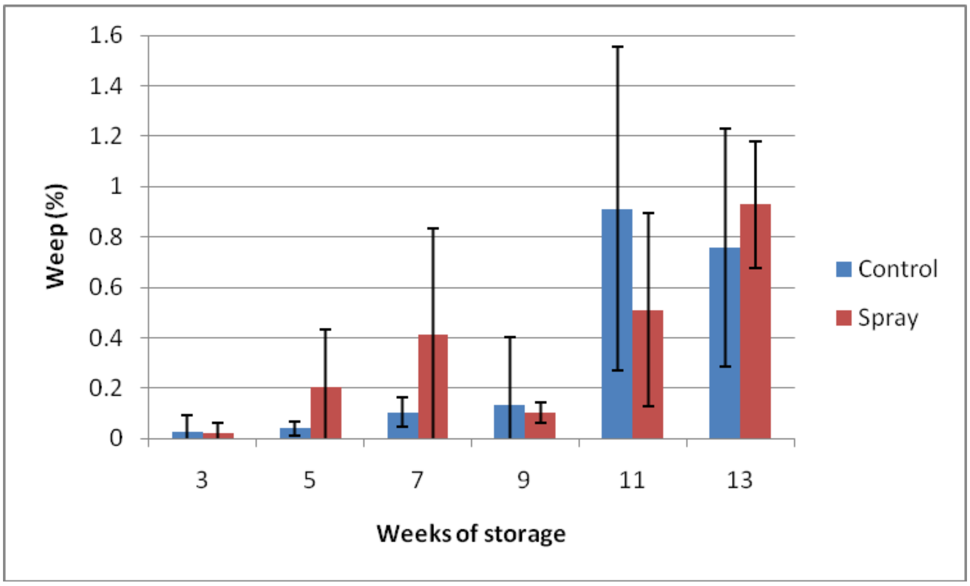

Figure 6: Weep from vacuum-packed shoulders (error bars show standard deviation)

Microbiological assessment

The total viable count (TVC) was quite high even at the time of packing when it ranged from 4 to 6 $log_{10}CFU/cm^2$. This was greater than normally observed for beef cuts and vacuum-packaged lamb (CSIRO, 2010) and the average for chilled carcases of 3.92 $log_{10}CFU/cm^2$ from the Australian baseline study (MLA, 2005). The TVC reached maximum values by week 7 of storage. The count on the racks was significantly lower (P <0.05) than on the legs and shoulders and peaked at 7 $log_{10}CFU/cm^2$ compared with 8 to 9 $log_{10}CFU/cm^2$ for the other cuts. This was in line with the physical assessment of the packs which indicated better appearance and less odour for the racks. Figures 7 and 8 show the counts for racks and shoulders respectively. Although the counts for the legs and shoulders were at what would normally be considered spoilage levels, the meat from both chilling regime was not in an objectionable state even at week 13.

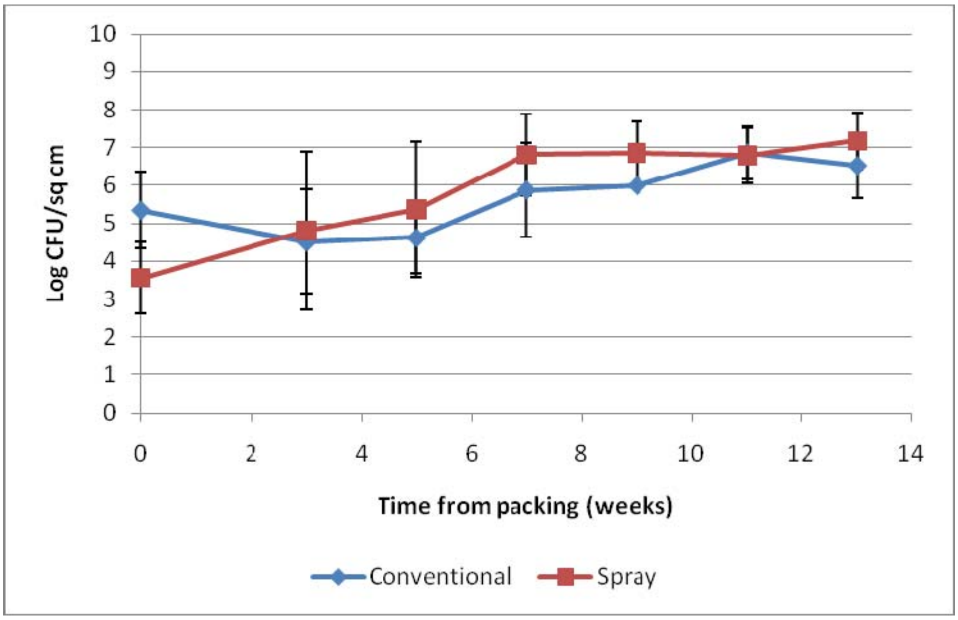

Figure 7: TVC ($log_{10}CFU/cm^2$) for lamb racks (error bars show standard deviation)

