Final report

Financial implications of using Rinse & Chill® at a dual species plant – OTH v owned animals

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Abstract

Red meat processing plants are unsure of the precise financial benefits per carcase type when using Rinse & Chill® Technology (RCT) from MPSC. Processors pay MPSC a fee per head, therefore processors apply RCT to the stock they own, however, for over the hooks (OTH) purchases, processing plants often choose not to rinse as they pay a rinse fee to MPSC and pay to producers the hot standard carcase weight (HSCW) gain. The purpose of this project was to calculate the lost meat revenue to the supply chain due to consigned OTH animals not being rinsed using data from processing plants.

The research trials undertaken identified and calculated the value proposition by animal type for lamb, mutton, light and heavy beef carcases (Angus and Angus cross). The loss in industry value due to existing MPSC customers in Australia not rinsing due to OTH purchases was calculated and estimated at $10.8 Million per year based on 2023 data (notwithstanding the need for market acceptance for RCT).

Further research is needed to quantify and validate by animal type the impact of using RCT®. Further research is needed with the proposed data points of dead weight, pre and post rinse weights to validate the calibration to create an OTH trim adjustment. It is envisaged that an OTH AUS-MEAT trim adjustment is required for the use of RCT for processing plants to apply RCT to both owned and OTH purchases. This would create a recognised mechanism to unlock value capture back to producers.

Executive summary

Background

Red meat processing plants are unsure of the precise return on investment (ROI) benefits per carcase type when using Rinse & Chill® technology (RCT) from MPSC. Processors pay MPSC a fee per head, therefore processors apply RCT to the stock they own for example saleyard purchases, however, for over the hooks (OTH) purchases, processing plants often choose not to rinse as they pay a rinse fee to MPSC and pay the hot standard carcase weight (HSCW) gain from using RCT to producers. The purpose of this project was to calculate the financial implications for processors and for industry of using RCT® for lamb, mutton and beef cattle comparing OTH to processor owned animals.

Industry is interested to understand the value lost because of OTH animals not being rinsed. The data required to quantify the impact at an individual carcase level was mapped to facilitate the development of a process and program to obtain a possible AUS-MEAT accredited OTH trim adjustment for the yield impact individualised for each carcase.

Objectives

The project objectives were to:

1. Independently validate the financial implications of using RCT for beef and sheep producers and processors for a range of carcase types.

2. Address the following barriers identified by Australian processing plants:
• ROI for use of RCT on OTH purchases
• ROI for use in own stock with sensitivity analysis on product prices including sale of offals.

3. Documentation of additional value propositions as a result of using RCT

4. Scoping of trial methodology and design taking into account data points + rigour required to gain potential AUS-MEAT approved trim adjustment for use of RCT

The project objectives were achieved. It was anticipated pre-implementation that historical processing plant boning room data could be accessed however a change in the way cuts were recorded in the system meant this wasn't possible.

Methodology

Controlled research trials were conducted on 1000 mutton and 220 Angus and Augus cross to quantify yield and temperature changes measuring carcases, liver and hearts comparing with and without the use of RCT. Interviews with key staff were undertaken at processing plants where RCT is currently installed. Financial implications of using RCT on OTH and own stock were calculated per animal type where data has been collected in scientific research trials and for plants with RCT installed.

Results/key findings

Rinsed mutton hearts and livers were on average 28 and 47 grams heavier respectively equating to $0.28 value gain per animal. Averaged hot carcase weight increased by 0.98% for the rinsed group valued at $3.18 per carcase. There was no significant difference in carcase temperatures measured on the shoulder. The rinsed mutton hearts surface temperature averaged 7.3°C colder and the rinsed livers were on average 2.4°C lower than the control. Overall supply chain benefit was calculated at $5.52 per animal for mutton dressing at 24 kilograms.

In the trials undertaken with Angus cross heifers and steers, the dressing percentage increase for rinsed carcases varied based on carcase type ranging from 3.58% for heavy cattle to 1.57% for young steers and heifers. The heavier rinsed cattle heart was 960 grams heavier (average of 2.19 kg verses 3.15kg), with an increase in value of $8.64. The total supply chain benefit per head for heavy cattle was $166.44 and for light cattle $61.06. Limited liver data was collected with 1.82 kg (31.9%) increase between rinsed and control groups. The rinsed heart surface temperature on the evisceration table was on average 8°C cooler and the livers were 5°C cooler.

Based on the current installations of RCT® in Australia, the lost opportunity due to plants not rinsing OTH livestock is over $10 million per annum (notwithstanding the need for market acceptance for RCT).

Benefits to industry

The research has quantified the value of RCT for 2 beef carcase types, identified additional value propositions and documented the proposed data points required for individual OTH carcase trim adjustment with further research and verification required.

Future research and recommendations

This research identified there was a variation between vendors and carcase types in the uptake pre scales. Further research is required to develop a system to allow individualised measurements and calculation of impact of RCT at an individual carcase. Future research is required to test and validate the proposed data points on the chain including dead weight, pre rinse weight, post rinse weight, rinse volume and hot carcase weight to develop a system for a potential Aus-Meat accredited OTH trim adjustment.

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1. Background

Rinse & Chill® Technology (RCT) is an approved processing aid which uses the animal's circulatory system to flush blood out of the hot carcase using a chilled isotonic solution. The rinse volume of the chilled solution is individually calibrated based on the animal's weight. The chilled rinse solution flows out via circulatory system while on the chain or is metabolised by the muscles pre rigour. A rigorous USDA testing program concluded there were no detectable residues of RCT in the final product (Hwang et al. 2022).

Red meat processing plants are unsure of the precise return on investment (ROI) benefits per carcase type when using RCT. Processors pay MPSC a per head rinse fee, therefore processors apply RCT to the stock they own for example bought in the saleyards, however, for over the hooks (OTH) purchases, processing plants often choose not to rinse as they pay a rinse fee to MPSC and additionally pay the hot standard carcase weight (HSCW) increase from using RCT to producers. The purpose of this project was to calculate the financial implications for processors and for industry of using RCT for lamb, mutton and beef cattle comparing OTH to processor owned animals.

Industry is interested to understand the value lost because of OTH animals not being rinsed. The data required to quantify the yield gain at an individual carcase level was mapped with the view to starting the process to obtain an AUS-MEAT accredited OTH trim adjustment for the yield gain individualised for each carcase.

RCT is utilised in the United States of America specifically in grinding beef and bison processing plants with colour (Kethavath et al. 2022) and eating quality improvements (Yancy et al. 2002) being recorded. The Australian red meat industry is predominantly focused on high quality products. There is evidence that RCT provides additional value propositions (Li, Warner & Ha 2023) with anecdotal and unpublished research on improved boning room efficiencies, increased saleable meat yield and reduced cooling requirements for offal.

As of June 2024, RCT® was installed in eight processing plants in Australia. Major and minor Tier 1 and Tier 2 meat processing companies have expressed interest in using RCT®, however there are a range of barriers to widespread industry adoption in higher quality market channels which need addressing. These barriers include (1) ability of the rinser to align with processing chain speed and (2) footprint size for lamb plants and (3) processing plants understanding the financial ROI for different carcase types and OTH purchases.

2. Objectives

The project objectives were to:

1. Independently validate the financial implications of using RCT ® for beef and sheep producers and processors for a range of carcase types.

2. Address the following barriers identified by Australian processing plants:
• ROI for use of RCT® on OTH purchases
• ROI for use in own stock with sensitivity analysis on product prices including sale of offals.

3. Documentation of additional value propositions as a result of using RCT ®

4. Scoping of trial methodology and design taking into account data points and rigour required to gain potential AUS-MEAT approved trim adjustment for use of RCT®

The project objectives were achieved. It was anticipated pre-implementation that historical processing plant boning room data could be accessed however a change in the way cuts were recorded in the system meant this wasn't possible.

3. Methodology

Controlled research trials were undertaken in sheep and beef processing facilities which had RCT® installed, with MPSC and Greenleaf Enterprises representatives measuring offal weights and surface temperatures. Based on the data collected during the trials as well as raw data collected in Australia by Wilesmith, Fowler & Rutley (2022) for lambs (RC n=697, Control n=702) and Rutley (202) for Wagyu cows (RC n=85, Control n=83), the value proposition for individual carcase types, plant and industry was calculated and modelled by Greenleaf Enterprises.

3.1Onsite data collection

3.1.1 Sheep trial

A trial was planned for a mutton processing plant which had RCT installed and who agreed to share current and historical plant HSCW and carton data with Greenleaf to enable the value proposition analysis.

On the 20th of February 2024 a mob of 1183 sheep arrived at the processing plant. The first 499 were rinsed and the second 501 were the control animals in a research trial conducted onsite with MPSC and Greenleaf. Each body as part of the trial was:

1. Weighed manually using an inline way scale post rinsing
2. Tagged with a number post rinse

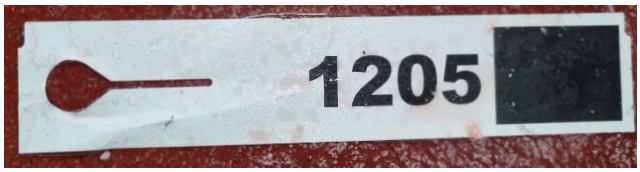

Figure 1: Tag for rinsed carcases

3. Tagged if missed rinse, incomplete rinse or on the retain rail

Figure 2: Tag for carcases on the retain rail

4. Rinse tag number was recorded at the hot carcase scale to map the order of flow of animals in the chain

A sample of hearts (control n=173, rinse n=222) and livers (control n= 112, rinse n=104) were weighed individually.

Offal surface temperature using an infrared thermometer (FLUS IR-865U) were recorded for livers (control n=480, rinsed n=474) and hearts for rinsed (n=391) and control (n=367).

Data analysis was undertaken using processing plant data and collected data.

3.1.2 Beef trial

A trial was undertaken at an MSA registered plant over three days on the 26th, 27th and 28th of March 2024 with a total of 221 carcases involved in the trial. 109 were rinsed and 112 were in the control groups. Six separate mobs of Angus and Angus cross steers and heifers were selected to participate in the research trial based on the visual uniformity within the group (consigned mob).

Table 1: Beef trial replicates by carcase type (vendor) at MSA registered plant

Trial date	Number Rinsed	Number Control	Total
26/03/2024	9	9	18
26/03/2024	10	10	20
27/03/2024	8	9	17
27/03/2024	10	10	20
27/03/2024	32	33	65
28/03/2024	25	25	50

Carcases selected to be used in the trial were tagged with sequential numbers. Carcases which were directed to the retain rail were tagged with a different tag to then exclude the carcase from the data analysis.

Temperature loggers: 22 carcase temperature loggers and 2 environmental temperature loggers were used on the 26th and 27th of March 2024 to measure deep butt temperature of 11 rinsed and 11 control carcases from chiller entry over a 16-hour period. Data was collected by MPSC and analysed by Greenleaf Enterprises.

Offal and byproduct weights were recorded including heart, liver, skirt and tail. The heart and liver surface temperatures were recorded using an infrared thermometer (FLUS IR-865U). Hot Standard Carcase Weights (HSCW) were provided to Greenleaf from the processing plant for value proposition analysis.

Beef	Control	Rinse	Total
Heart	65	62	127
Kidney	65	62	
Liver			
Skirt	27	25	52
Tongues	39	40	79

3.2Financial Analysis

The financial analysis undertaken to determine the value propositions per plant by animal type (sheep and beef) and for the industry were considered from a carcase perspective for 6way mutton, red meat value for beef, offal for sheep and beef and processing plant throughput.

3.2.1 Sheep carcase value calculations

The unrealised return (value) for producers by processors not rinsing over the hooks purchased animals due to inability to apply a trim adjustment was calculated using the average price for lamb and mutton per year from the National Livestock Reporting Service shown in Figure 3.

Sheep & Mutton prices

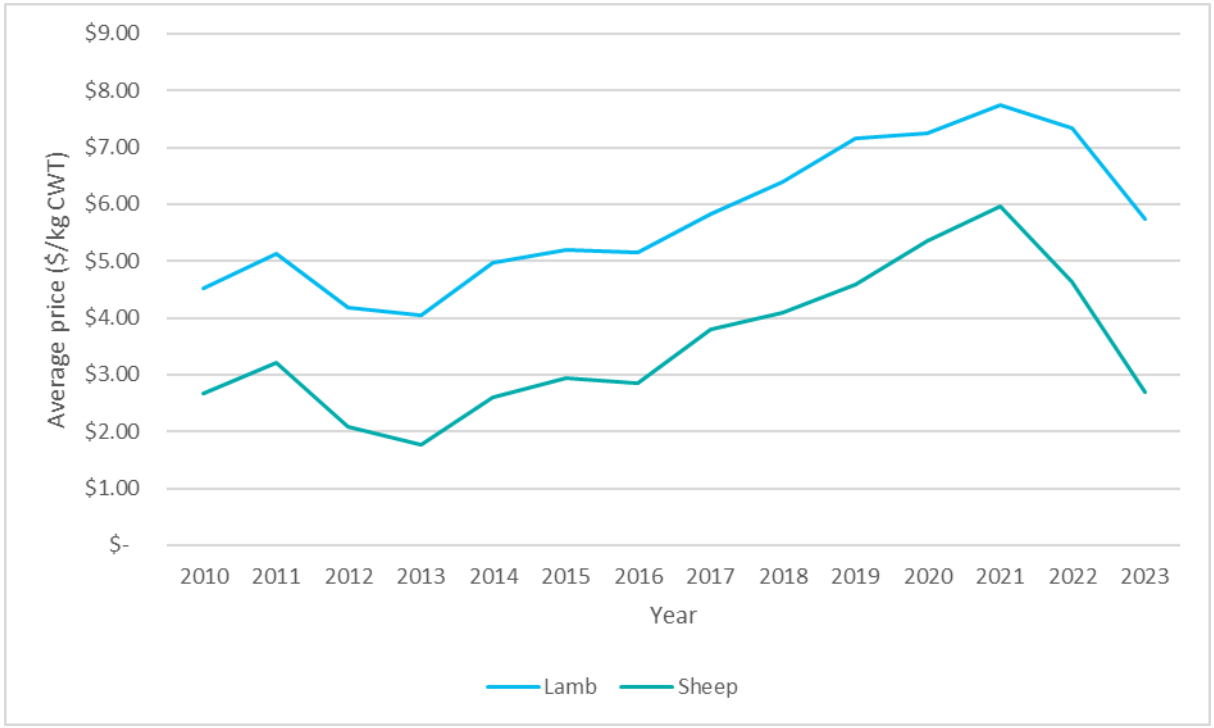

Figure 3: Sheep and lamb average yearly prices for Eastern States

Source: National Livestock Reporting Service

Beef carcase grids

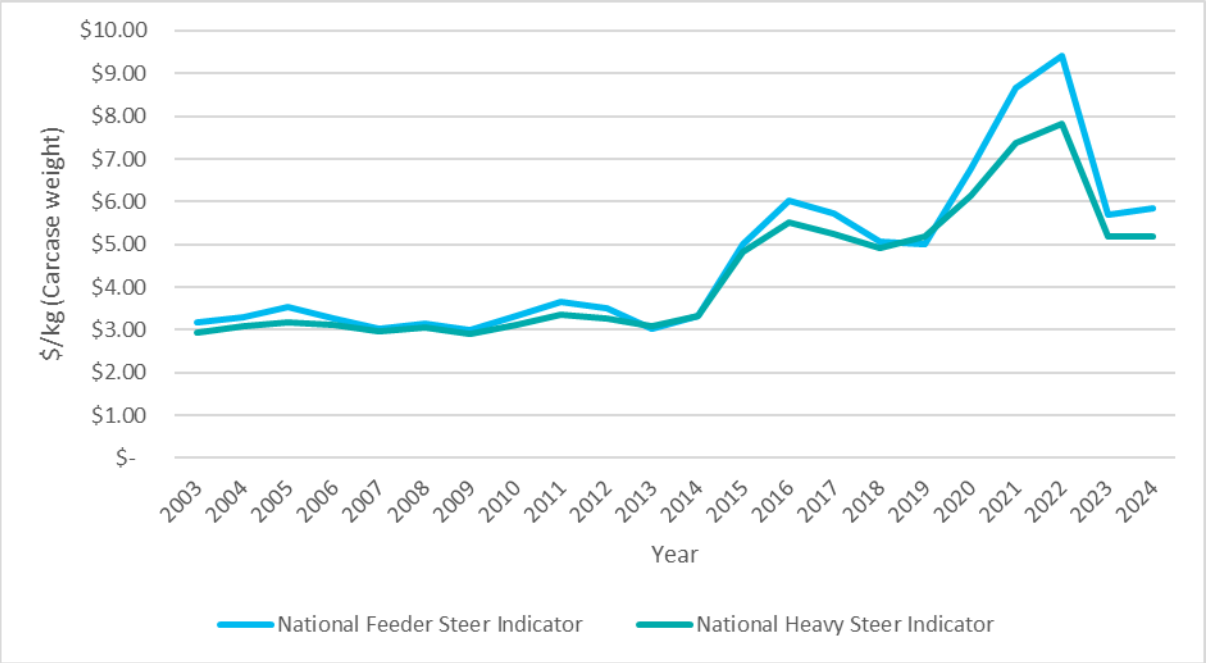

Figure 4: Average cattle prices $/kg over the hook by type

Source: National Livestock Reporting Service

The livestock carcase payment grids which livestock are purchased using will impact the value propositions and costs associated with animals purchased over the hooks by the processors. The beef grids are more complex than the grids for sheep and lamb. Figure 5 is an example of a beef grid which was publicly available. The following variables need to be considered in the value to producers and processor from the utilisation of RCT® in beef plants:

- Teys Wagga Wagga (Figure 5) variables in grid which are affected by the Rinse and Chill application:
  - Boning groups
  - Meat colour
  - Weight

GRASS FED	GRASSLANDS		ANGUS	MSA STEER	STEERS						
BONING GROUPS	1 – 4	5 – 8	1 – 8	1 – 8	YG S	YP S	PR S	S	S1	S2	S3
TEETH	0-4	0-4	0-4	0-4	0-2	0-4	0-6	0-8	0-6	0-8	0-8
FAT	5-22	5-22	5-22	5-22	5-22	5-22	5-22	5-22	3-22	3-22	0-22
FAT PENALTIES	Fat penalties apply over 22mm										
BRUISING	NIL	NIL	NIL	NIL	0-6	0-6	0-6	0-6	0-6	0-6	0-9
MEAT COLOUR	1A - 4	1A - 4	1A - 4	1A - 4	1A - 4	1A - 4	1A – 4	1A – 5	ANY	ANY	ANY
FAT COLOUR	0-4	0-4	0-3	0-3	0-3	0-3	0-4	0-5	ANY	ANY	ANY
WEIGHT	240-420	240-420	160-360	160-360	160-420	240-420	240-420	240-420	160-440	160-480	ANY
WEIGHT	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**
360+	PREMIUM PRICES CONTACT YOUR NEAREST TEYS BUYER				700	695	690	660	650	640	630
340-360					700	695	690	660	650	640	630
320-340					700	695	690	660	650	640	630
300-320					700	695	690	660	650	640	630
280-300					695	690	685	655	645	635	625
260-280					690	685	680	650	640	630	620
240-260					685	680	675	645	635	625	615
220-240					680	-	-	-	630	620	610
200-220					675	-	-	-	625	615	605
180-200					670	-	-	-	600	590	580
160-180					655	-	-	-	590	580	570
140-160					-	-	-	-	-	-	490
120-140					-	-	-	-	-	-	470
100-120					-	-	-	-	-	-	450
< 100					-	-	-	-	-	-	440

