final report

Project title: Evaluation of Spray Chilling

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Evaluation of spray chilling at a meat processing site

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1 Why Spray Chill

The chilling process uses circulating cold air to cool hot carcasses. The cooling process results from cold air evaporating carcass surface moisture. As the cooling process continues and surface moisture has been evaporated, deeper tissue is cooled as moisture is drawn to the surface. The evaporation is rapid in the initial stages as there is a large difference between the hot carcass temperature and the chiller air temperature. Evaporation rate declines as the temperature gap reduces.

The evaporation, termed carcass shrinkage is the moisture/weight lost by the carcass due to the chilling process. This is a significant cost to the processing facility. Spray chilling uses sprays of water to offset the evaporative loss of carcass chilling. Sprayed water is then evaporated from the carcass and moisture is not drawn from deeper in the tissue. Timing of sprays and amount of water sprayed is key to get the shrinkage as close to zero as possible. Shrinkage and carcass chilling are also influenced by other variables; including but not restricted to: chiller design, operating conditions, carcass size and carcass fat cover.

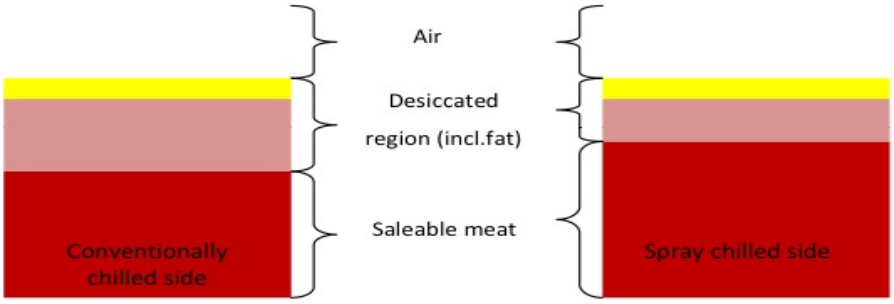


Figure 1. Cross section comparison of Conventionally chilled and Spray chilled sides.

Note the increase in saleable meat for the Spray chilled side.

2 Spray Chilling Process

All components of the spray chilling system are monitored and controlled via a computer program. These components include: spraying pump, holding tank, refrigeration heat exchanger and isolation valves. Carcass scales are also connected to the computer system and take the carcass weights before and after chillers. These scales provide all data for the performance of the conventional and spray chilling.

Chlorinated water is chilled in a holding tank and then pumped around in a ring main through all the chillers. Water is chilled to assist in the rapid cooling of the external surface of the carcass. Shrinkage is greatest while the surface temperature is high. The current regime for water sprays follows the same trend. In the first stage of the cycle, sprays are used frequently to keep the surface moisture up. As the surface cools, sprays are fewer, until the end of the chiller cycle where sides are left to dry before boning.

3 Regimes used

Initial trials used a regime where sprays were set at constant amounts and intervals.

This regime was tested for E.coli and Total Plate Counts on the first lots sprayed chilled. This regime was then trialled over a week of spray chilling and then an extended period of 6 months for E.coli, TPC and shelf life testing.

Following testing of Regime #1, the computer system was upgraded to allow variable spray amounts and intervals within the same spray cycle. This allowed more intensive spraying in early stages and reduction towards the end of the cycle.

4 Results and evaluation of effectiveness

The spray regime was reducing the shrinkage and showing no adverse effects on microbiology, meat quality or aesthetics of packaged product. At this point a trial was needed to determine if reduced shrinkage actually improves the saleable meat yield.

Two different methods were used to test if the shrinkage reduction translated into increased saleable meat yield; individual body comparisons and large scale, boning room yield tests. Each trial method involved comparing sprayed carcasses with non-sprayed carcasses. Carcasses used for each trial were all similar size, condition and fat coverage. For each trial, the shrinkage was calculated for the comparison to saleable meat yield.

The following tests were completed:
a) Full scale yield test using 100 sides of Jap Ox carcasses per test

b) Individual Body yield test using 3 bodies of Jap Ox carcasses where the Left side was conventionally chilled and the Right side was spray chilled

Each trial showed that the saleable meat yield increased more than the shrinkage saved. Further large scale trials were conducted to verify the results and confirmed the benefit of spray chilling. Specific shrinkage and yield numbers are not shown as they are very site specific and vary significantly depending on type of cattle, chiller design and regimes etc.

5 Cost effectiveness

Given that carcass weight saved via shrinkage reduction translates directly into saleable meat; the financial benefit of spray chilling is significant. The company involved in the trial was convinced by the results that the implementation of spray chilling generated real commercial returns justifying the investment required.