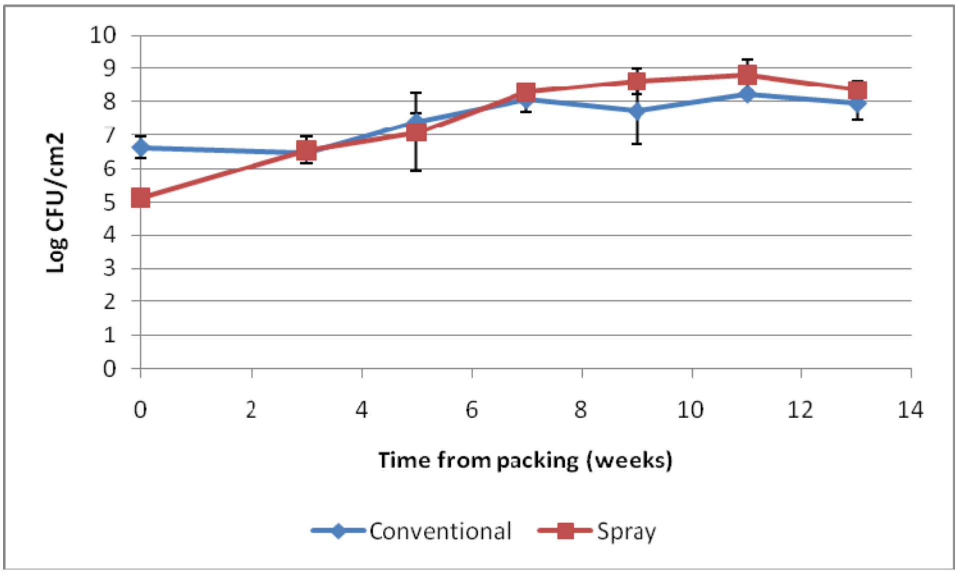

Figure 8: TVC ($log_{10}CFU/cm^2$) for boneless lamb shoulder (error bars show standard deviation)

The conventionally chilled cuts had a higher count than the spray chilled ones at the point of packing while it tended to be the reverse later. Assuming there was no error during sampling and analysis, possible explanations are that the spray-chilled carcases were boned first up on clean equipment and tables or that there was some washing or dilution effect of the spray chilling. Greer and Dilts (1988) found that conventional chilling significantly reduced mesophilic bacterial numbers on pig carcases while spray chilling did not significantly alter bacterial numbers. However Eustace *et al* (1998) showed that spray chilling of beef carcases resulted in a more rapid reduction of surface temperature on the brisket and loin and no difference in bacterial levels between conventionally and spray-chilled carcases.

In the current trial, spray chilling did not result in significantly higher total viable counts on any of the cuts throughout the storage period.

Lactic acid bacteria (LAB) were not determined at Week 0, but from when they were counted at Week 3, their numbers rose during the storage period from 4 to 5 $log_{10}CFU/cm^2$ at Week 3 to 7 to 8 $log_{10}CFU/cm^2$ by Week 13 to be the predominant organism. Again the counts on the racks were lower than on the legs and shoulders. The overall average LAB counts for the three cuts over the storage period are shown in Figure 9. Counts on the different primal cuts are reported in Appendix B.