	GRASSLANDS		ANGUS	MSA HEIFER	HEIFERS			COWS				
								MSA COW	2ND	3RD	4TH	5TH
BONING GROUPS	1 – 4	5 – 8	1 – 8	1 – 8	YG H	YP H	PR H	1 – 8	C&H	C&H	C&H	C&H
TEETH	0-4	0-4	0-4	0-4	0-2	0-4	0-7	0-8	0-8	0-8	0-8	0-8
FAT	5-22	5-22	5-22	5-22	5-22	5-22	5-22	3-32	3-12	13-22	3-32	0-32
FAT PENALTIES	Fat penalties apply over 22mm							Fat Penalties apply over 33mm on MSA Cow & 4th C&H				
BRUISING	NIL	NIL	NIL	NIL	0-6	0-6	0-6	NIL	NIL	NIL	0-6	ANY
MEAT COLOUR	1A - 4	1A - 4	1A - 4	1A - 4	1A - 4	1A - 4	1A - 4	1B - 4	1A – 5	1A – 5	1A – 5	ANY
FAT COLOUR	0-4	0-4	0-3	0-3	0-3	0-3	0-4	0-4	0-5	0-5	0-5	ANY
WEIGHT	240-420	240-420	160-360	160-360	160-420	160+	160+	180-420	160+	160+	160+	ANY
WEIGHT	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**	**PRICE**
360+	PREMIUM PRICES CONTACT YOUR NEAREST TEYS BUYER				695	690	685	CONTACT YOUR NEAREST TEYS BUYER	620	615	610	590
340-360					695	690	685		620	615	610	590
320-340					695	690	685		620	615	610	590
300-320					695	690	685		620	615	610	590
280-300					690	685	680		615	610	605	585
260-280					685	680	675		610	605	600	580
240-260					680	675	670		605	600	595	575
220-240					675	665	650		590	585	580	560
200-220					670	655	640		585	580	575	555
180-200					665	640	625		560	555	550	530
160-180					650	620	605		475	470	465	445
140-160					-	-	-		-	-	-	410
120-140					-	-	-		-	-	-	390
100-120					-	-	-		-	-	-	390
< 100					-	-	-		-	-	-	390

Figure 5: Sample beef carcase grid from which price per kilogram for the carcase is calculated

Source: https://au.teysgroup.com/wp-content/uploads/2021/05/011-21-WAGGA-GRASS-p.pdf

Meat Colour Benefit:

The first step of the calculation is to identify for every carcase – what is the change. Once this has been completed the price differences between each grade is applied. The following is an example:

- A YG steer has graded correctly for all carcase traits except for meat colour which it has presented a meat colour 6. The following discount is applied to the animal.
    - 320kg YG steer (meat colour between 1A & 4) price = $7.00
    - 320 kg steer with a meat colour of 6 is downgraded to a S1, which is prices at $6.50.
    - Price differential between the animals is $7.00 – $6.50 = $0.50/kg discount.
    - Overall cost of the dark cutter = $160/head cost to the producer for supplying the animal.
- Every carcase requires the above calculation completed for them for the rinsed and non-rinsed animals. The cost of the meat colour change will then be summed and divided by the total number of carcases processed. The discounts to be imposed on these all-steer carcases are listing in Table 3.
- This benefit will all be attributed to the producer by the processer will gain an increase in boxed meat value per kilogram for the carcases when boned. These calculations are identified later in this section of the report.

Table 2: Traits which impact of the quality grade of animals based on Figure 5

CARCASE TRAIT	YG S	YP S	PR S	S	S1	S2	S3
TEETH	0-2	0-4	0-6	0-8	0-6	0-8	0-8
FAT	5-22	5-22	5-22	5-22	3-22	3-22	0-22
BRUSING	0-6	0-6	0-6	0-6	0-6	0-6	0-9
MEAT COLOUR	1A-4	1A-4	1A-4	1A-5	ANY	ANY	ANY
FAT COLOUR	0-3	0-3	0-4	0-5	ANY	ANY	ANY
WEIGHT	160-420	240-420	240-420	240-420	160-440	160-440	ANY

Table 3: Discounts imposed resulting from a meat colour change

MEAT COLOUR	START GRADE	END GRADE	DISCOUNT ($/KG)
1A TO 4.		No Change	
5	YG S	S	$0.40
	YP S	S	$0.35
	PR S	S	$0.30
6	YG S	S1	$0.50
	YP S	S1	$0.45
	PR S	S1	$0.40
	S	S2	$0.10

3.2.2 Red meat value calculations

Increased saleable meat from carcases; the result of having a higher weight per carcase packed and the increase in value of cuts due to the increase in value from meat colour change. The following section outlines the variables which were included in the value created for boning rooms by processing rinsed animals.

- **Increase weight of boxed meat** is a result of:
    - **Heavier carcases** entering the boning room results in an increase in weight of product packed. The value creation is the difference in value of purchasing carcasses (based on HSCW) and the weight of product packed through the boning room utilising a standard boning yield from non-rinsed animals.
    - **Increase boning room yields** due to an increase in weight per cut as a result of carcases being easier to bone.

Increase value of boxed meat considers the individual products which are being produced through the boning room and where there is a value differential between cuts for different meat colour grades. Typically, these will be specific to individual primals and will not always be realised. This analysis will be specific to beef animal types.

Figure 6 showing the lamb and mutton average export sale price per kilogram for lamb and mutton will be used when calculating the value propositions in relation to increase in volume (weight) of boxed sheep meat as an impact of RCT.

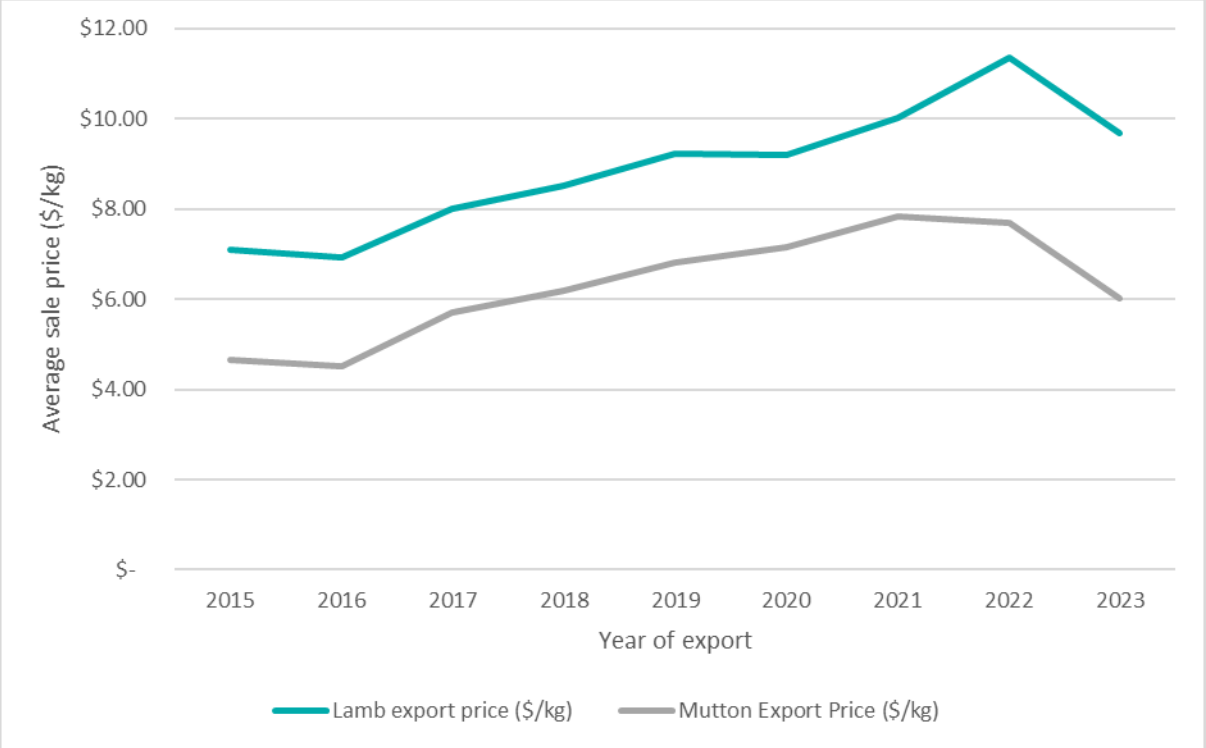

Figure 6: Average annual export price for sheep and lamb products

Source: Comtrade

3.2.3 Offal

The offal prices used in the analysis were sourced from the National Livestock Reporting Service.

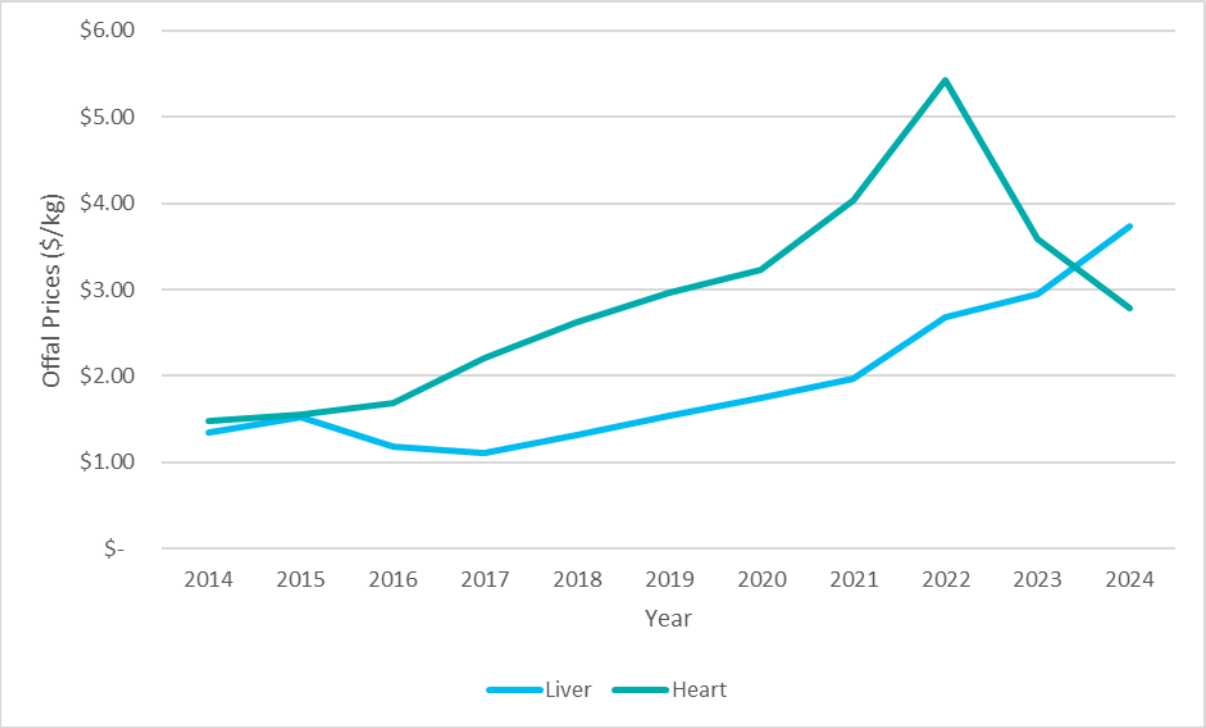

Figure 7: Average offal prices for sheep heart and liver

Source: National Livestock Reporting Service

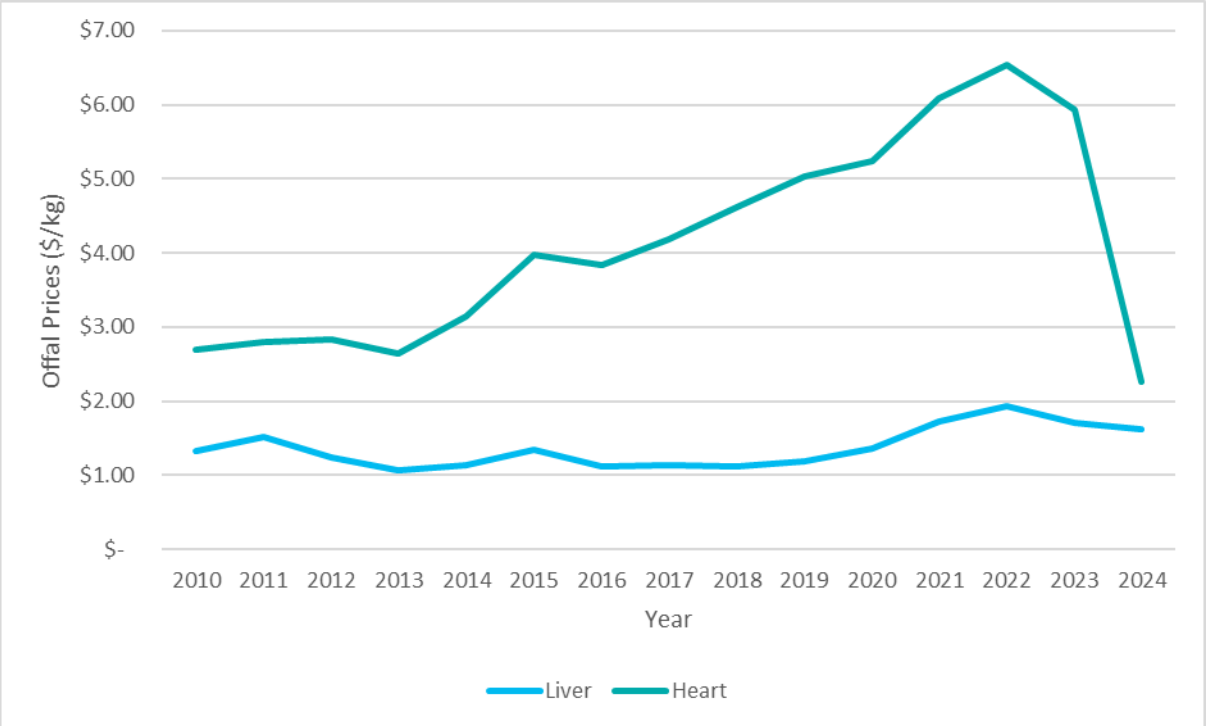

Figure 8: Average offal prices for beef heart and liver

Source: National Livestock Reporting Service

3.2.4 Throughput

Cost per kilogram boned: the boning room analysis methods outlined will provide the platform for this analysis to show the volume (both number of carcases and kilograms boned) processed by the boning room as well as the percentage rinsed. To calculate throughput this is then matched with the labour units and positions in the boning room on a particular day. The number of full-time equivalents (FTEs) in the room will be used to show the overall cost of operating the room and divide this cost by the number of carcases processed and the kilograms boned.

4. Results

4.1 Sheep trial results

4.1.1 Sheep carcase yield

Analysis of the data collected at the research trials show an increased dressing percentage of 0.95% for the rinsed carcases over the control. The first 500 animals in the mob were rinsed and the second 500 in the mob were regarded as the control. The first 500 animals were on average 2.9 kilograms heavier when live and 2.6 kilograms heavier over the Hot Standard Carcase Weight scales. The distribution of liveweight between the control and rinsed groups is shown in Figure 9.

Table 4: Mutton liveweight, HSCW and dressing percentage for rinsed and control groups

Live weight (kg)	**Control**	**Rinsed**	**Difference**
Mean	44.81	47.69	2.88
Max	81.80	77.20	
Min	24.20	21.30	
N	501	499	
HSCW (kg)			
Mean	22.62	25.24	2.62
Max	42.00	46.40	
Min	11.20	9.40	
N	371	419	
Dressing %			
Mean	51%	52%	0.95%
Max	70%	70%	
Min	35%	35%	
N	259	343	