There are additional costs for the operation of the Spray System:

- Purchase and disposal of water
- Labour to wet carcasses
- Electricity for water pumps
- Electricity for Refrigeration of spray water
- Maintenance of spray equipment

6 AQIS Approval Process

The AQIS On Plant Veterinary Officer (OPV) and the Area Technical Manager (ATM) were notified in writing of the intention to conduct an initial Spray chilling trial on 5 sides to determine any potential food safety impacts of spray chilling. Accompanying this letter was the results of the water testing from the sprays post cleaning of the system. The 5 sides were swabbed as per the ESAM process and results were compared to the average for that cattle type in that period.

Due to results showing no detrimental impact, larger scale trials on a whole chiller was approved. ESAM data was collected from for these trials and also Shelf life trials were conducted. This information was compiled into a report and presented to the ATM (Appendix 1 & 2). With the submission of the report a request for extensive testing over 6 months was approved.

A Standard Operating Procedure (SOP) was written detailing the Spray chilling process, responsibilities, monitoring and Corrective Actions. This document was developed by the QA department and discussed and modified in collaboration with Plant staff, AQIS OPV and ATM. This SOP has been stamped and approved by the ATM to accept the Spray chilling process at the processing plant.

7 Monitoring the Spray Chilling Process

Critical to the Spray chilling process is the recording of the data. The weight recorded before the chillers and after must be correct to provide reliable data. Thus the scales are calibrated by an electrician every morning then checked by a QA and then checked throughout the day and night by the engine drivers.

Shrinkage data can be potentially affected by a multitude of variables. The most basic is to ensure that the pre-set regime on the computer program is actually what is occurring in the chillers. This is monitored throughout the day and night by the engine drivers and verified by a QA daily, who checks spray records and physically checks in the chillers. Daily checks by the QA also include Humidity logging in chillers and HMA, while also checking that other shrinkage related improvements are in place. A monthly nozzle checking/cleaning register has also been developed to ensure that all sprays are working correctly.

8 Potential risks and their mitigation

8.1 Weights and measure and AIS ECMMP orders 2005

Due to the nature of the spraying system, individual sides may increase weight at the end of the chiller cycle. Regimes will be set-up to reduce shrinkage to as low as possible but avoid adding weight to carcasses. Carcasses will be averaged for shrinkage across an entire chiller or lot. In the event of an entire lot adding weight they will be further chilled to reduce weight before boning.

8.2 Increased microbiology counts and reduced shelf life

The ESAM testing protocol was used on the initial carcasses and subsequent lots to ensure meat microbiology was not affected. Following initial trials (see appendix 1), an extended 6 month trial was conducted to monitor any affects to microbiology. No significant variance was detected in any of the ESAM tests. Subsequent modifications to the system were also subject to microbiological testing, (see Appendix 3).

Shelf life was tested and compared to primals from carcasses that were not spray chilled. Results of the shelf life testing showed no detrimental affects from spray chilling (see appendix 2). Shelf life testing is conducted periodically as part of the Plant Quality system and ESAM are conducted daily. These continually monitor microbiological performance.

8.3 Spray chilling cycle adversely affecting meat quality characteristics

Chiller cycles have been carefully structured to ensure that carcass pH declines pass the required window to ensure that meat quality is at its best. While trialling spray chilling (temperature/fans/timing) were not adjusted, spray chilling may potentially influence the carcass pH decline.

pH declines have been conducted where any modifications to chiller cycle have occurred (see appendix 4). No adverse impacts on meat quality were observed. pH declines are conducted weekly as per our Quality System which continue to monitor meat quality.

8.4 Water marks and meat discolouration

Water sprayed onto carcasses can cause lines and water marks on fat and red bark, particularly on the Rump, Striploin and Navel End Brisket. These marks could be seen during boning and still after the product had been cryovaced; however after the product was chilled for 24 hours these marks had dissipated. Tests were conducted between non-sprayed primal cuts and watermarked spray chilled cuts. After 24 hours of carton chilling, the appearance of both were the same.

9 Fine tuning the system

Measuring and logging relative humidity in chillers and hot marshalling area (HMA) was required to determine effectiveness of modifications and target areas for improvement. Humidity and Temperature loggers were purchased for this purpose.

Humidity readings for the HMA showed that this was an area that needed to have humidity increased, to reduce moisture drawn from the hot carcasses. The following strategies were implemented to combat this:

Hot Marshalling area improvements completed:

- Fan speeds reduced
- Fan direction was changed
- Relative humidity was increased in the HMA

Scales installed to enable separation of HMA shrinkage from chiller shrinkage and determine the impact of each area