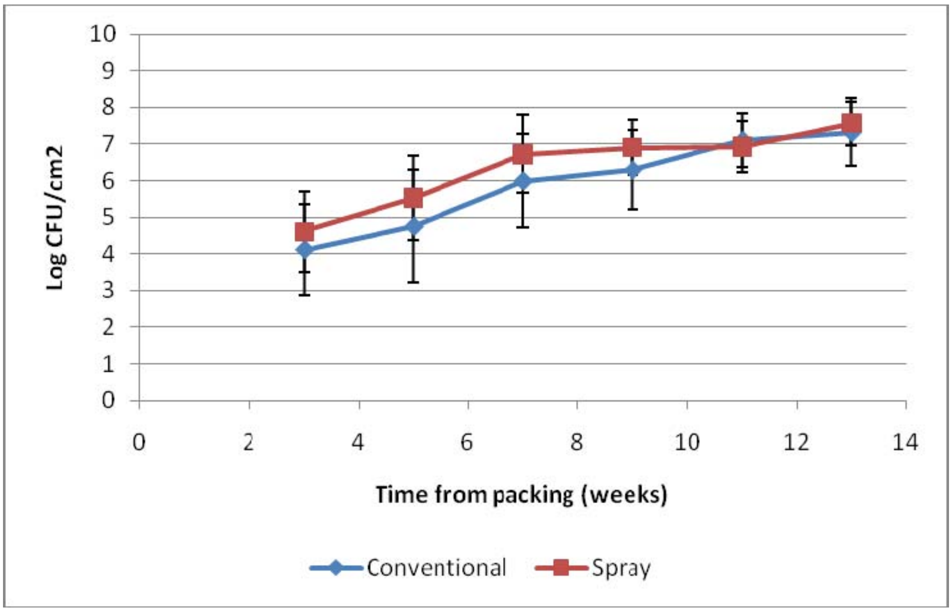

Figure 9: Growth of LAB – average for the three cuts (error bars show standard deviation)

The numbers of the spoilage organism *Brochothrix thermosphacta* increased during storage from about 2 $log_{10}CFU/cm^2$ at Week 0 to 4 to 5 $log_{10}CFU/cm^2$ by Week 13. *Br. thermosphacta* are more common on lamb than beef and under anaerobic conditions only grow on meat at a pH higher than 5.8 (Campbell *et al*, 1979). *E. coli* and *Salmonella* were not detected at any of the samples at any of the assessment times.

The bacterial numbers on these vacuum-packed lamb primal cuts was much higher than found on spray and conventionally chilled beef cuts from the earlier project. This is likely to be due to a higher level of initial contamination and the higher pH of 5.8 to 6.0 measured in the loin muscle. Despite this few cuts were noticeably spoilt and they were considered acceptable after 13 weeks storage at -0.5 to 0°C. This storage life should be sufficient to service most markets. Microbial numbers on cuts from spray-chilled carcases were generally not significantly higher than on those from conventionally chilled carcases.

Conclusions and recommendations

Spray chilling of lamb carcases by application of ambient water spray for 20 seconds every 20 minutes for the first 8 hours of chilling reduced carcase weight loss from near 3% to 0.6%. Results from an initial yield trial with 6 carcases indicated that an increase in saleable meat yield of 2.3% was achievable from spray-chilled carcases when compared with similar bodies that had been conventionally chilled. This suggests that nearly all of the evaporative weight loss saved is transferred to the carton.

The cuts from the spray-chilled carcases had a very similar appearance to those from conventional chilling and there was no increase in weep in vacuum packs. Assessment of vacuum packs of bone-in leg, rack and boneless shoulder indicated that cuts from both treatments were similar and acceptable throughout the 13 weeks. However due to the test product being mistakenly frozen for nearly 2 weeks, it may be prudent to assume a confirmed shelf life of 11 weeks.

The initial level of microbiological contamination on the lamb cuts was higher than normally experienced with beef and by others for lamb and bacterial levels increased during storage. However the vast majority were lactic acid bacteria that do not produce unpleasant odours or flavour until spoilage levels are reached.

It is recommended that:

1. The spray chilling system in Chiller 2 at Brooklyn be operated over an extended period to allow:

    a. Assessment of improvement in weight loss and yield on a larger number and range of carcases;

    b. Detection of any operational issues, including increased water use and effluent volume;

    c. Evaluation of market acceptance of product from spray-chilled carcases.

2. Measures be taken to improve operational hygiene to improve the microbial status of sheep and lamb carcases.

3. Action be taken to reduce stress during transport and handling of lambs so that number of high pH carcases is minimised.

4. When the operation has been proven at Brooklyn extend spray chilling to other sheep processing facilities in the JBS Australia group.

References

Campbell, R.J., Egan, A.F., Grau, F.H., and Shay, B.J. (1979). The growth of *Microbacterium thermosphactum* on beef. *Journal of Applied bacteriology* **47**, 505-509.

CSIRO (2010). Shelf life of chilled, vacuum-packed lamb. Meat Technology Update 3/10 – June 2010.