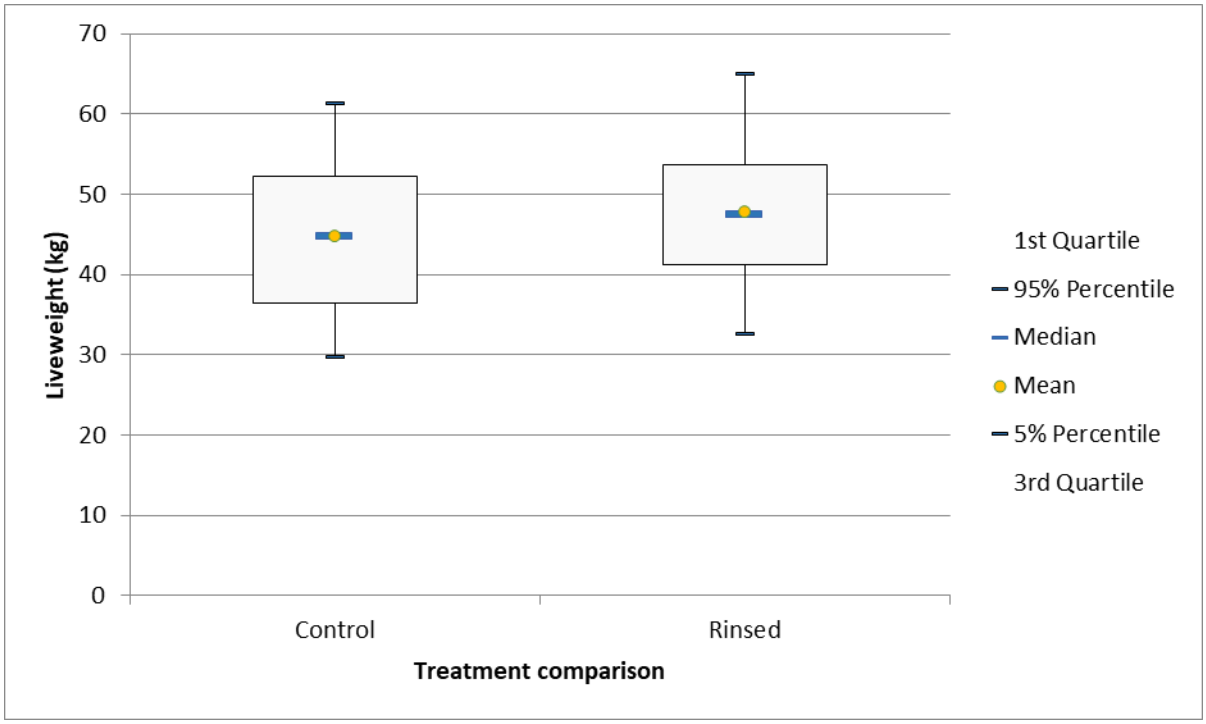

Figure 9: Live weight distribution

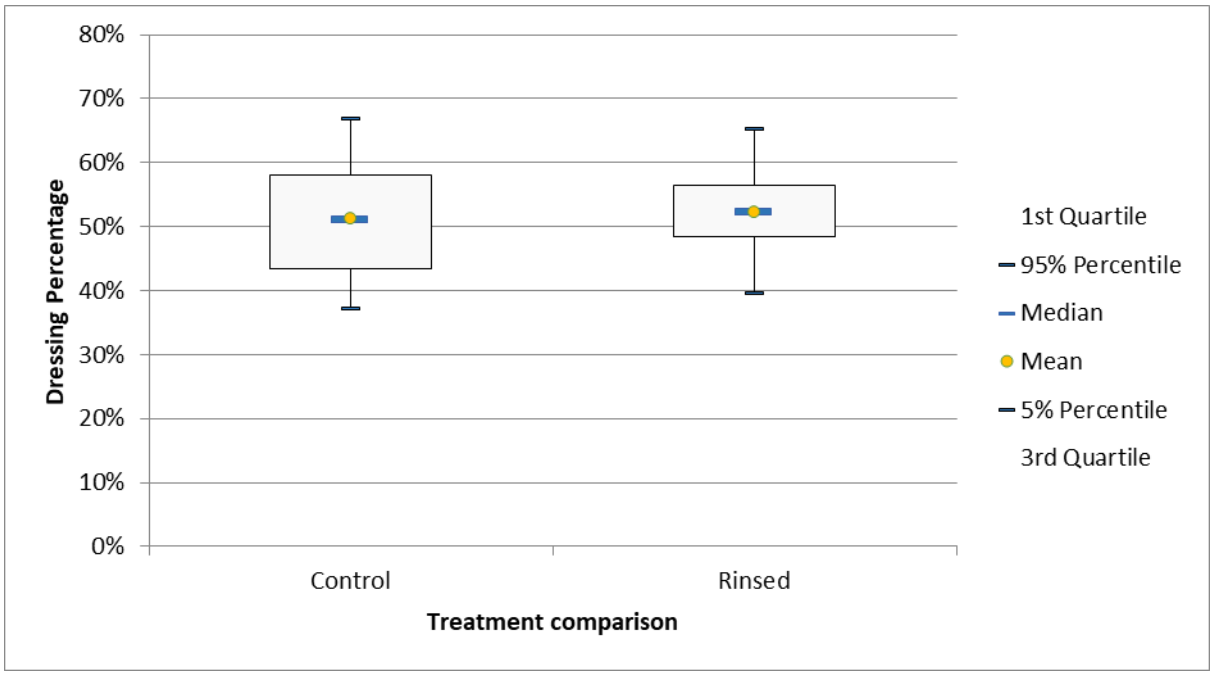

Figure 10: Carcase dressing percentage distribution for sheep carcases

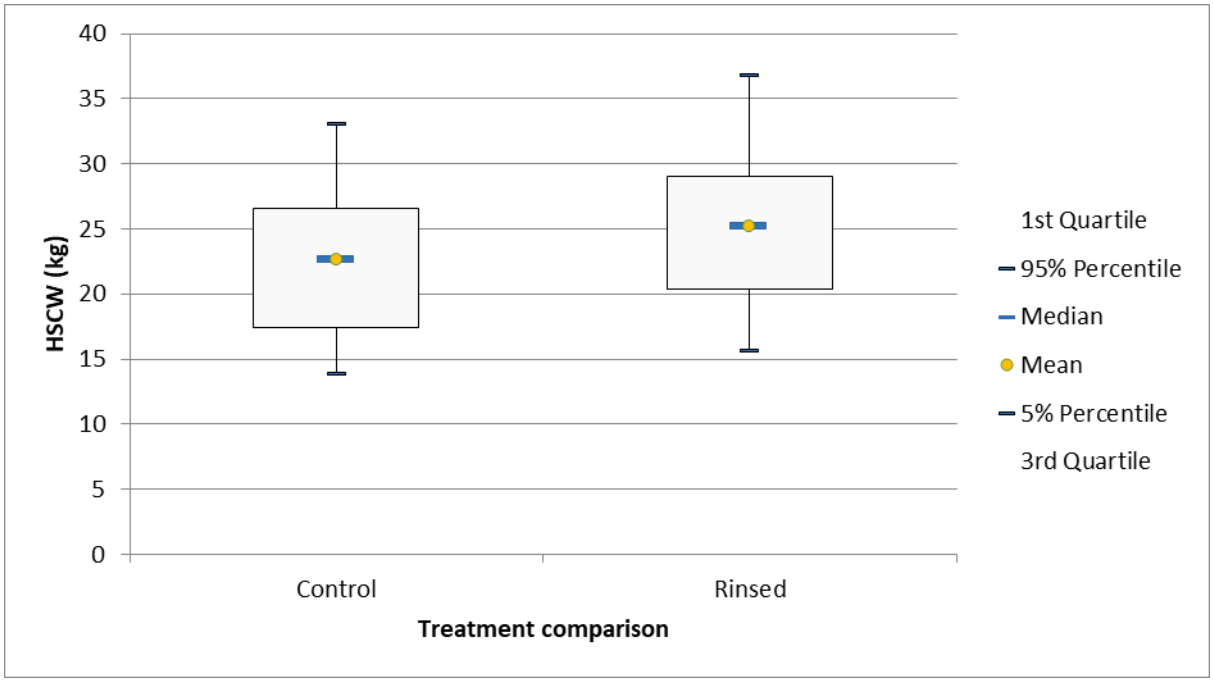

Figure 11: HSCW distribution

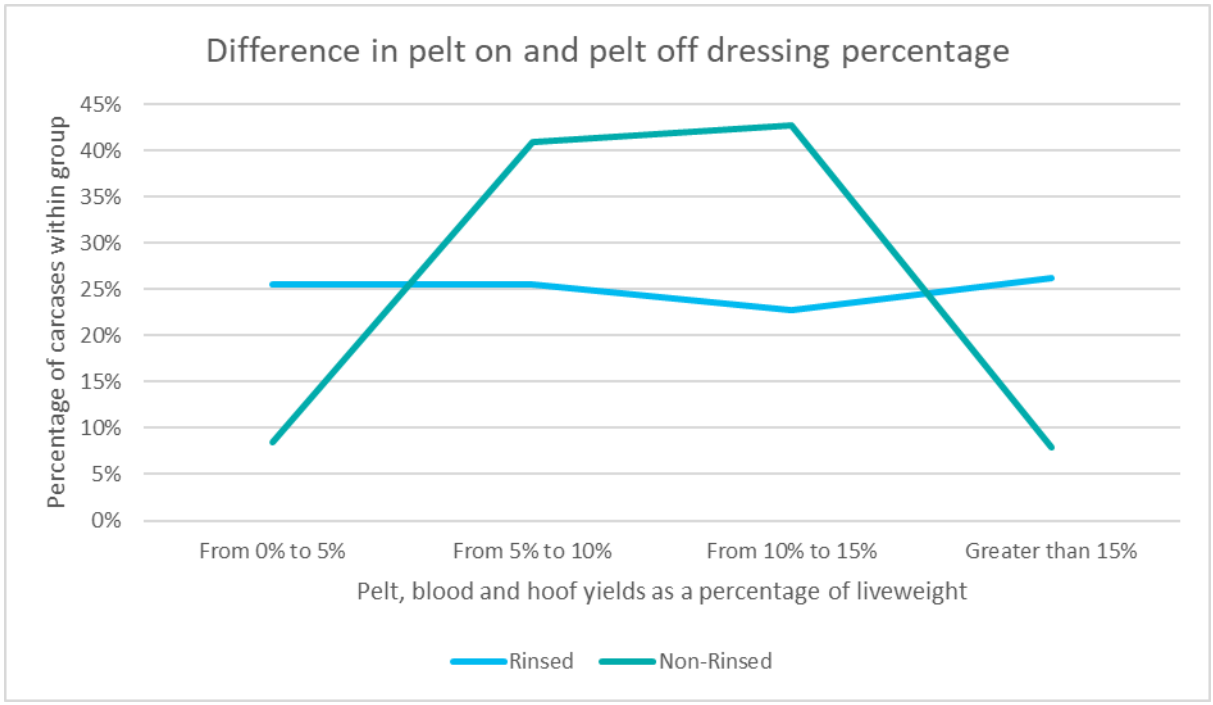

Figure 12: Pelt, hock and blood yield percentage as a percentage of Live weight (head off)

Figure 12 shows the impact when comparing the liveweight recorded for sheep head off when compared to the weight recorded by the MPSC infeed scales which record either front or back leg weight and then using a standard conversion factor to calculate the overall carcase weight.

The dressing % for pelt on comparing the rinsed and non-rinsed animals was highly variable (P value 0.15) indicating the need for improved weights along the sheep slaughter chain to determine an accurate impact of RCT on the live to dressed percentage.

The variation in these weights recorded means the following for an AusMeat accredited trim adjustment:

- The weight of the pelt is going to have a significant impact on the overall weight of the overall weight variation dressing percentage of the carcases, for this reason we have used the MPSC weight of the dressing percentage.
- The MPSC scales will need to be collecting an overall body weight by weight the front and back legs. The difficulty has always been how is a weight captured accurately with a solid continuous chain.

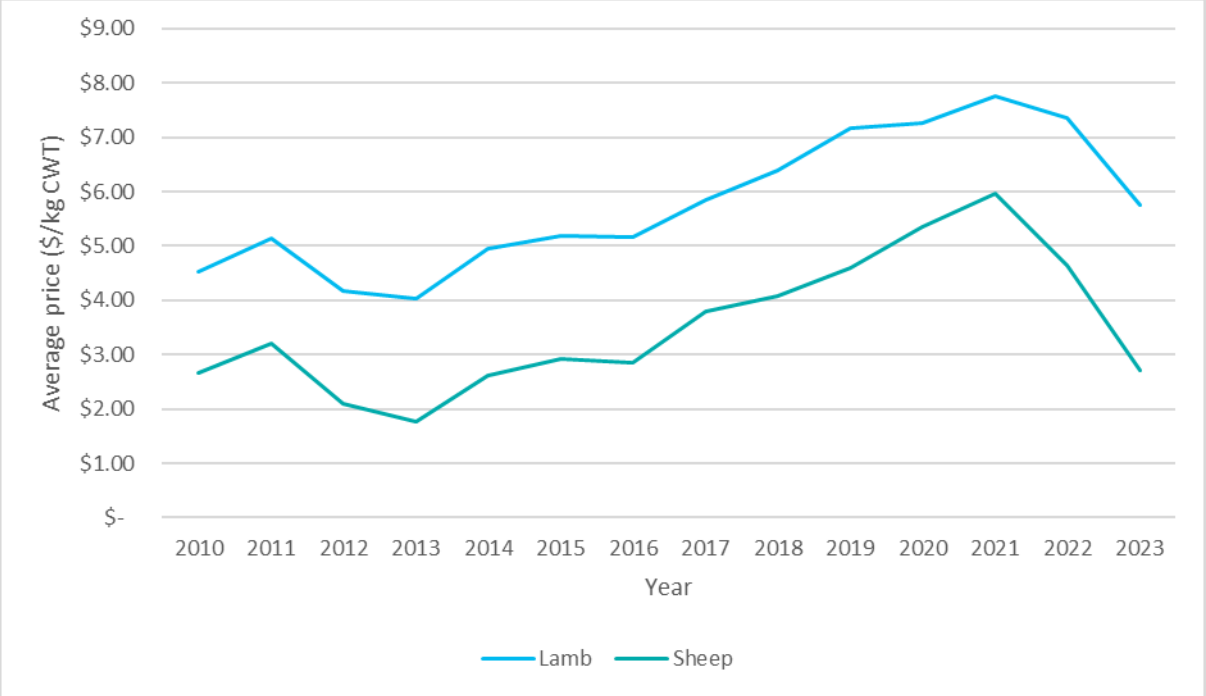

Figure 13: Lamb and Mutton average prices per year since 2010

Source: MLA statistics

Using the increase in dressing percentage from the research trial and the average 2022 sheep prices the benefit gain for HCW is $3.18 per head.

Table 5: Value created by RCT through an increase in HCW for Mutton using 2022 average livestock price

	Non-rinsed	Rinsed
Carcase dressing Percentage	50.8%	52.3%
Calculated HCW	23.49	24.18
Carcase yield increase		
Difference		0.69
Average value per KG	$ 4.64	$ 4.64
Benefit		**$ 3.18**

4.1.2 Liver and heart impact

The livers and hearts were weighed with a noticeable difference between the rinsed and non-rinsed treatments as shown in Figure 14 and

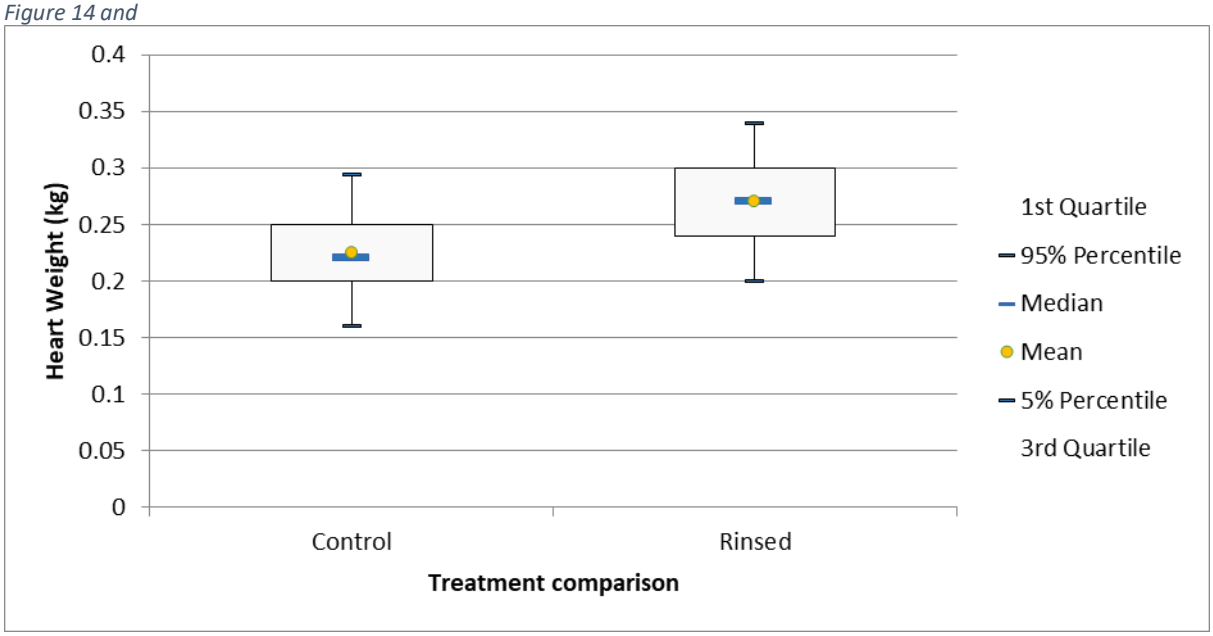

Figure 15 with the value creation through the use of RCT summarised and presented in Table 6.

Table 6: Value created through an increase in sheep heart and liver yields

	Non-rinsed	Rinsed
Heart	**Heart**	
Heart yield	0.98%	1.07%
Heart weight	0.23	0.26
Heart Value ($/kg)	$ 5.43	$ 5.43
Weight Difference		0.03
Value Difference		**$ 0.15**
Liver	**Liver**	
Liver Yield	3.13%	3.23%
Liver weight	0.73	0.78
Liver Value	$ 2.68	$ 2.68
Liver value per head	$ 1.97	$ 2.10
Weight Difference		0.05
Value Difference		**$ 0.13**

The heart and liver value per kilogram is based on 2022 industry averaged data.

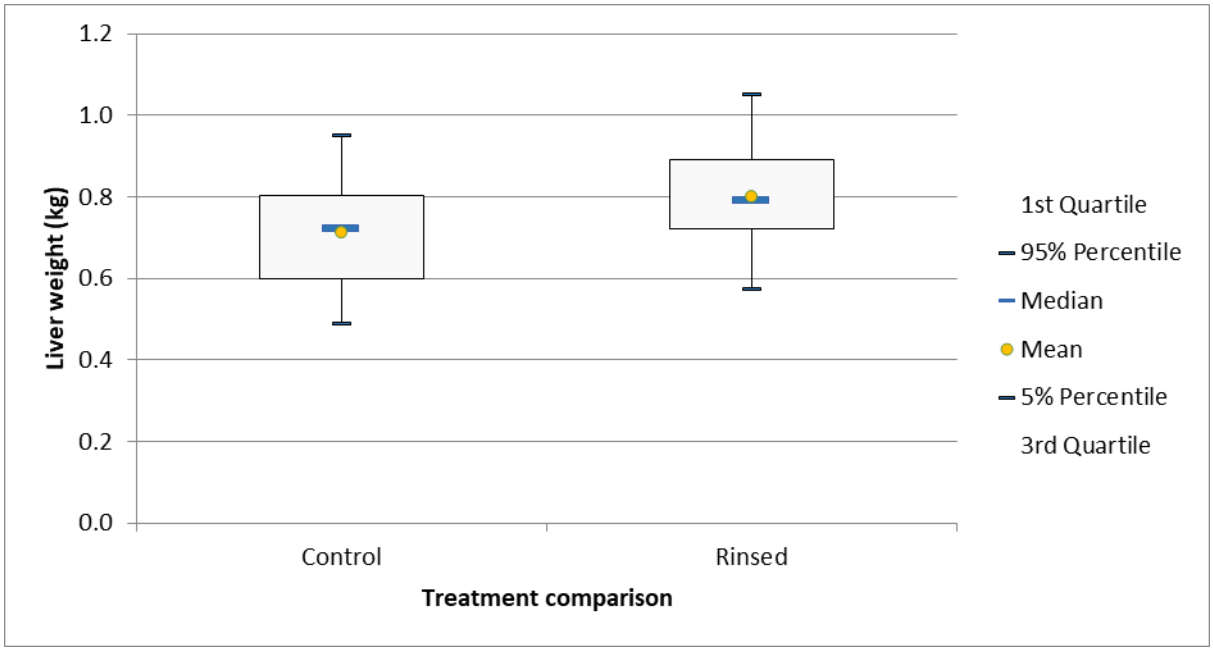

Figure 14: Liver yields (kg) for rinsed and non-rinsed animals

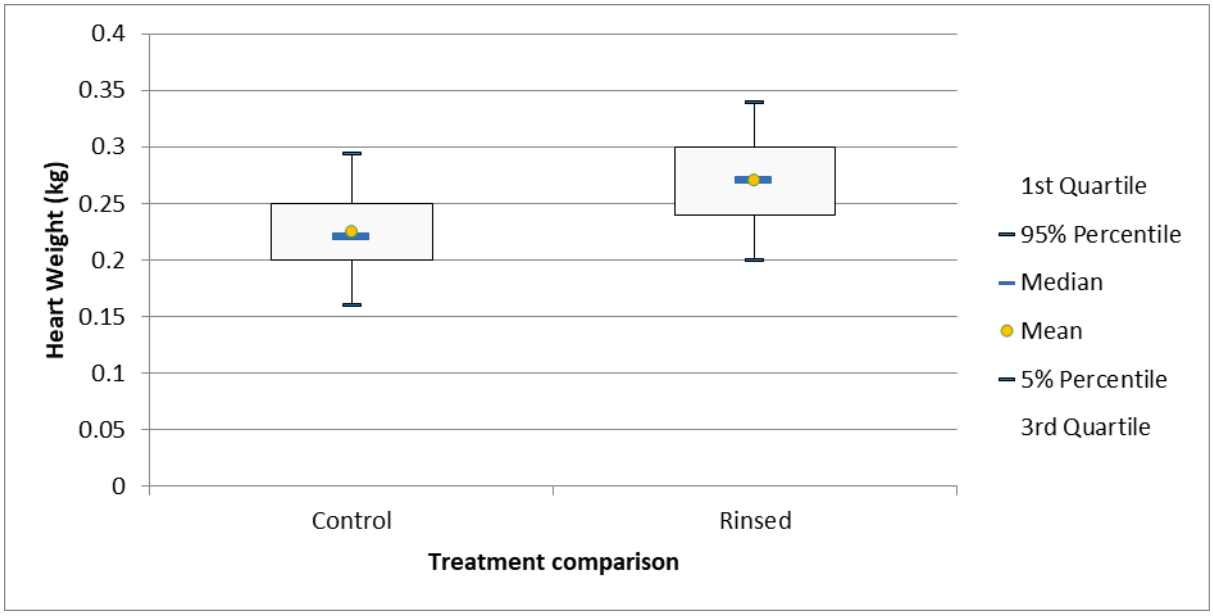

Figure 15: Heart yields for rinsed and non-rinsed animals

4.1.3 Sheep offal surface temperature

The difference in temperature between the control and treatment (rinsed) livers was statistically significant with a P value of 0.02. This P value indicates the observed difference in sheep liver temperature means were not due to random chance and there is strong evidence of a real effect.