10 Appendices

10.1 Appendix 1 – Microbiology results from initial spray chilling trials

Microbiological Comparisons

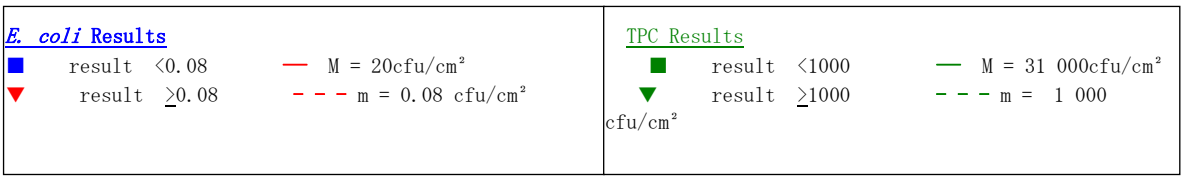
Prior to the commencement of Spray Chilling, the system was cleaned, sanitised and flushed. After the system had been flushed water samples were taken from one old and one new chiller and sent away for Micro testing. Results can be seen in Table 1.

Sample	SPC 22 C/72 hr (cfu/mL)	Coliform Count (cfu/100mL)	Thermotolerant Coliforms (cfu/100mL)	Escherichia coli (cfu/100mL)
Chiller 7 (old)	<1	<1	<1	<1
Chiller 8 (new)	<1	<1	<1	<1

Table1. Microbiological water testing for Chiller 7 & 8.

A small scale trial was then performed on five sides in chiller 8. Five microbial swabs were then taken, following the AQIS ESAM procedures. The results of the trial can be seen in the figures below.

A graph of ESAM results on Conventional Chilling for that period has been included as a reference.