Eustace, I.J., McPhail, N.G. and Spooncer, W.F. (1998). Microbiological verification of spray chilling in an export establishment. Report by Australian Meat Technology Pty Ltd.

Greer, G.G. and Dilts, B.D. (1988). Bacteriology and retail case life of spray-chilled pork. *Canadian Institute of Food Science and Technology Journal* **21**(3), 295-299.

Meat and Livestock Australia (2005). Microbiological quality of Australian beef and sheepmeat – results of the industry's third national abattoir study.

Appendix A: Photographs

Figure A1: Racks after 7 weeks storage

Figure A2: Racks after 13 weeks storage

Figure A3: Legs after 7 weeks storage

Figure A4: Legs after 13 weeks storage

Appendix B: Growth of lactac acid bacteria

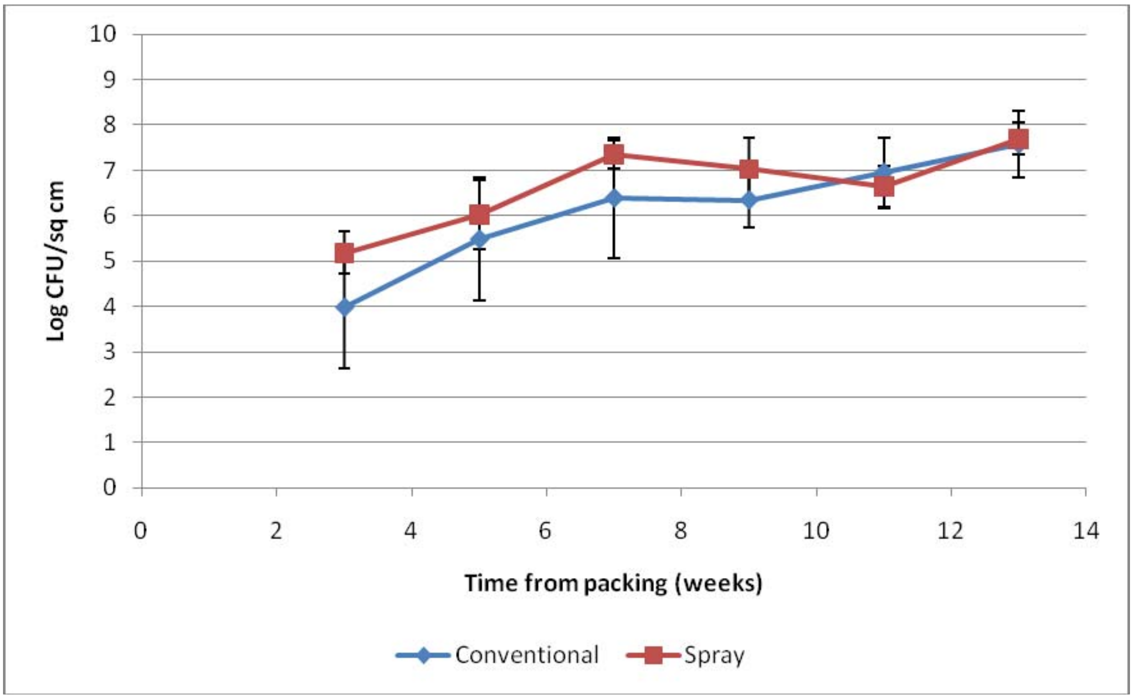

Figure B1: LAB growth on legs

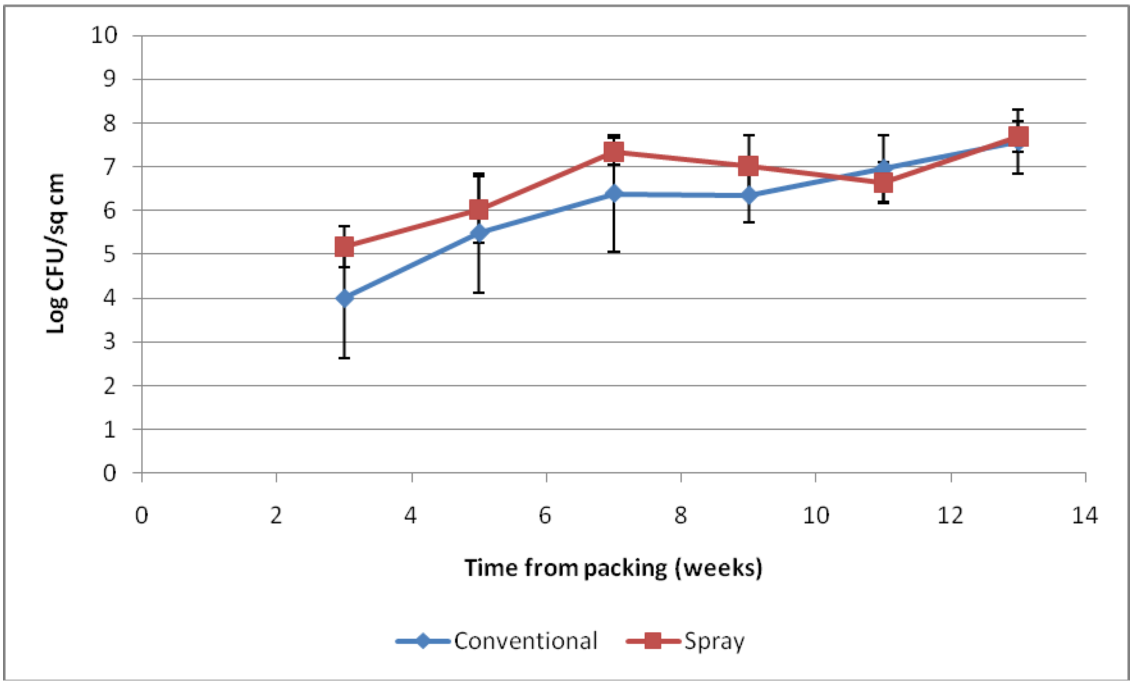

Figure B2: LAB growth on racks

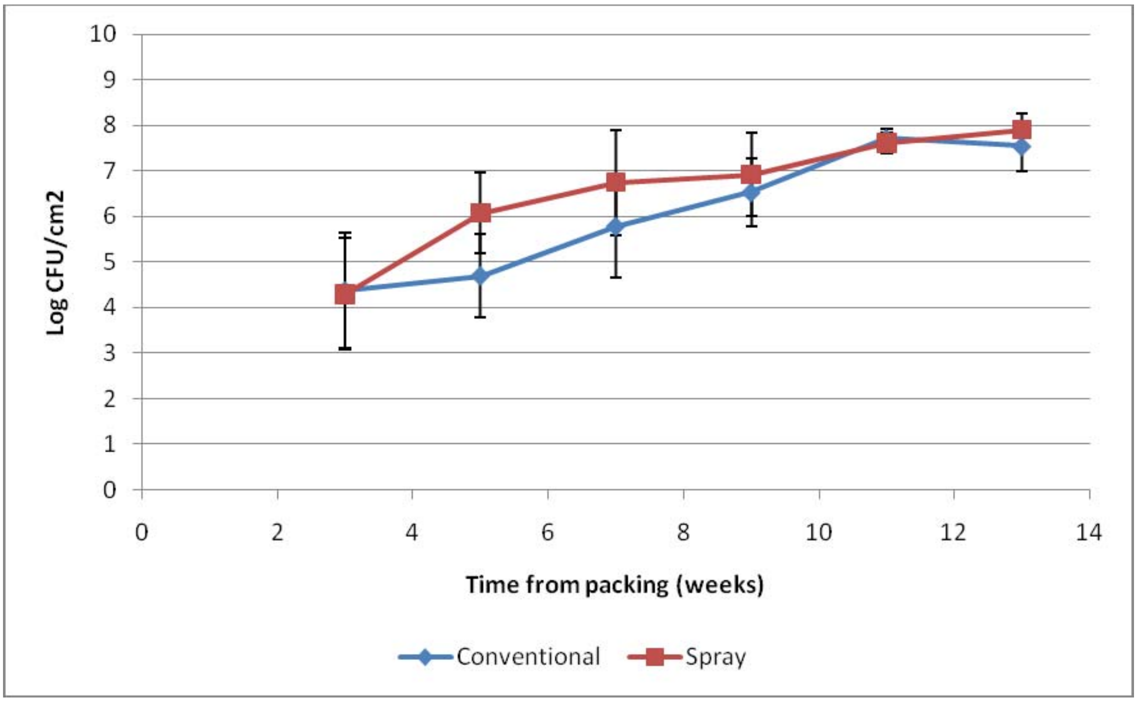

Figure B3: Lab growth on boneless shoulders