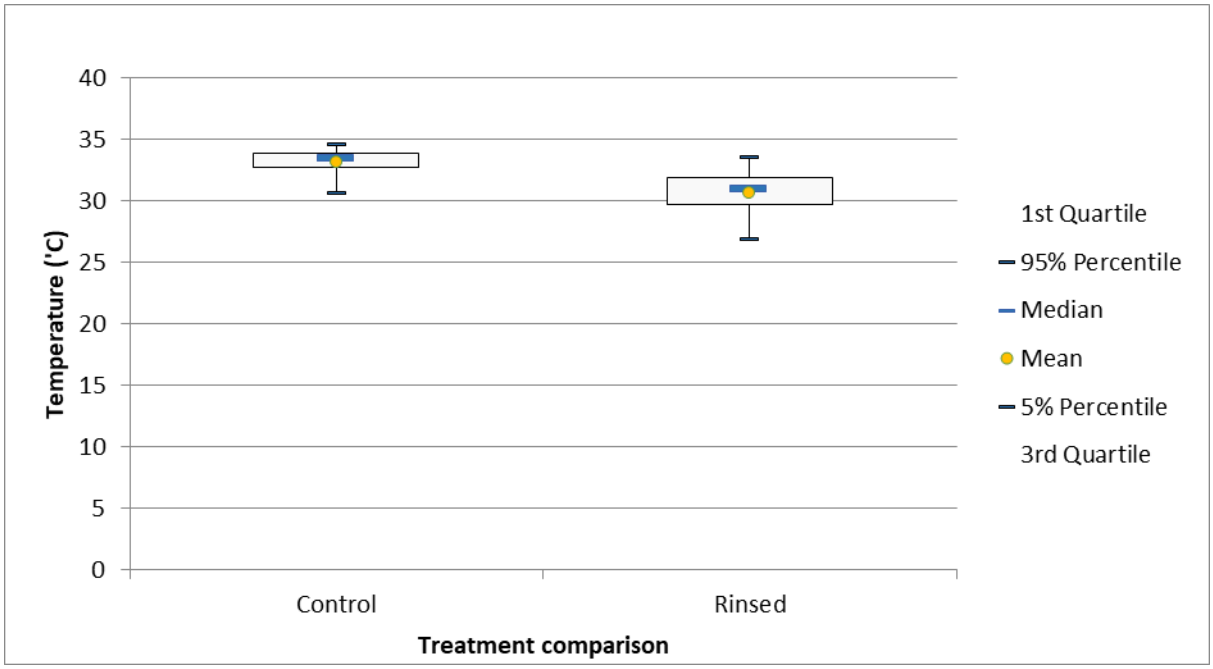

Figure 16: Temperatures (°C) of Control and Rinsed sheep livers

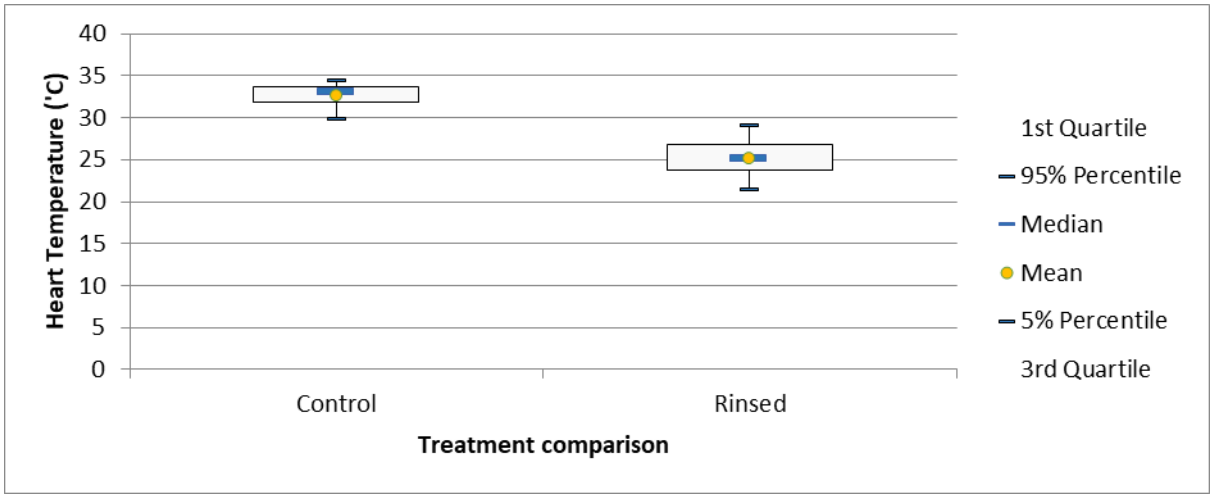

Figure 17: Surface temperatures (°C) of Control and Rinsed sheep hearts

The heart which was rinsed was significantly colder (7.4°C) than the non-rinsed heart, while the liver was 2.4°C colder. Colder hearts and livers reduce the energy required by the offal chilling systems (ice water baths to plate or blast freezers). The economic value of faster chilling times and or less energy required to chill the livers and hearts wasn't calculated and included in the value proposition presented in this report.

4.1.4 Supply Chain Value Proposition

Mutton

The total benefits calculated for a Mutton processing plant is presented in Figure 18.

	Non-rinsed	Rinsed
Carcase dressing percentage	50.8%	52.3%
Calculated HSCW	23.49	24.18
Carcase yield increase		
Difference		0.69
Average value per KG	$ 4.64	$ 4.64
Benefit		**$ 3.18**
Offal yields	**Offal yields**	
Heart	**Heart**	
Heart yield	0.98%	1.07%
Heart weight	0.23	0.26
Heart Value ($/kg)	$ 5.43	$ 5.43
Weight Difference		0.03
Value Difference		**$ 0.15**
Liver	**Liver**	
Liver Yield	3.13%	3.23%
Liver weight	0.73	0.78
Liver Value	$ 2.68	$ 2.68
Liver value per head	$ 1.97	$ 2.10
Weight Difference		0.05
Value Difference		**$ 0.13**

Shrink loss reduction	**Shrink loss reduction**	
Shrink loss	2.0%	1.9%
Weight loss	0.46	0.46
Weight value	$ 4.64	$ 4.64
Cost of loss	$ 2.15	$ 2.15
Lost weight reduction		-
Value Reduction		**$ -**

Slaughter & Chilling benefit	**$ 3.46**

Boning room benefits	**Non-rinsed**	**Rinsed**
Infeed value of carcases into boning room	$ 109.06	$ 112.24
Infeed weight	23.03	23.72
Carcase weight increase		0.69
Export Mutton price	$ 7.70	$ 7.70
Boning room yield of products coming out of room	97%	97%
Value of product through boning room	$ 172	$ 177
Benefit from boxed meat sales		**$ 1.94**

Labour efficiency - Boning room		
Boning room throughput (Head/min)	4.26	4.26
Boning room throughput (kg/min)	96.73	101.11
Difference (kg/min)		4.37
FTE's for room	20	20
Hourly Cost	$ 35.10	$ 35.10
Cost per head boned	$ 2.74	$ 2.74
Cost per kg boned	$ 0.121	$ 0.116
Benefit per kilogram		$ 0.005
Benefit per head		$ 0.12

Boning Room benefit		$ 2.06

Supply Chain Benefit		**$ 5.52**

Figure 18: Mutton processing plant benefits

Using the change in value of mutton meat sold over time, the gross benefit for the processing plant owned stock has been calculated and presented in the graph below.

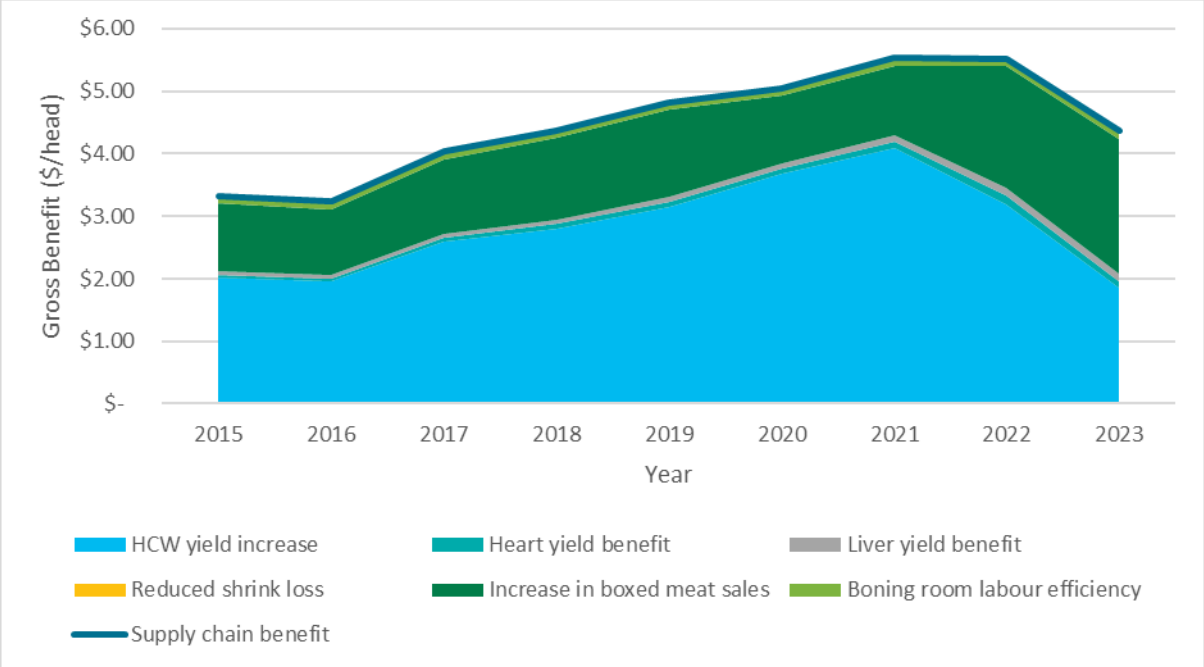

Figure 19: Processing plant owned stock gross supply chain benefit ($/head)

Figure 20: Processor benefit for OTH mutton

Gross benefits gained by processors rinsing over the hooks were calculated and graphed which included processors paying the producer for the increase in hot carcase weight – note this doesn't take into account the MPSC rinse fees paid by the processor.

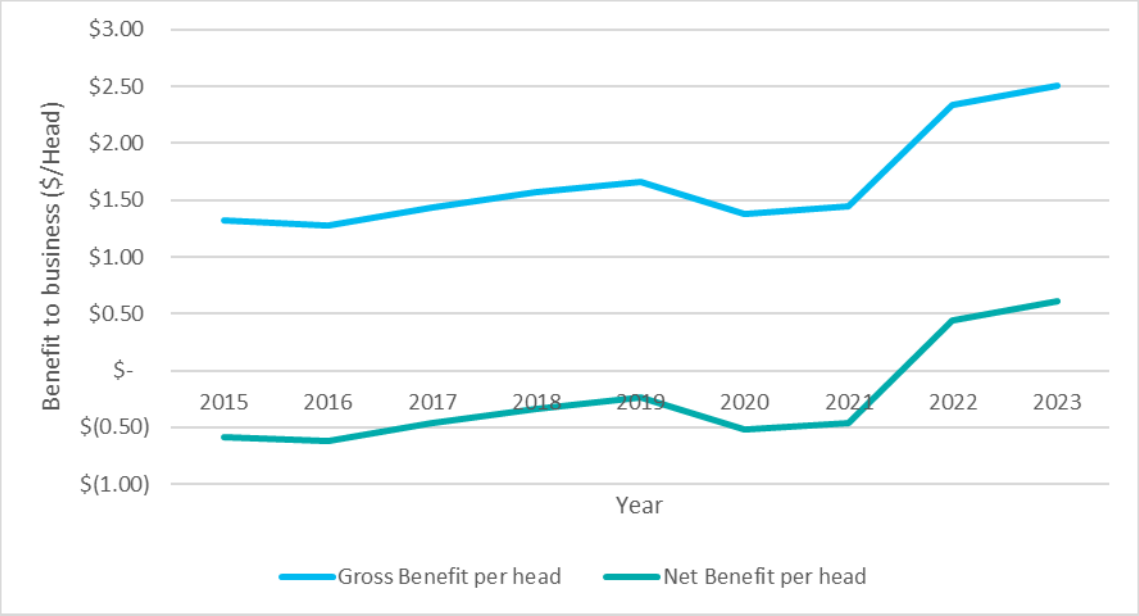

Figure 21:Gross and net benefit per head for processors rinsing animals processed over the hook

Figure 25 Net benefit per head takes into the account the rinse fee paid to MPSC, the average OTH price and the average mutton sale price per year. Note this is calculated on one vendor and doesn't take into consideration vendor variation, body condition score, transport distances, seasonal variation, etc. The Gross benefit per head line is from Figure 20.

Lamb

The total gross benefit per head for the processor (

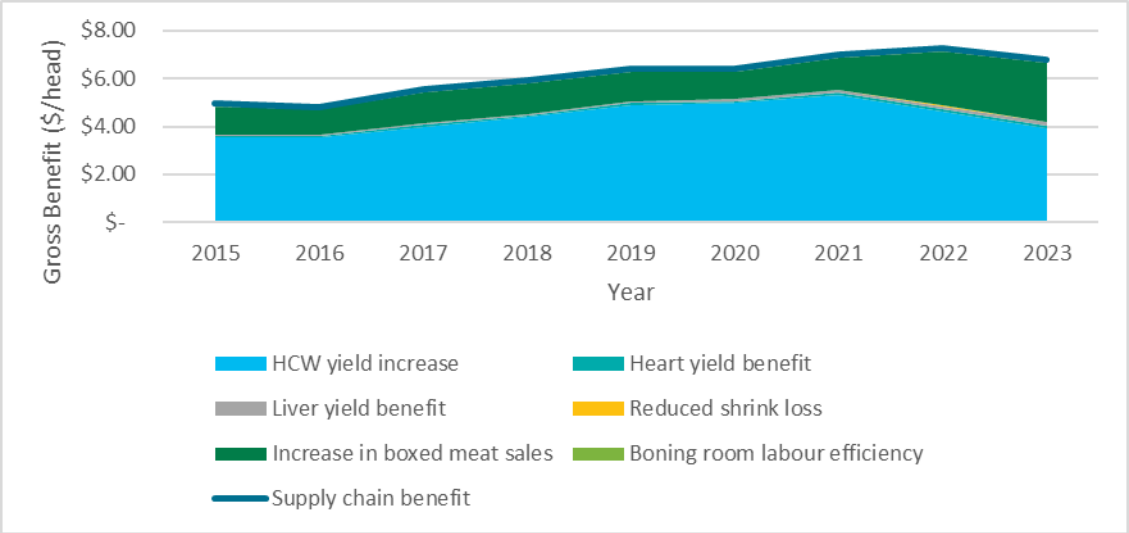

Figure 22) was calculated for the past 9 years using average selling prices multiplied by the increase in quantity of product sold over non-rinsed lambs.

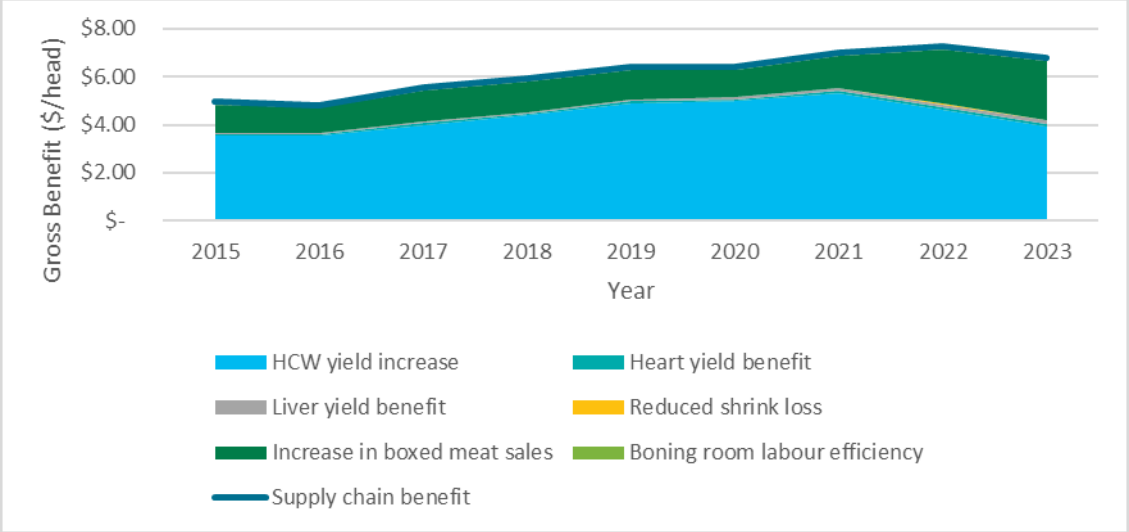

Figure 22: Lamb gross supply chain benefit ($/head)

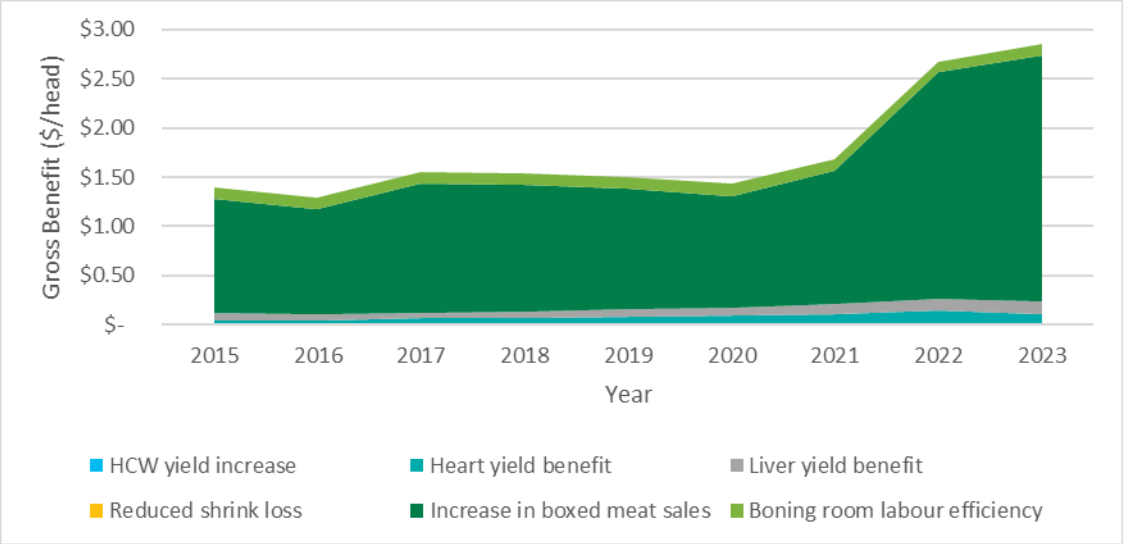

Figure 23 is the benefit to the processor for over the hooks (OTH) purchases as the producer gets the HCW yield increase post rinsing. The benefits are from the boning room and increased boxed meat sales.