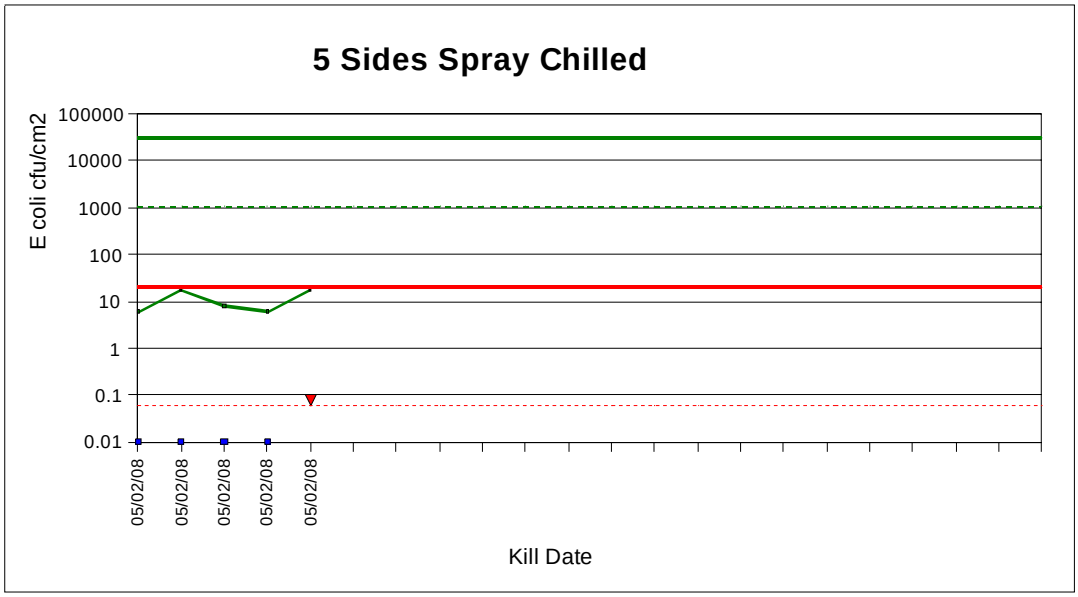


Figure 1. ESAM Results for 5 Side Spray Chill Trial

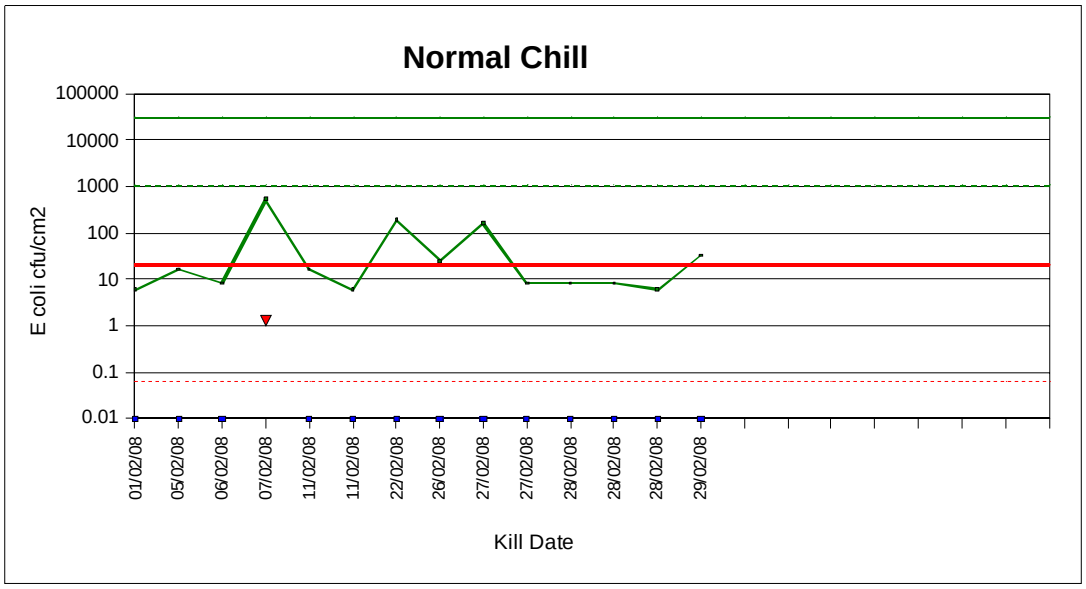


Figure 2: ESAM results for February Period for Cow/Bull

Larger scale microbiological tests have been performed, by comparing weekly periods of Spray chilling and Conventional chilling. Steer/Heifer and Cow/Bull ESAM results were used for comparison 1. The results from the trial are from the official ESAM records and can be seen in the Figures below.