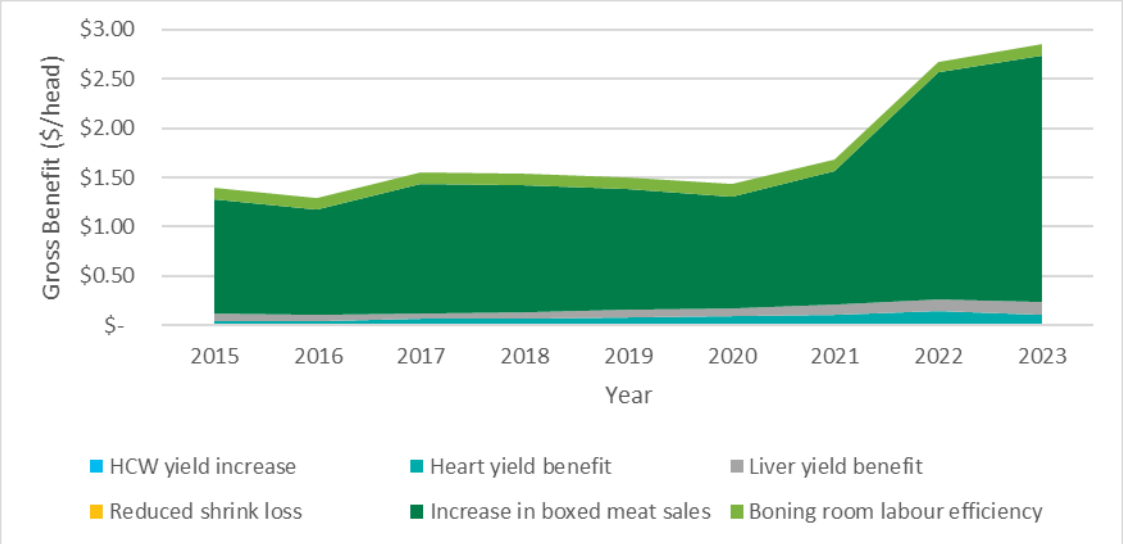

Figure 23: Processor benefit for OTH purchases using current payment methods

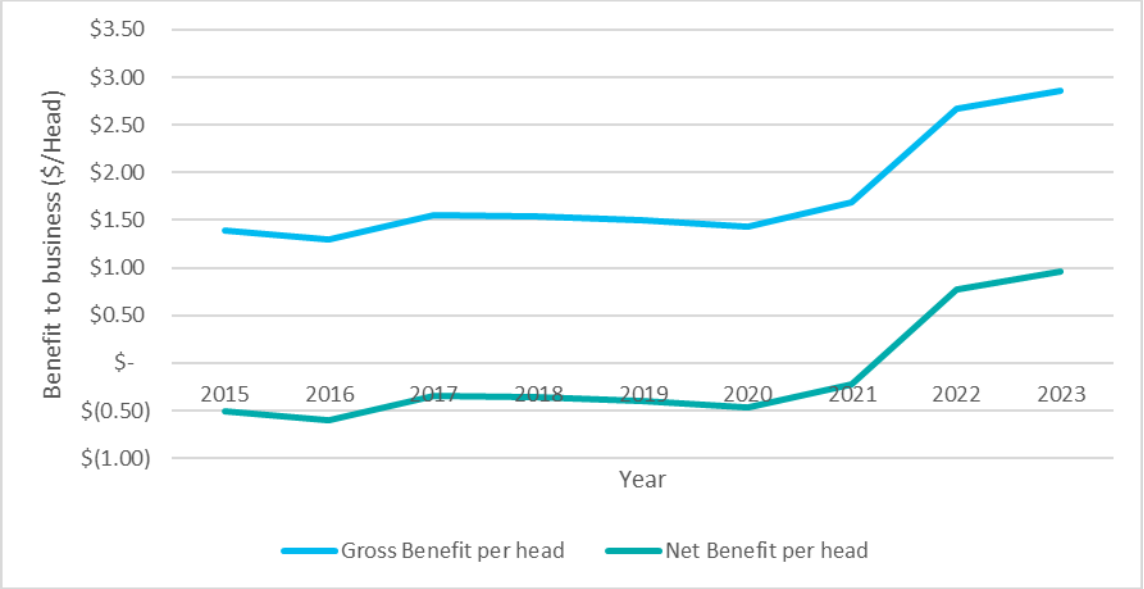

Figure 24: Gross and net benefit per head for processors rinsing lambs processed over the hook

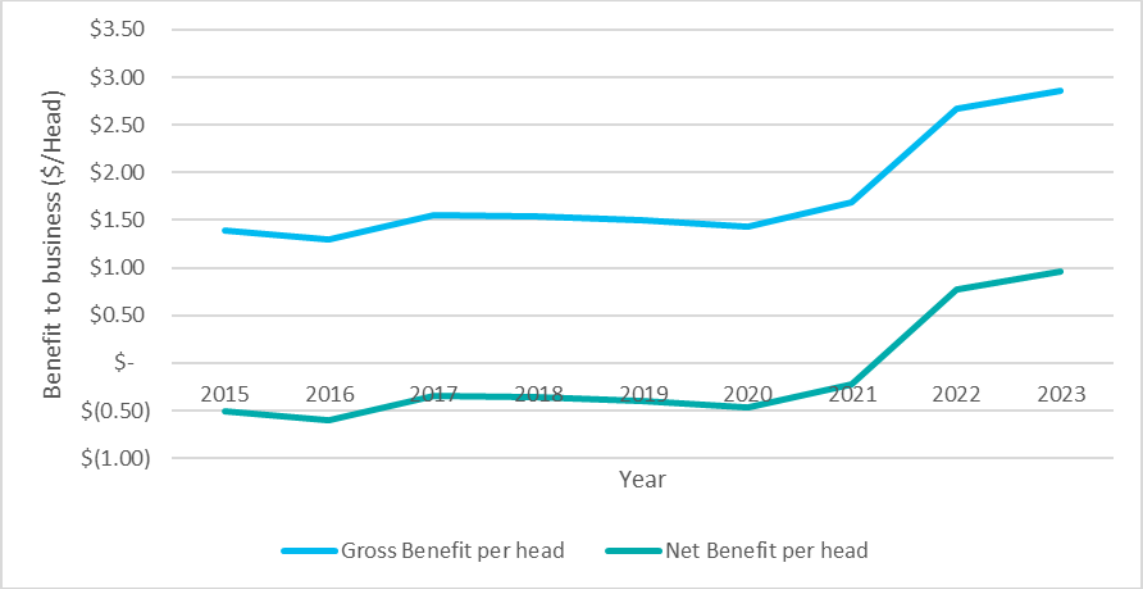

Figure 24 is the Gross Benefit per head when rinsing lambs purchased over the hooks compared with the Net Benefit per head which takes into account the rinse fees which the processor pays to MPSC on a fee per head basis. These graphs are calculated using the average price per kilogram for livestock and the average price per kilogram for meat sales per year. The processors were making a book loss if they were rinsing lambs they purchased over the hooks up until the first quarter of 2021.

Given this scenario, processors are hesitant to rinse stock which are not their own livestock as there is not an Aus-Meat accredited trim adjustment for the use of RCT. As a result of processors who have RCT installed and they are not rinsing stock, this is a lost value to industry – both to the processor (longer shelf life, better presented product, more meat sold, increased boning room efficiencies) and to the producer.

4.2Beef trial results

4.2.1 Beef carcase yield

During this project beef yield data was collected from a MSA registered processing plant in controlled trials by Greenleaf and MPSC. Previously conducted controlled trials undertaken by prominent Australian meat scientists with Wagyu animals and cows were also included in the data analysis and value propositions. The research trials conducted in this project were summarised into the carcase types of 'heavy cattle' and 'light cattle'.

Table 7: Dressing % difference between control and rinsed animals by carcase type

	Cows	Wagyu	Heavy Cattle	Light Cattle
Liveweight difference (kg)	6.40	8.56	0.29	3.36
HSCW difference (kg)	17.80	0.05	20.05	7.98
Dressing % difference	3.19%	8.69%	3.58%	1.47%

The liveweight difference in Table 7 refers to the difference between the control and the treatment (Rinse & Chill® treated) groups. The HSCW difference is post rinsing which gives an indication of the carcase yield increase for the treatment group over the control group.

The current location of the liveweight scales limits the ability to compare the liveweight of animals between rinsed and non-rinsed animals. This is due to non-rinsed animals being slaughtered using the thoracic sticking methods, but non-rinsed animals are not processed using the Thoracic sticking method. Noting the 1 to 1.5% variation in blood loss due to Thoracic sticking shown in Figure 25. There needs to be a liveweight scale implemented prior to exsanguination to be able to monitor the variation in weight due to processing method when developing the AusMeat trim adjustment requirements. All liveweights were obtained for these trials with carcases that were not thoracic stuck.

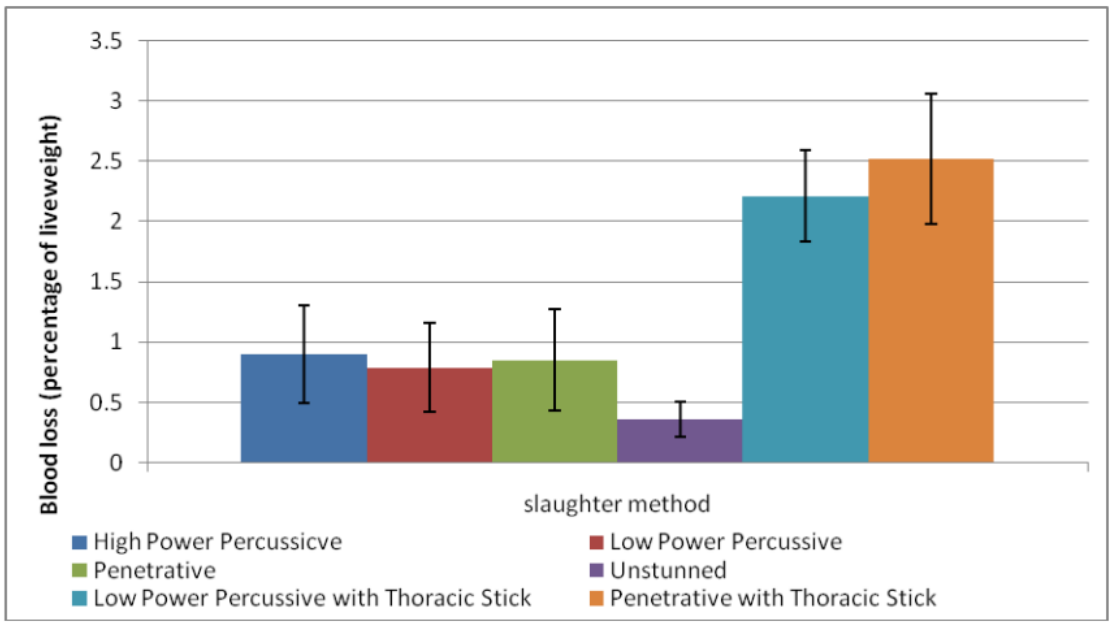

Figure 25: Blood loss as a percentage of carcase weight Impact of Thoracic sticking on blood loss

Source: Idrus et al. (2014 p25)

Heavy Cattle

For the research trial conducted at an MSA registered processing plant there were a total of 104 livestock processed which were categorised as heavy cattle being predominantly Angus steers. Overall, the heavier animals dressed 3.58% more when rinsed than the control group with an extra 20 kilograms in carcase weight.

Table 8: Liveweight, HSCW and dressing percentage between rinsed and non-rinsed cattle

Heavy Cattle			
Variable & processing group	**Control**	**Rinsed**	**Difference**
Live weight (kg)			
Mean	587	587	0.3
Max	866	955	
Min	383	346	
N	53	51	
HSCW (kg)			
Mean	324	344	20.1
Max	507	562	
Min	198	196	
N	53	51	
Dressing %			
Mean	55.0%	58.6%	3.58%
Max	59.4%	63.6%	
Min	46.8%	49.7%	
N	53	51	

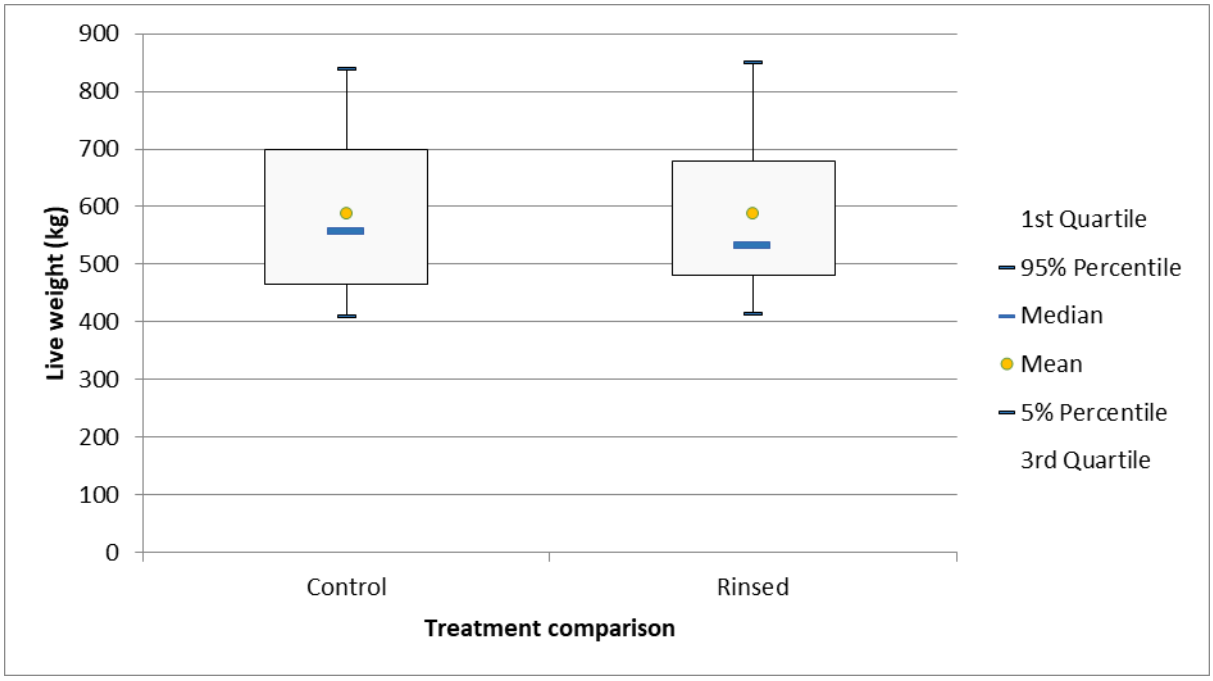

Figure 26: Liveweight statistics for 'heavy' cattle processed in March 2024 trials

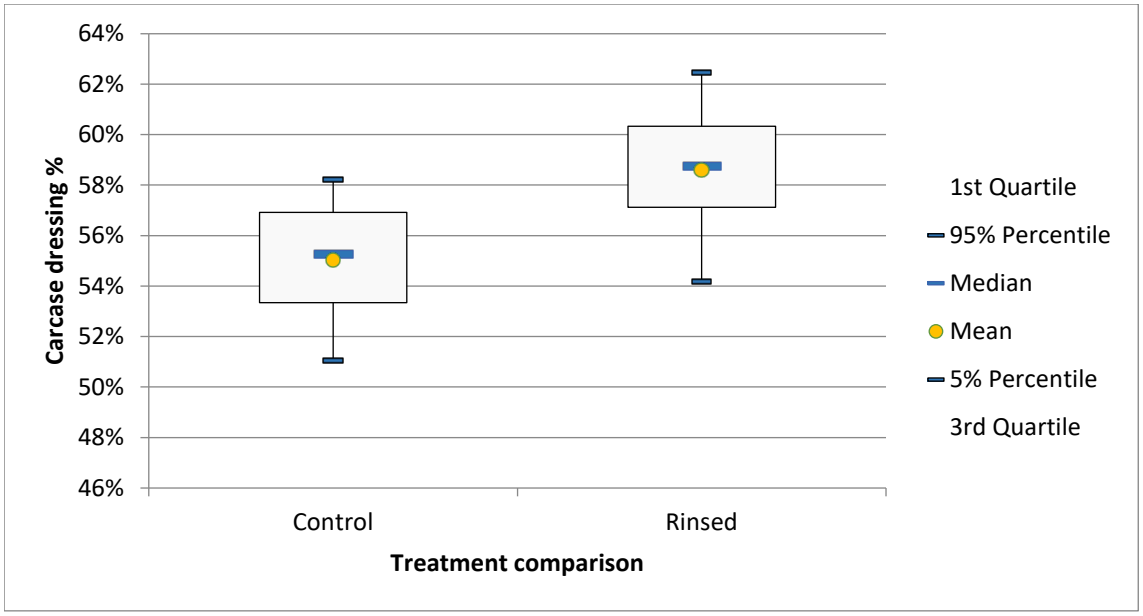

Figure 27: Distribution of carcase dressing percentage of heavy cattle

The rinsed animals had a higher average dressing percentage and HSCW averaged across all vendors.

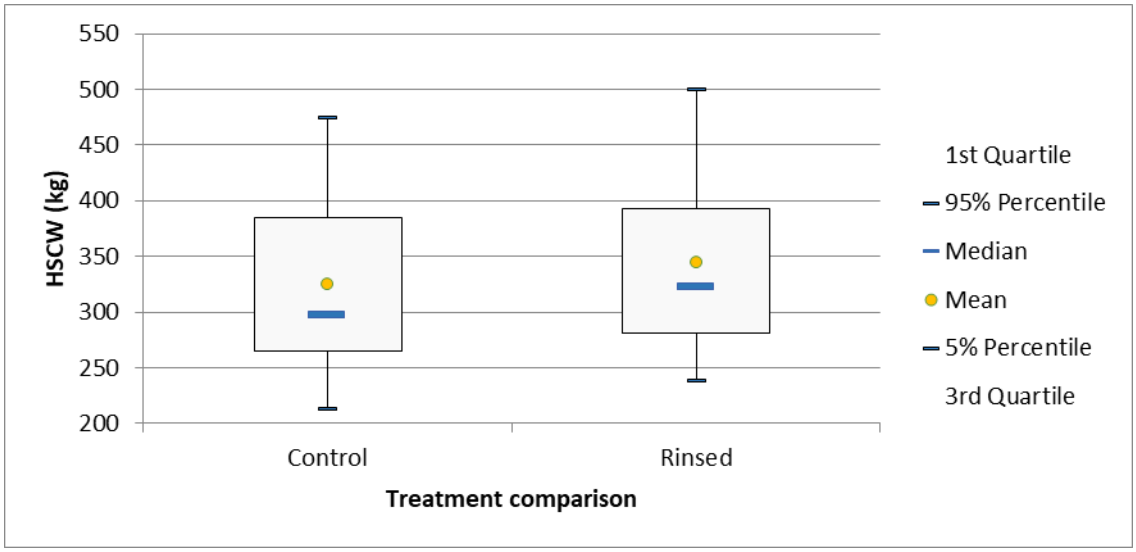

Figure 28: Distribution of HSCW of heavy cattle processed throughout the trials

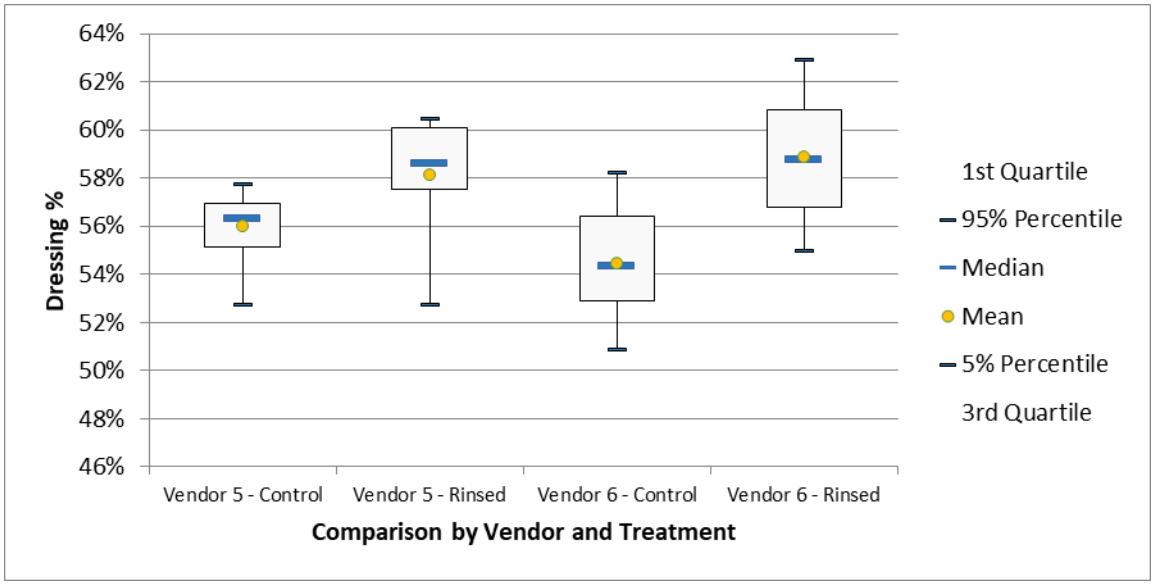

Figure 29: Vendor dressing % difference between rinsed and non-rinsed cattle from the sale purchase locations

When the trial groups were separated by vendor differences between dressing % and HSCW between the rinsed and control groups are evident. The limited sample size meant understanding causation of differences between vendors wasn't possible.