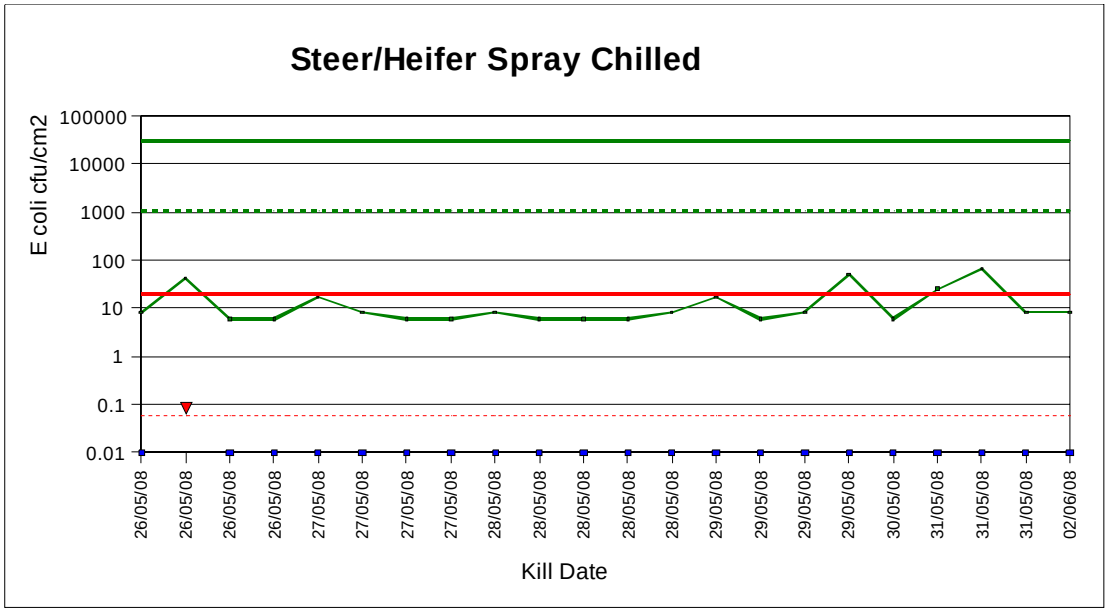


Figure 3. ESAM results for Spray Chilled Steer/Heifer trial in May

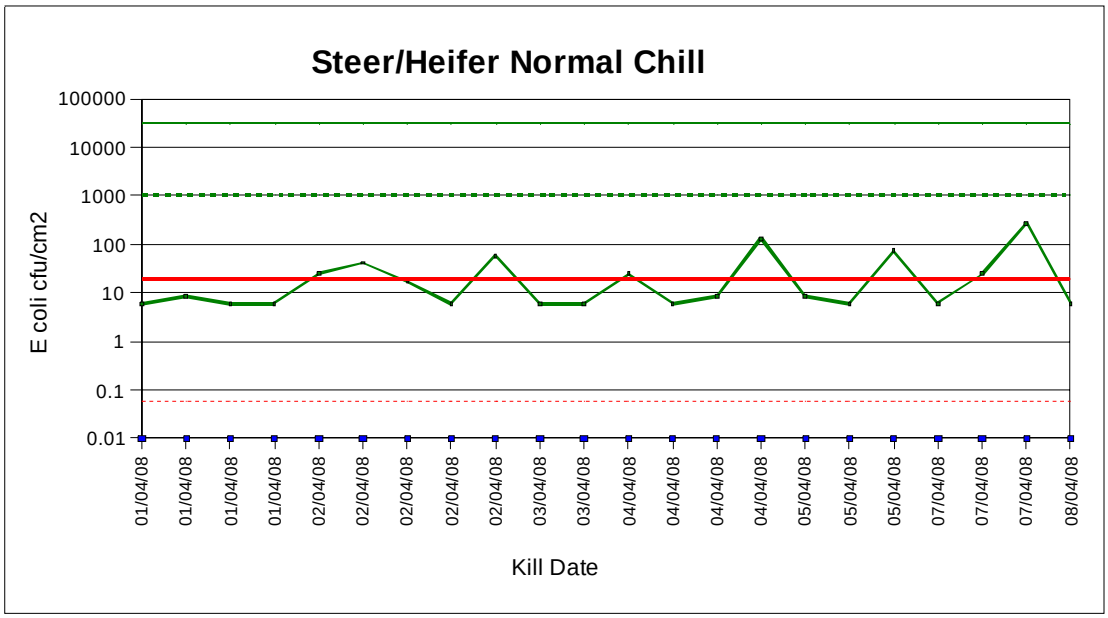


Figure 4. ESAM results for Steer/Heifer in April

1 April was used for comparison due to Spray Chilling trials taking place from May onward.

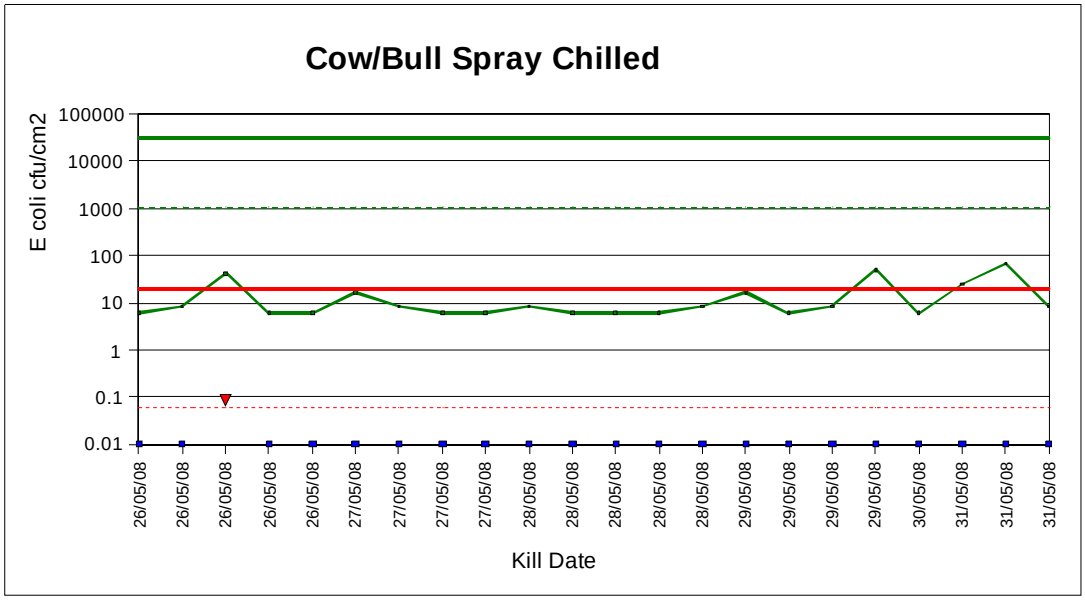


Figure 5. ESAM results for Spray Chilled Cow/Bull trial in May

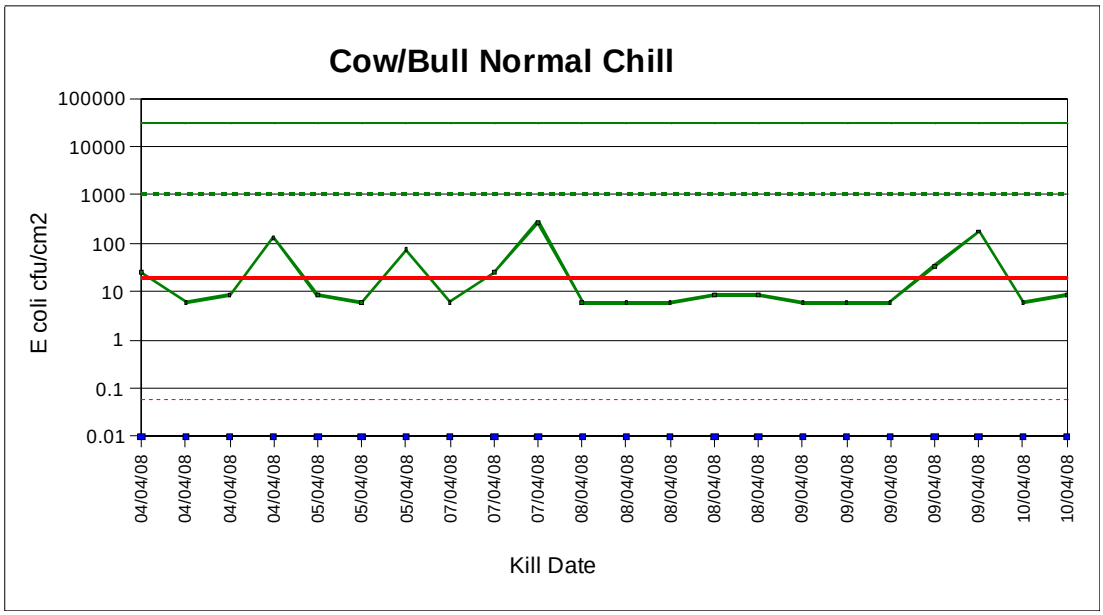


Figure 6. ESAM results for Cow/Bull in April

10.2 Appendix 2 – Shelf life comparison between spray chilled carcasses and conventionally chilled carcasses

Shelf Life Test

While the impact of spray chilling has been tested over the carcass chilling process, further tests on the bacterial growth after packaging have been conducted. For this purpose a shelf life test was conducted. Spray Chilling results are in Table 1. Results from a shelf life test conducted on conventionally chilled carcasses can be seen in Table 2.

Table 1. Shelf Life results for 12hr Spray Chilling

Lab Sample no.	Sample Details					Organoleptic / Chemical Results			TPC	*E. coli*	Coliforms	*S. aureus*
	Date Sampled	Date Tested	Date Read	Age (days)	Cut	Meat colour	pH	Odour	Result cfu/g	Result cfu/g	Result cfu/g	Result cfu/g
SL08-1R	13/06/08	14/06/08	16/06/08	0	Topside (8505)	2	5.50	fresh	4,700	<10	<10	<10
SL08-2R						2	5.60	fresh	400	<10	<10	<10
SL08-3R						1C	5.73	fresh	4,000	<10	<10	<10
SL08-4R					Blade (8509)	3	5.58	fresh	1,900	<10	<10	<10
SL08-5R						3	5.80	fresh	5,800	<10	<10	<10
SL08-6R						3	5.50	fresh	200	<10	<10	<10
SL08-7R					Rump (8021)	1 c	5.80	fresh	<100	<10	<10	<10
SL08-8R						1 c	5.90	fresh	400	<10	<10	<10
SL08-9R						1 c	5.60	fresh	2,800	<10	<10	<10
SL08-10R	22/09/08	23/09/08 1300 AC	25/09/08 1200 RC	101	Topside (8505)	2	5.44	ok	60000	<10	<10	n/a
SL08-11R						3	5.47	ok	12000	<10	<10	n/a
SL08-12R						1C	5.46	ok	120000	<10	<10	n/a
SL08-13R					Blade (8509)	1C	5.75	fresh	28000	<10	<10	n/a
SL08-14R						1C	5.84	fresh	560,000	<10	<10	n/a
SL08-15R						3	5.75	fresh	180,000	<10	<10	n/a
SL08-16R					Rump (8021)	1B	5.71	fresh	110,000	<10	<10	n/a
SL08-17R						1B	5.67	fresh	60,000	<10	<10	n/a
SL08-18R						1C	5.67	fresh	2,000,000	<10	<10	n/a
SL08-19R		02/10/08 1900 SH		110	Topside (8505)	2	5.65	ok	92,000,000	<10	<10	n/a
SL08-20R						2	5.63	ok	28,000,000	<10	<10	n/a
SL08-21R						1C	5.52	ok	11,700,000	<10	<10	n/a
SL08-22R					Blade (8509)	2	5.85	ok	52,000,000	<10	<10	n/a
SL08-23R						2	5.74	ok	40,000,000	<10	<10	n/a
SL08-24R						1C	5.77	ok	16,000,000	<10	<10	n/a
SL08-25R					Rump (8021)	1B	5.74	ok	124,000	<10	<10	n/a
SL08-26R						2	5.65	ok	6,200,000	<10	<10	n/a
SL08-27R						2	5.66	ok	7,400,000	<10	<10	n/a
SL08-28R		14/10/08 1100 AC		120	Topside (8505)	1C	5.56	ok	8,800,000	10^{-1} 0	<10	<10	n/a
SL08-29R						1C	5.74	fresh	14,000,000	10^{-1} 0	<10	<10	n/a
SL08-30R						1C	5.49	fresh	5,900,000	10^{-1} 0	<10	<10	n/a
SL08-31R					Blade (8509)	1B	5.98	ok	3,300,000	10^{-1} 0	<10	<10	n/a
SL08-32R						1C	5.88	ok	4,900,000	10^{-1} 0	<10	<10	n/a
SL08-33R						1C	6.00	fresh	10,000,000	10^{-1} 0	<10	<10	n/a
SL08-34R					Rump (8021)	1C	5.54	fresh	12,000,000	10^{-1} 0	<10	120	n/a
SL08-35R						1C	5.64	ok	14,000,000	10^{-1} 0	<10	30	n/a
SL08-36R						1C	5.72	ok	16,000,000	10^{-1} 0	<10	<10	n/a