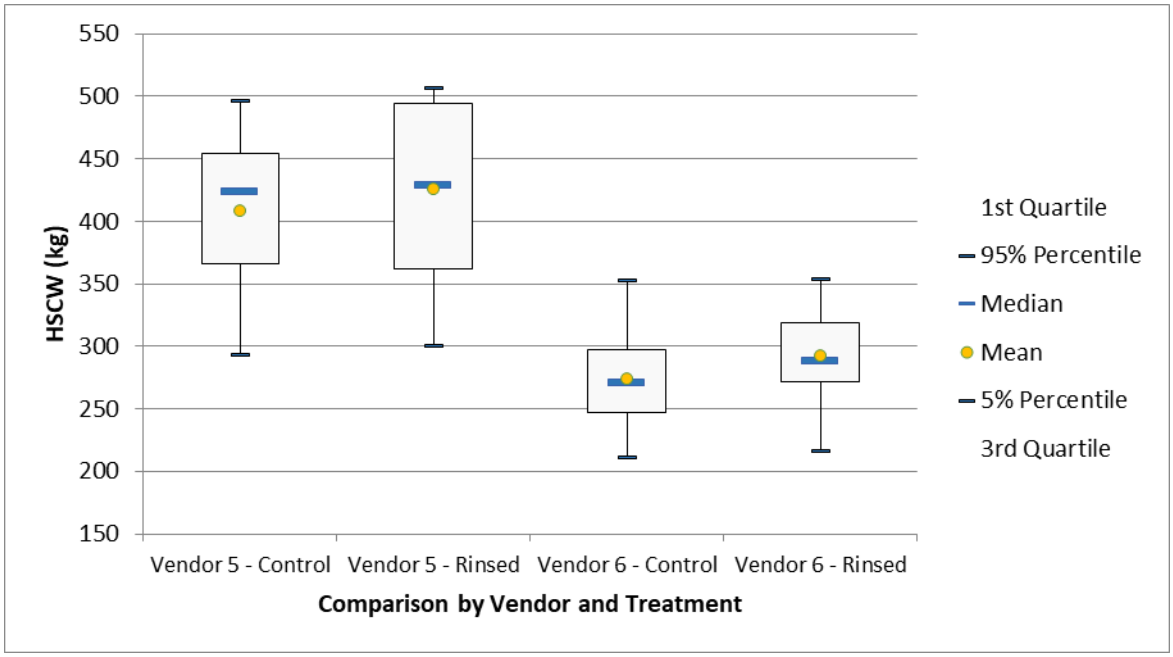

Figure 30: Vendor HSCW difference between rinsed and non-rinsed cattle from the sale purchase locations

Light Cattle

In the controlled experiments undertaken in this project at an MSA registered processing plant, Angus cross and Angus steers and heifers that were younger animals in good condition were deemed 'lighter cattle' with a target dress rate of less than 230-250kg. Some of the heifers were in early stages of pregnancy. It was not possible to align the foetus weight with the carcase to adjust dressing percentage in this trial.

Table 9: Liveweight, HSCW and dressing percentage between rinsed and non-rinsed cattle

Light Cattle			
Variable & processing group	**Control**	**Rinsed**	**Difference**
Live weight (kg)			
Mean	400	403	3.4
Max	485	463	
Min	335	309	
N	59	58	
HSCW (kg)			
Mean	223	231	8.0
Max	274	281	
Min	181	171	
N	60	58	
Dressing %			
Mean	55.9%	57.4%	1.47%
Max	62.6%	61.4%	
Min	50.0%	47.1%	
N	60	58	

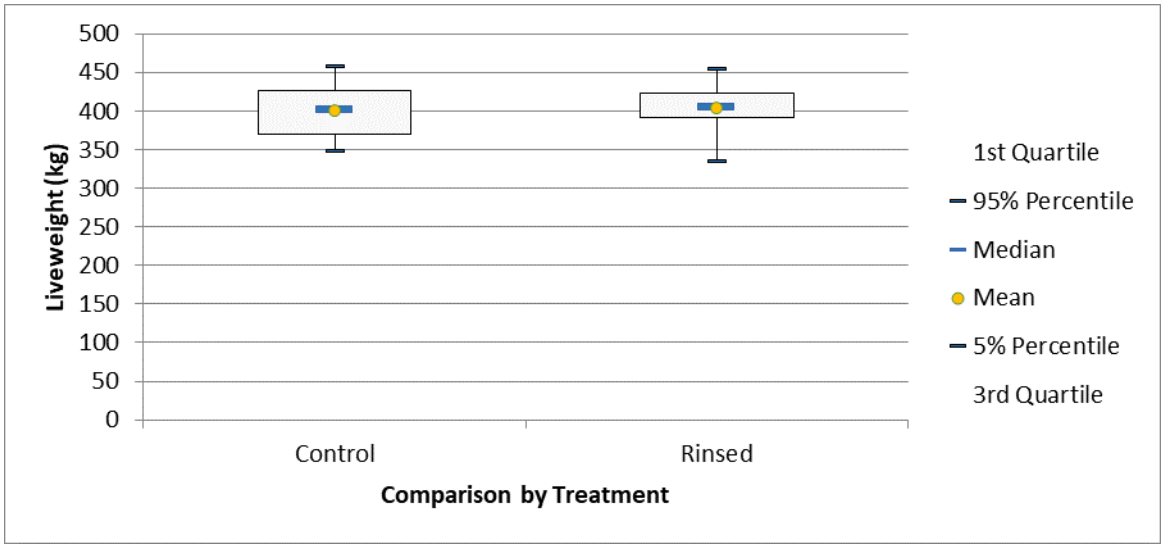

Figure 31: Distribution of liveweight of 'light' cattle processed during the trials

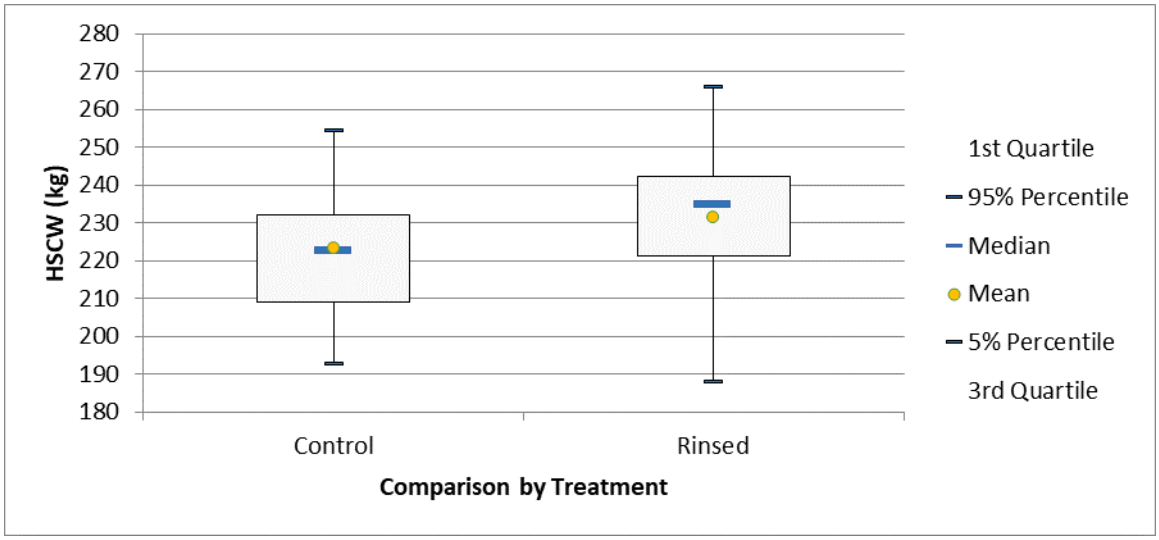

Figure 32: HSCW of 'light' cattle processed throughout the trials

The difference in HSCW between the control and rinsed (treatment) groups for light cattle were statistically significant (P value 0.04).

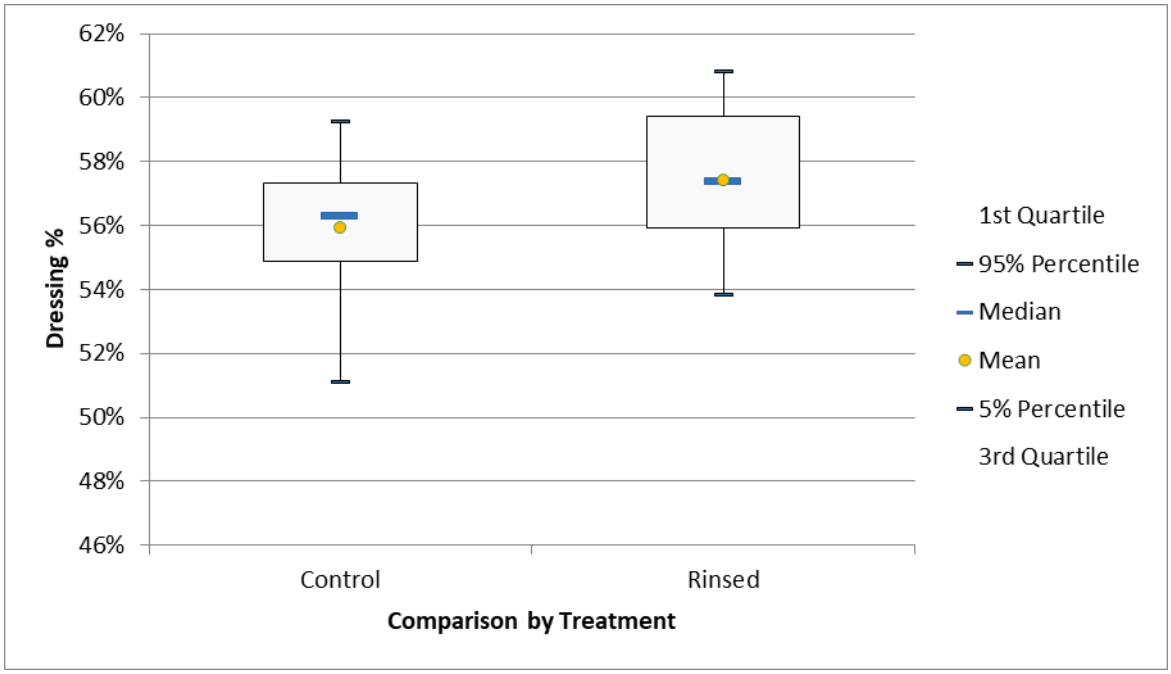

Figure 33: Dressing percentage of light cattle processed throughout the trials

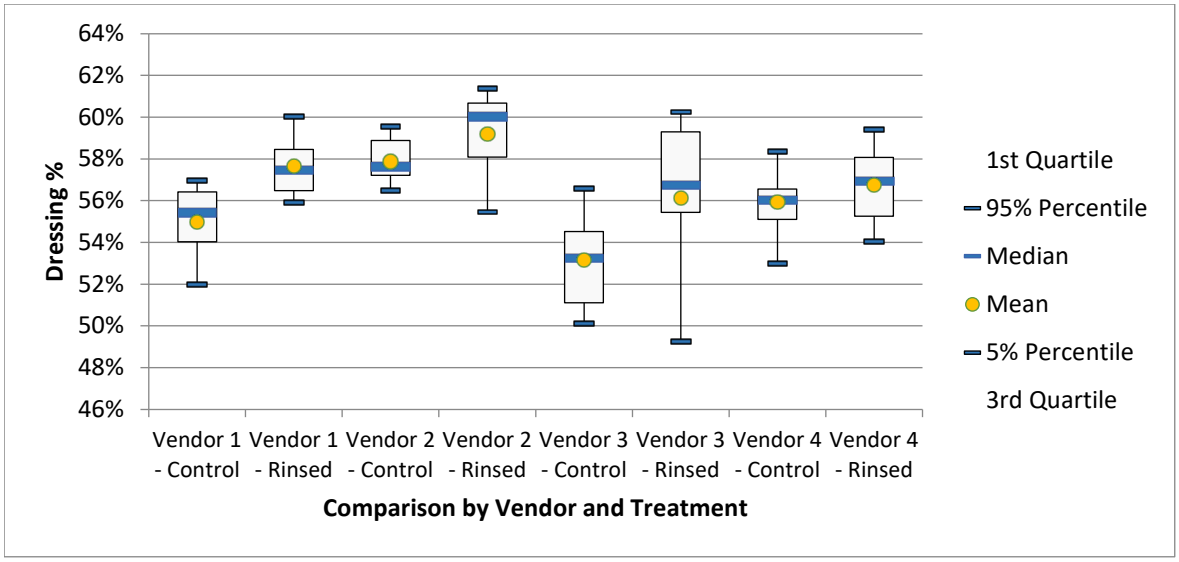

Figure 34: Vendor dressing % difference between rinsed and non-rinsed 'light' cattle

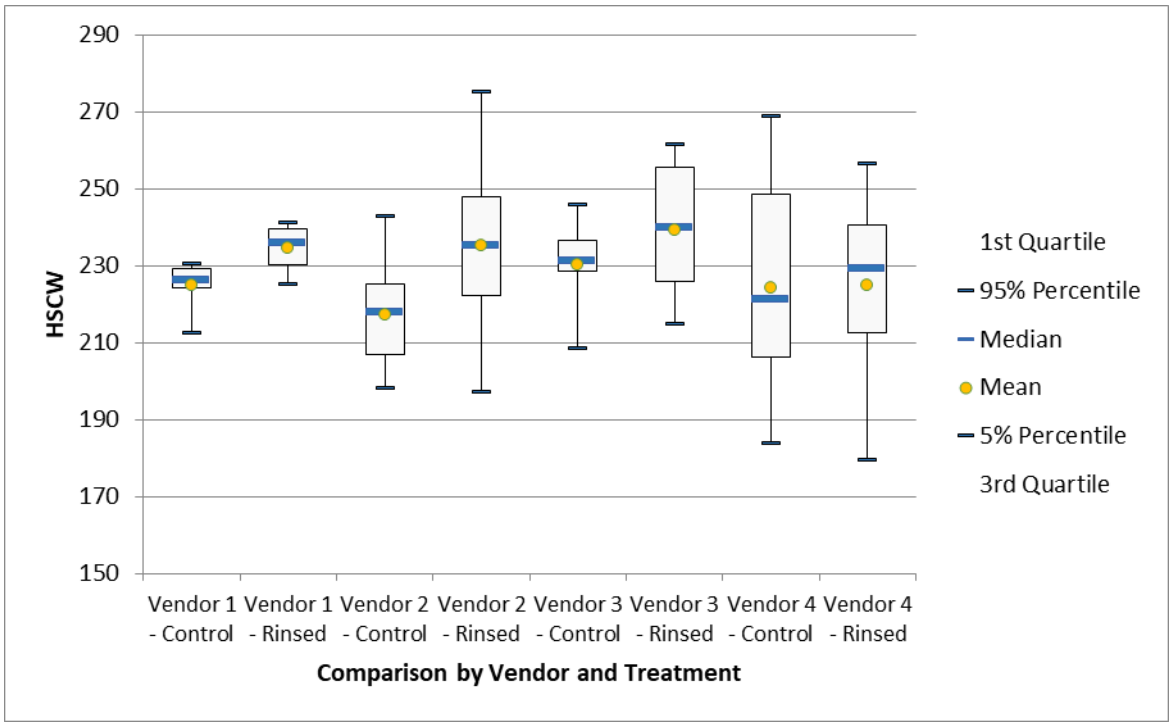

Figure 35: Vendor HSCW difference between rinsed and non-rinsed 'light' cattle

Overall Value Proposition for carcase traits

The value of RCT per carcase type was calculated based on increase in carcase weight by carcase type from data collected in this project. For carcases with average weight of 344 kilograms, carcases were 19.88 kilograms heavier, with meat value estimated at $58.17 per head (Table 10). For the lighter cattle with an average weight of 229 kilograms, the increase in weight per carcase was calculated at 6.2 kilograms per head giving an additional value of $19.62. For animals purchased OTH, the processor pays the MPSC rinse fee and the additional carcase weight to the producer meaning most processing plants do not rinse livestock purchased OTH.

Table 10: Value difference when purchasing heavy grass-fed cattle OTH based on the variation in HSCW

Animal Type	Rinsed	Non-rinsed
Heavy		
Count	51	53
Live weight	29,951	31,110
Average live weight	587	587
Overall average live weight		587
HSCW	17,559	17,185
Carcase Number	51	53
Average Carcase weight	344	324
Average Carcase yield	58.63%	55.24%
Dressing % increase		3.39%
Normalised Carcase weight	344	324
Carcase weight difference (kg)	19.88	
Beef Carcase Values	$ 2.93	$ 2.93
Carcase value	$ 1,007	$ 949
Total value difference ($/hd)	$58.17	

Table 11: Value difference when purchasing light grass-fed cattle OTH based on the variation in in HSCW

	Rinsed	Non-rinsed
Light		
Count	58	59
Live weight	23,378	23,583
Average live weight	403	400
Overall average live weight		401
HSCW	13,420	13,172
Carcase Number	58	59
Average Carcase weight	231	223
Average Carcase yield	57.41%	55.85%
Dressing % increase		1.55%
Normalised Carcase weight	229	223
Carcase weight difference (kg)	6.20	
Beef Carcase Values	$ 3.16	$ 3.16
Carcase value	$ 726	$ 706
Total value difference ($/hd)	$19.62	

4.2.2 Beef offal impact

The offal which was measured by Greenleaf in this project included heart, kidney, liver, tongue, thick skirt, thin skirt and tail. The average increase in offal weights due to the use of RCT for the specific cattle types is listed in Table 12.

Table 12:Differential in offal weight observed between treatment and control by cattle types

	Heavy cattle	Light cattle
Heart (kg)	0.96	0.61
Kidney (kg)	0.20	0.07
Liver (kg)		1.82
Tongue (kg)	0.05	- 0.00
Thick Skirt (kg)	- 0.00	0.33
Thin Skirt (kg)	0.20	0.35
Tail (kg)		0.00

The different in the skirts is dependent on slaughter floor operators rather than a direct attribution to a treatment and control differential. The impact of RCT for tongue and tail was taken as no difference (scale margin of error) for the lighter cattle.

Offal impact on heavy cattle

The heart and liver have been included in the value proposition calculations as the weight increases could be reliably attributed to the impact of RCT®.

Table 13: Quantitative statistics of offal yields collected on heavy cattle

Heavy cattle			
Variable & processing group	**Control**	**Rinsed**	**Difference**
Heart (kg)			
Mean	2.19	3.15	1.0
Max	2.97	5.16	
Min	1.33	1.845	
N	53	45	
Kidney (kg)			
Mean	1.33	1.52	0.2
Max	2.275	2.02	
Min	0.98	1.01	
N	37	13	
Tongue (kg)			
Mean	1.36	1.42	0.1
Max	1.84	2.085	
Min	1.055	0.91	
N	49	51	
Thick Skirt (kg)			
Mean	2.00	1.99	- 0.0
Max	3.185	3.235	
Min	1.13	1.035	
N	36	33	
Thin Skirt (kg)			
Mean	2.49	2.69	0.2
Max	3.87	4.9	
Min	1.37	1.745	
N	35	32	

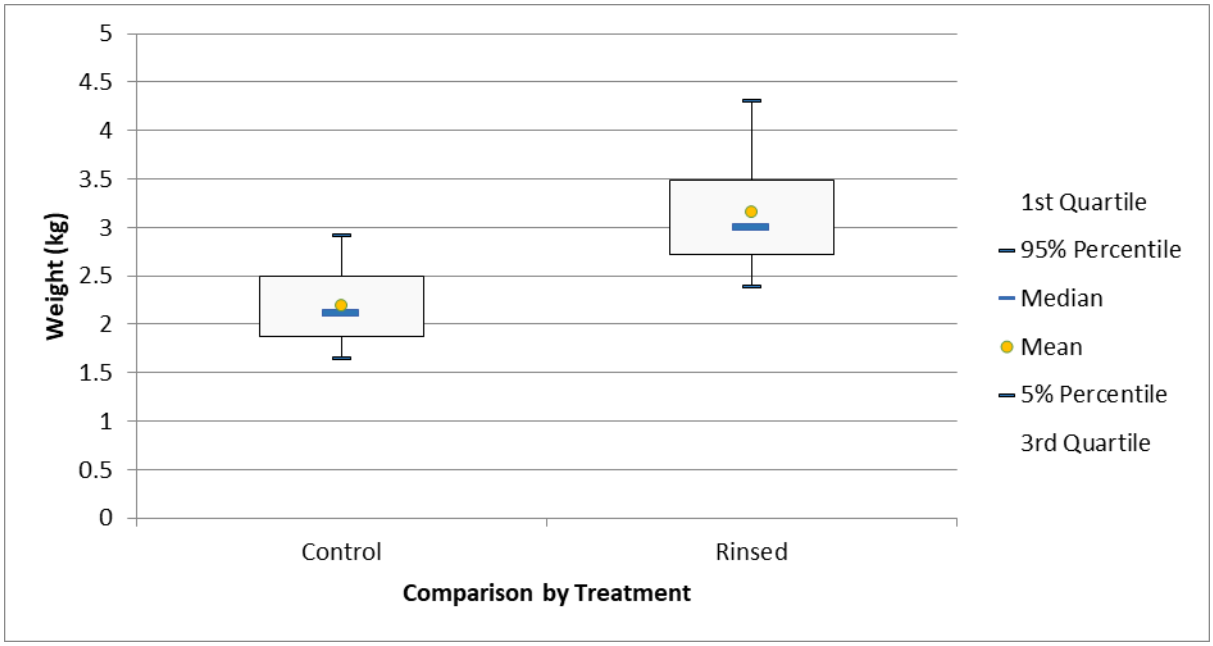

Figure 36: Heart yields from rinsed and non-rinsed heavy cattle

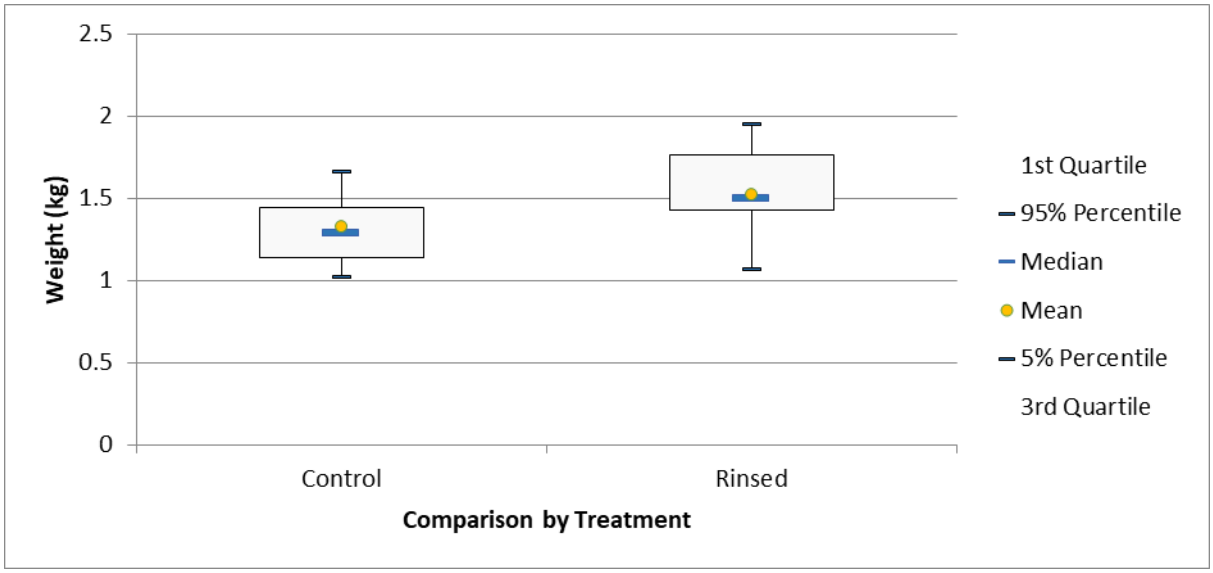

Figure 37:Kidney yields from rinsed and non-rinsed heavy cattle

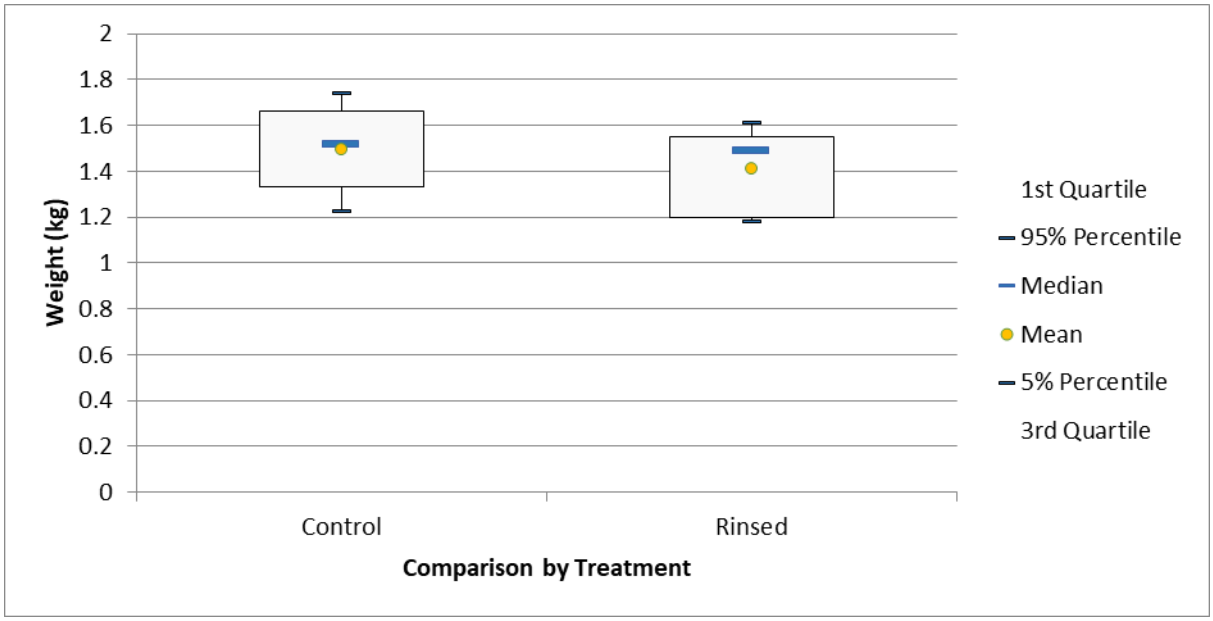

Figure 38: Lung yields from rinsed and non-rinsed heavy cattle

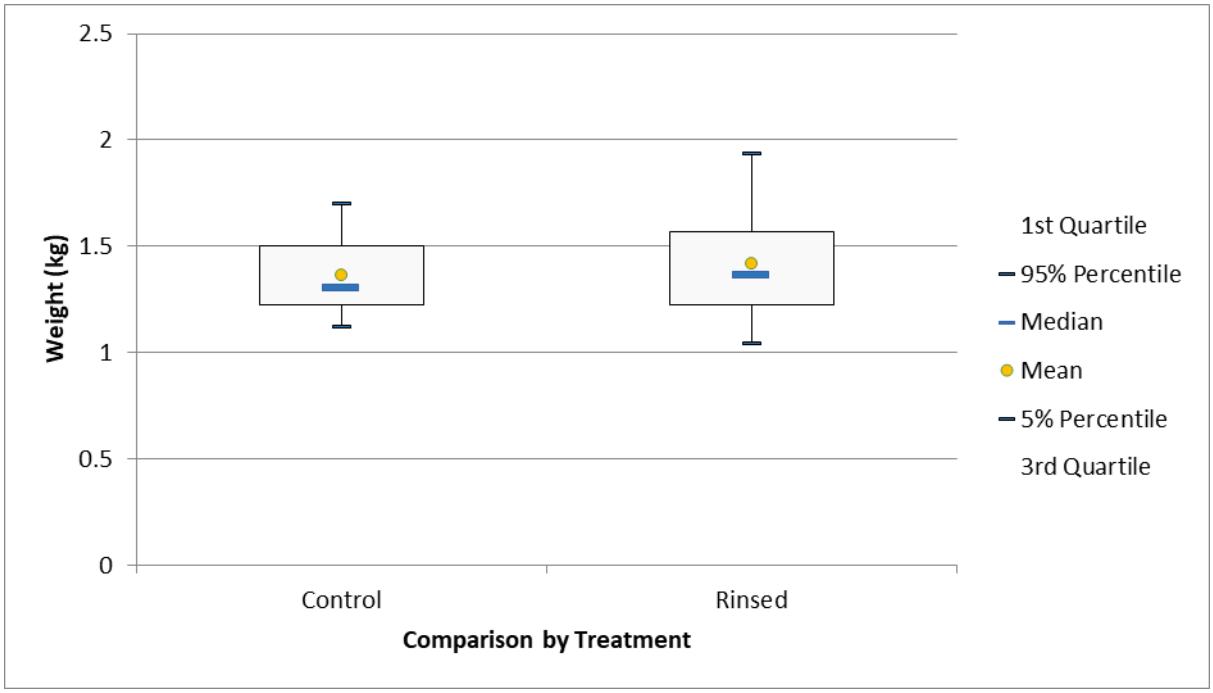

Figure 39: Tongue yields from rinsed and non-rinsed heavy cattle

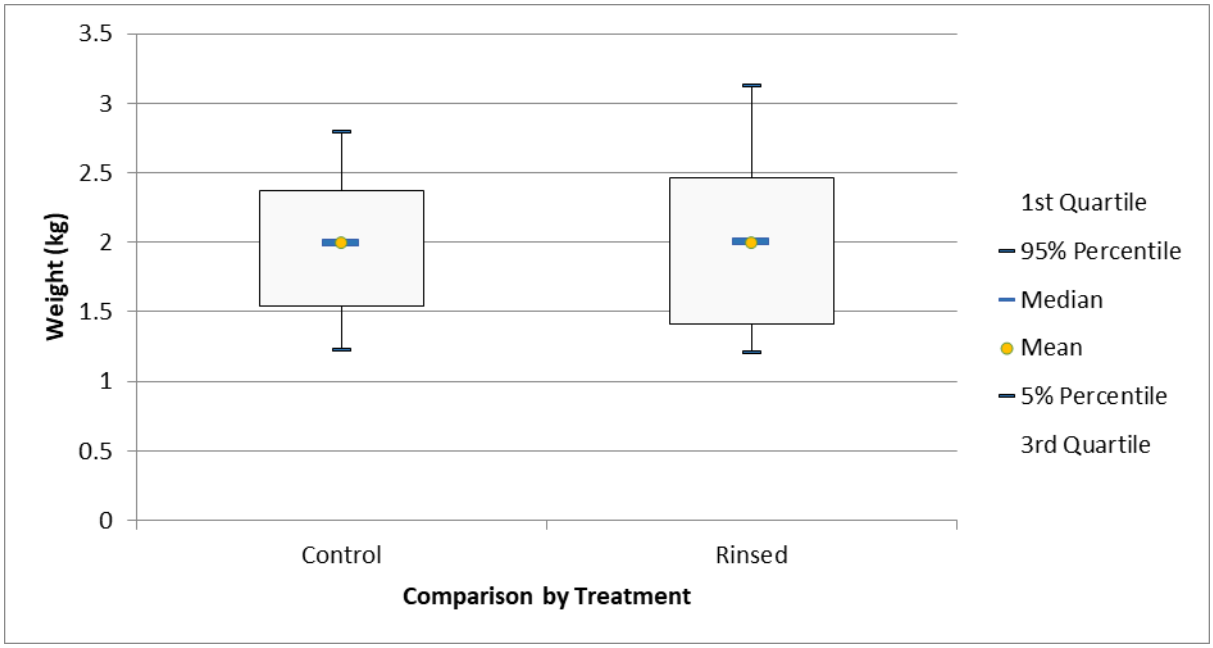

Figure 40: Thick skirt yields from rinsed and non-rinsed heavy cattle

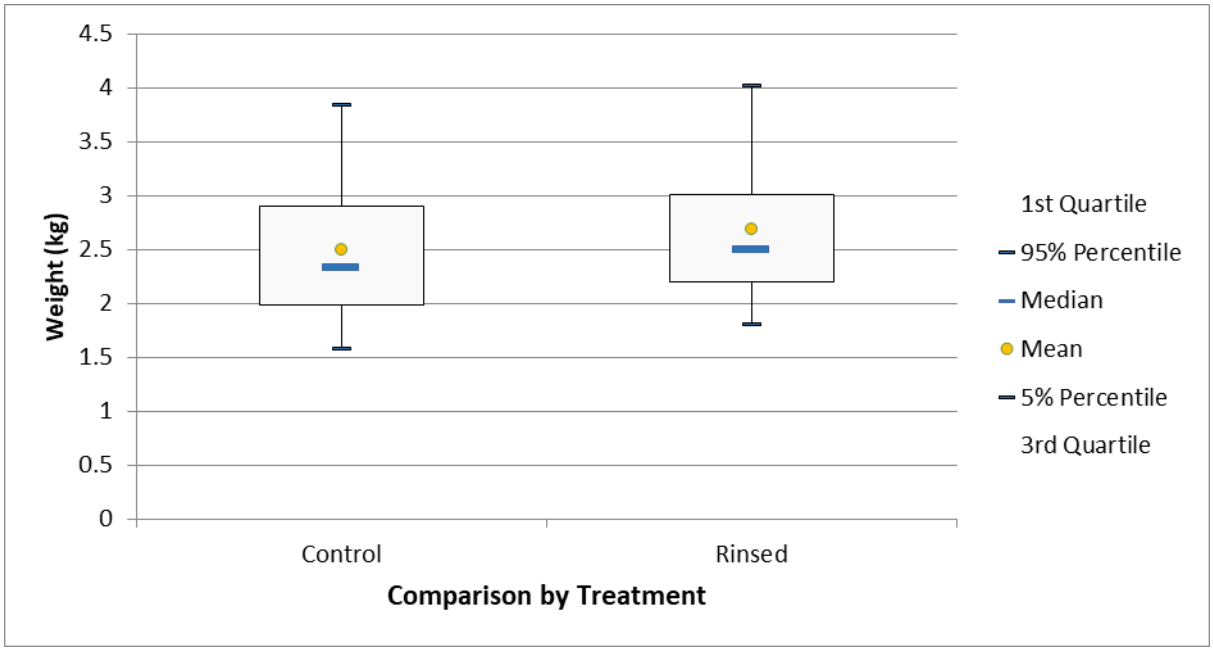

Figure 41: Thin skirt yields from rinsed and non-rinsed heavy cattle

Value benefit from increase offal weights

The value of rinsing for hearts is calculated in Table 14 calculated at $8.64 per heart for trials involving heavy cattle at the MSA registered processing plant. Livers weren't packed for the heavy animals.

Table 14:Increase saleable heart value from rinsing

Hearts		
Animal Type	Rinsed	Non-rinsed
Heavy		
Count	51	53
Live weight	29,951	31,110
Average live weight	587	587
Overall average live weight		587
Heart Details		
Heart weight - Total	141.821	116.102
Heart Number	45	53
Average heart weight	3.15	2.19
Average heart yield	0.54%	0.37%
Normalised heart weight	3.15	2.19
Heart Weight difference	0.96	
Beef heart Values	$ 9.01	$ 9.01
Heart value	$ 28.38	$ 19.74
Total value difference ($/hd)	$8.64	

Table 15: Increase saleable liver value from rinsing heavy cattle

Liver - Calculated - No data collected		
Heavy		
	Rinsed	**Non-rinsed**
Count	51	53
Live weight	29,951	31,110
Average live weight	587	587
Overall average live weight	0	587
Liver Details		
Liver weight - Total	88	13
Liver Number	8	7
Average Liver weight	10.97	8.39
Average Liver yield	1.87%	1.43%
Normalised Liver weight	10.97	8.39
Liver Weight difference	2.58	
Beef Liver Values	$ 1.73	$ 1.73
Liver value	$ 18.97	$ 14.52
Total value difference ($/hd)	$4.46	

Weights impacted Light cattle

There was no liver weights collected on light cattle as the plant was not packing them at the time of the trials. A pro-rata calculation was undertaken based on yield gains as a % of body weight and % gain based on heavy cattle measurements.

Table 16: Offal yields collected on light cattle during trials at an MSA registered processing plant

Light cattle			
Variable & processing group	**Control**	**Rinsed**	**Difference**
Heart (kg)			
Mean	1.58	2.19	0.6
Max	2.19	2.815	
Min	1.065	1.39	
N	56	55	
Kidney (kg)			
Mean	1.12	1.19	0.1
Max	1.415	1.585	
Min	0.845	0.77	
N	26	39	
Liver (kg)			
Mean	5.71	7.53	1.8
Max	6.23	8.385	
Min	5.18	6.77	
N	6	7	
Tongue (kg)			
Mean	1.02	1.02	- 0.0
Max	1.28	1.29	
Min	0.835	0.77	
N	39	40	
Thick Skirt (kg)			
Mean	1.49	1.81	0.3
Max	2.065	2.385	
Min	0.91	1.425	
N	27	25	
Thin Skirt (kg)			
Mean	1.73	2.08	0.4
Max	2.69	2.71	
Min	0.615	0.75	
N	25	21	
Tail (kg)			
Mean	0.95	0.95	0.0
Max	1.62	1.335	
Min	0.65	0.655	
N	22	24	