Table 2. Shelf Life results from Conventionally Chilled carcasses

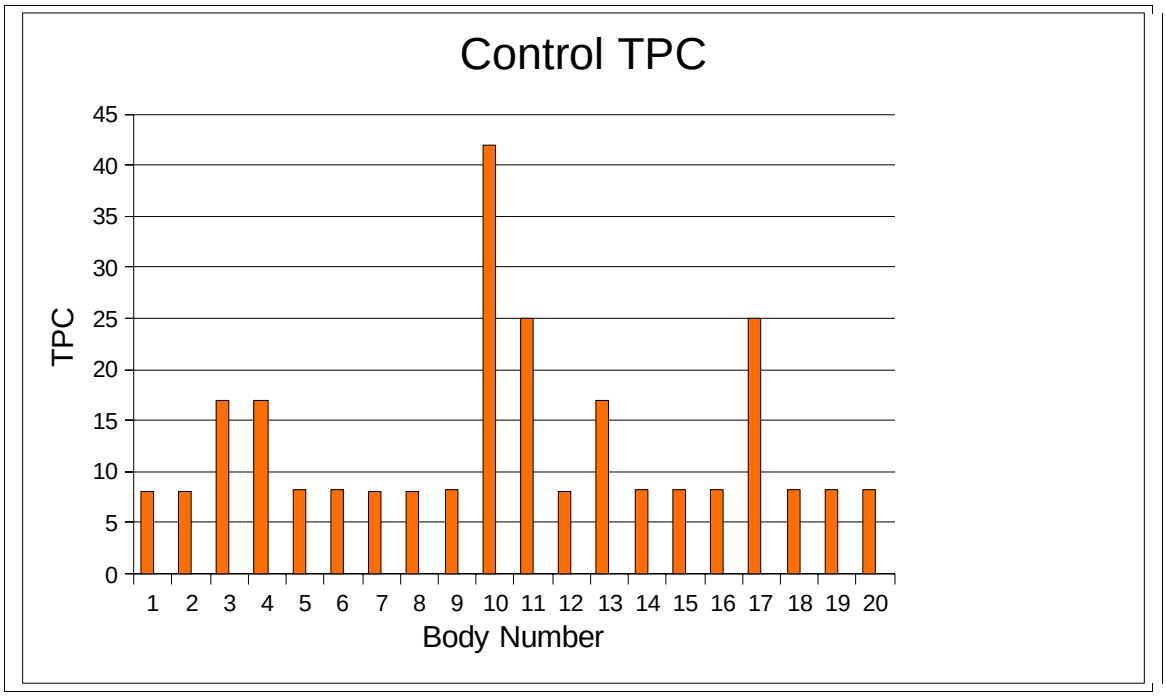
Lab Sample no.	Sample Details					Organoleptic / Chemical Results			TPC	*E. coli*	Coliforms	*S. aureus*
	Date Sampled	Date Tested	Date Read	Age (days)	Cut	Meat colour	pH	Odour	Result cfu/g	Result cfu/g	Result cfu/g	Result cfu/g
SL08-1R	09/04/08	10/04/08	12/04/08	0	Topside (S-INSCO)	1C	5.48	fresh	300	<10	<10	<10
SL08-2R						2	5.40	fresh	200	<10	<10	<10
SL08-3R						1C	5.5	fresh	12,000	<10	<10	<10
SL08-4R					Blade Oyster (3720 3719)	1C	5.48	fresh	100	<10	<10	<10
SL08-5R						2	5.50	fresh	400	<10	<10	<10
SL08-6R						2	5.48	OK	<100	<10	<10	<10
SL08-7R	17/07/08	18/07/08	20/07/08	100	Topside (S-INSCO)	1B	5.77	OK	2,600,000	<10	<10	<10
SL08-8R						2	5.76	OK	35,000	<10	20	<10
SL08-9R						1C	5.78	OK	150,000	<10	490	<10
SL08-10R					Blade Oyster (3720 3719)	2	5.73	fresh	2,600,000	<10	<10	<10
SL08-11R						2	5.76	fresh	160,000	<10	<10	<10
SL08-12R						1C	5.79	fresh	5,400,000	<10	<10	<10
SL08-13R	07/08/08	08/08/08	10/08/08	120	Topside (S-INSCO)	2	5.77	OK	15,000,000	<10	160	n/a
SL08-14R						2	5.79	OK	36,000,000	<10	<10	n/a
SL08-15R						1C	5.56	OK	200,000	<10	<10	n/a
SL08-16R					Blade Oyster (3720 3719)	1C	5.88	fresh	25,000,000	<10	<10	n/a
SL08-17R						1C	5.87	fresh	23,000,000	<10	<10	n/a
SL08-18R						1C	5.90	OK	14,000,000	<10	<10	n/a

10.3 Appendix 3 – Microbiology results and pH declines for modifications for spray chilling operation

Report Detailing Spray Chilling Modifications and their Verification

Before changes to the regime were applied, a control test was conducted to establish TPC and pH declines as a comparison to results recorded after changes were applied. The control results for TPC are displayed in Figure 1.

Figure 1: Control TPC. Recorded in Hot Marshalling Area



Control pH declines are illustrated in Figure 2.

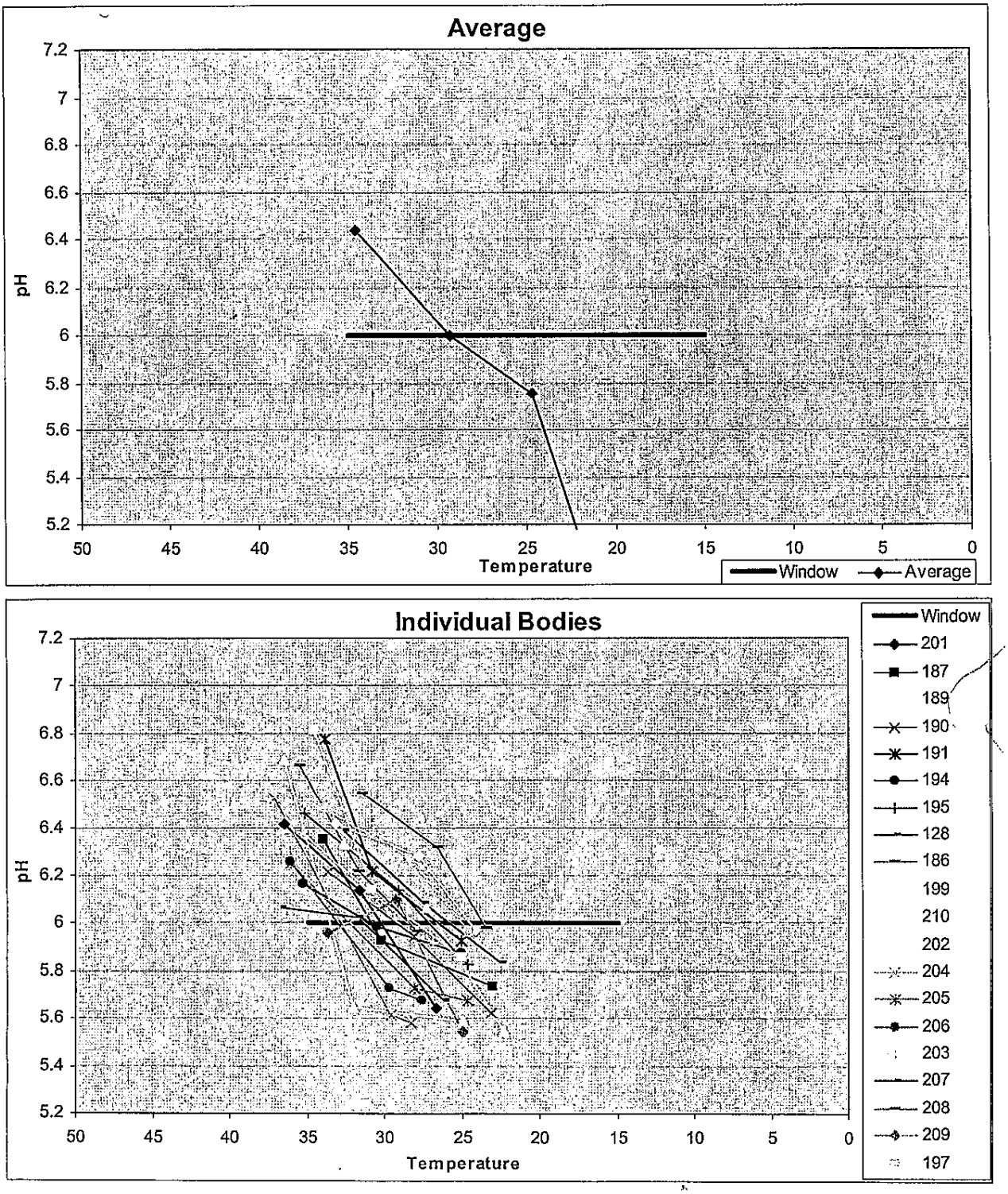


Figure 2: Control pH Declines