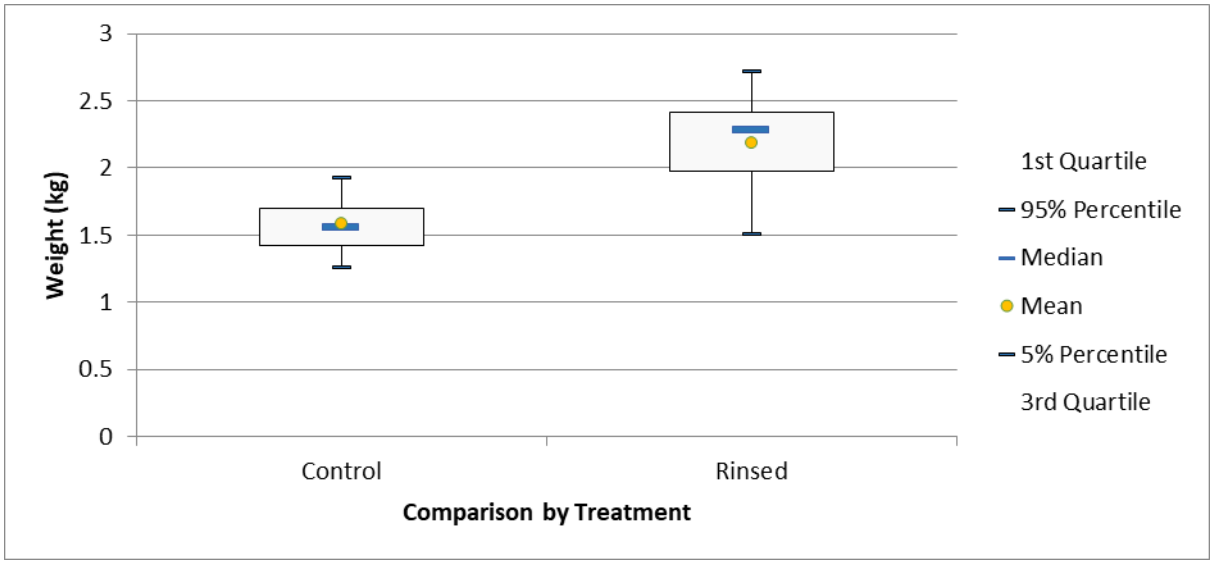

Figure 42: Heart yields from rinsed and non-rinsed light cattle

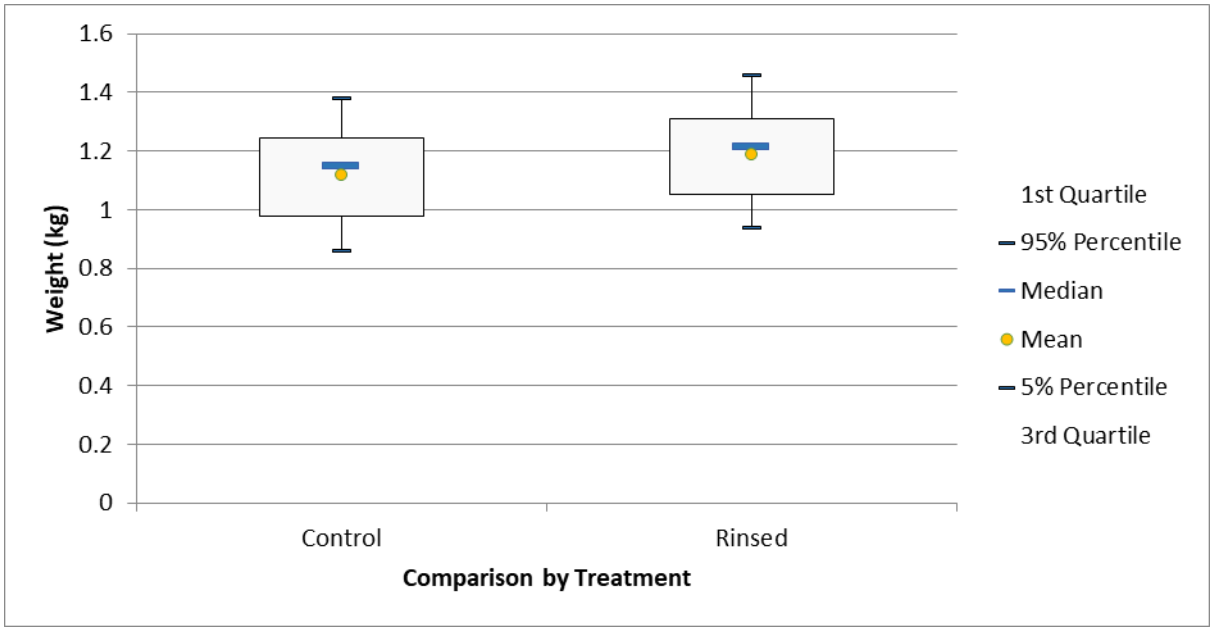

Figure 43:Kidney yields from rinsed and non-rinsed light cattle

Benefit from increase offal weights for light cattle

Table 17:Increase saleable heart value from rinsing light cattle

Hearts		
	Rinsed	Non-rinsed
Light		
Count	58	59
Live weight	23,378	23,378
HSCW	403	396
Overall average live weight		400
Heart Details		
Heart weight - Total	120.254	88.524
Heart Number	55	56
Average heart weight	2.19	1.58
Average heart yield	0.54%	0.40%
Normalised heart weight	2.17	1.59
Heart Weight difference	0.57	
Beef heart Values	$ 9.01	$ 9.01
Heart value	$ 19.53	$ 14.36
Total value difference ($/hd)	$5.17	

Table 18: Increase saleable liver value for light cattle using % liver gain from heavy cattle

Liver		
Light		
	Rinsed	**Non-rinsed**
Count	58	59
Live weight	23,378	23,583
HSCW	403	400
Overall average live weight		401
Liver Details		
Liver weight - Total	52.71	34.28
Liver Number	7	6
Average Liver weight	7.53	5.71
Average Liver yield	1.87%	1.43%
Normalised Liver weight	7.50	5.74
Liver Weight difference	1.76	
Beef Liver Values	$ 1.73	$ 1.73
Liver value	$ 12.97	$ 9.92
Total value difference ($/hd)	$3.05	

Temperature differences

- Recorded whilst sitting on the evisceration table
- No impact on the cost of chilling and freezing offal's has been included in the value proposition but is expected to enable plants to pack, freeze and ship offal quicker.

Table 19: Quantitative statistics of offal temperatures collected on cattle

Variable & processing group	Control	Rinsed	Difference
Heart (°C)			
Mean	31.63	23.66	8.0
Max	37.8	33.3	
Min	28	17.6	
N	65	62	
Kidney (°C)			
Mean	30.06	26.57	3.5
Max	37.7	33	
Min	25.3	20.7	
N	61	55	
Liver (°C)			
Mean	31.96	26.95	5.0
Max	33.9	30.1	
Min	29.5	22.2	
N	65	62	
Lung (°C)			
Mean	31.81	26.25	5.6
Max	34.6	33	
Min	27.3	21.4	
N	64	61	
Skirt (°C)			
Mean	30.05	25.75	4.3
Max	35.6	31.6	
Min	26	20.7	
N	62	58	

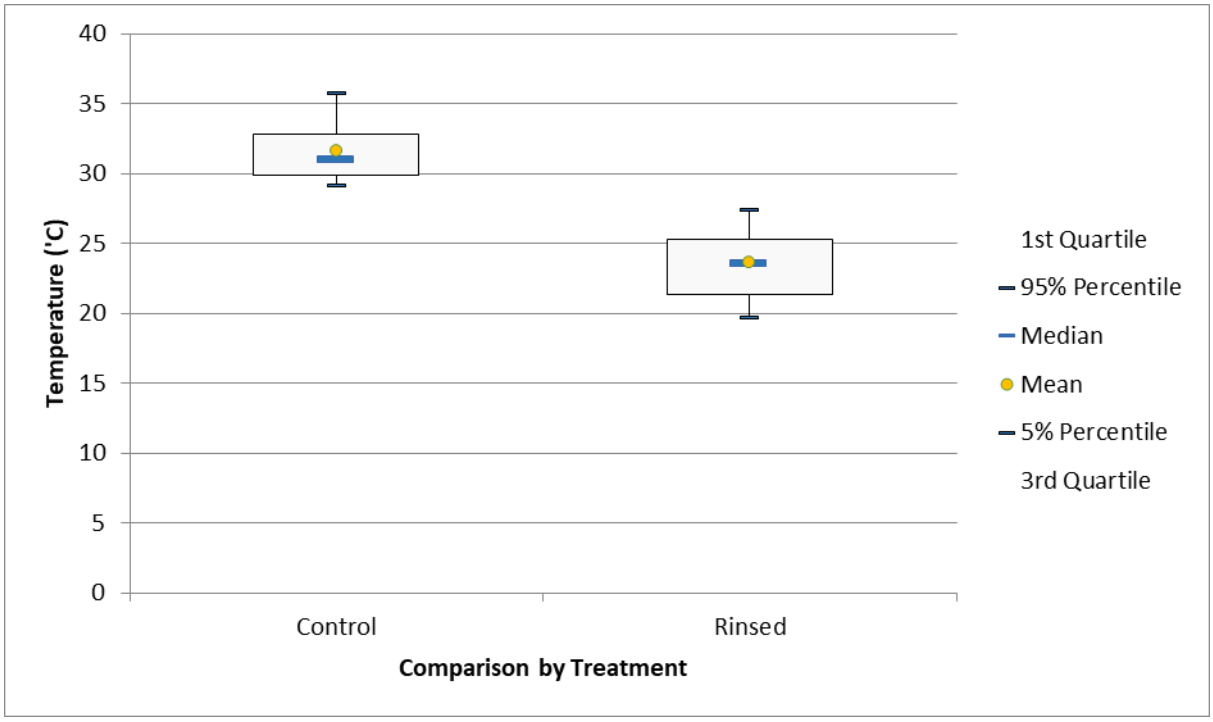

Figure 44: Heart surface temperature differences observed on cattle on the evisceration table

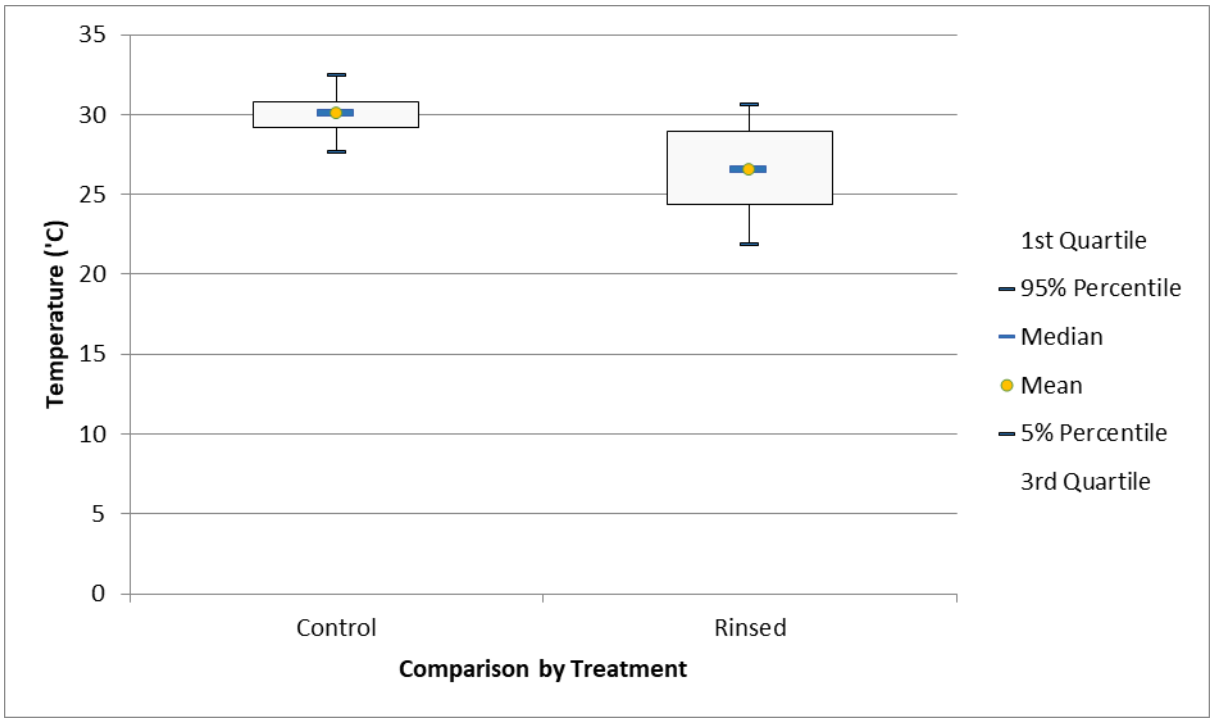

Figure 45: Kidney surface temperature differences observed on cattle on the evisceration table

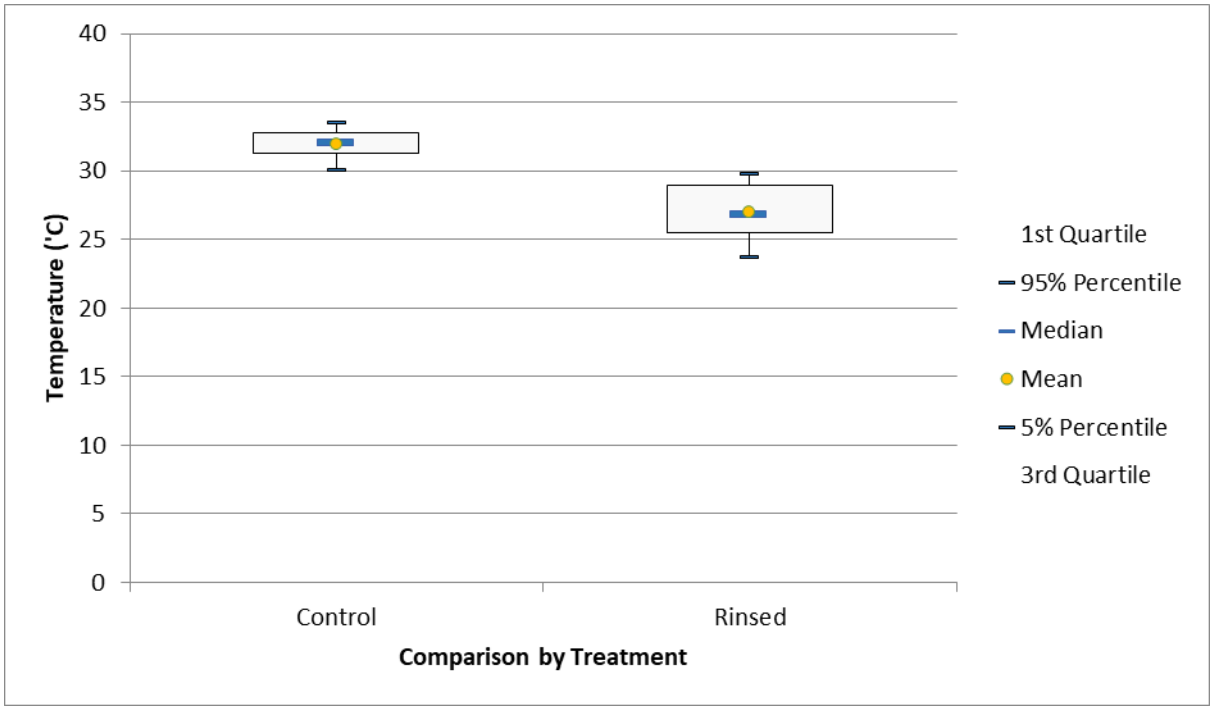

Figure 46: Liver surface temperature differences observed on cattle on the evisceration table

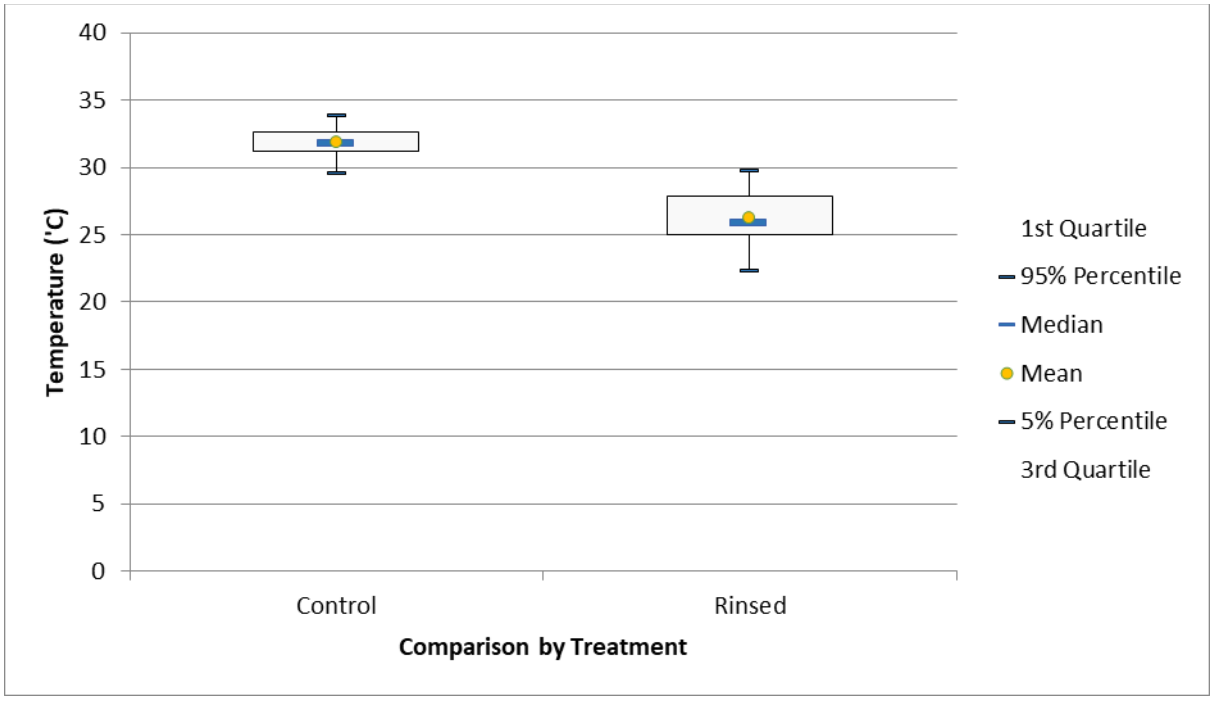

Figure 47 :Lung surface temperature differences observed on cattle on the evisceration table

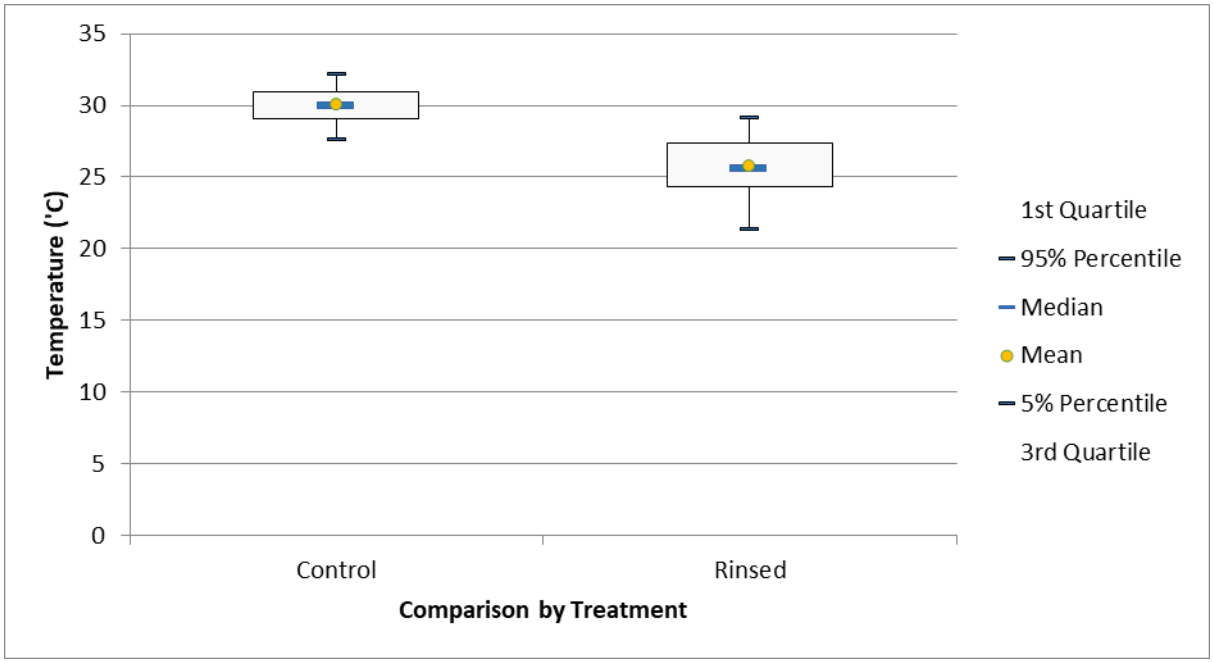

Figure 48: Skirt surface temperature differences observed on cattle on the evisceration table

4.2.3 Boning room impact

The individual packed weight gains are based on 6 months of actual yields at an MSA registered processing plant with the carcase weight gain distributed evenly across the carcase. The data provided didn't facilitate the alignment between rinsed and non-rinsed animals and yields through the boning room to calculate exact % increase at a primal level.

Heavy cattle

Infeed weight increase

Table 20: Increase packed meat weight due to an increase in carcase weight entering the boning room for heavy cattle.

Increase carcase weight benefit

	Rinsed	Non-Rinsed	Overall
Carcase weight	68,825	64,848	133,673
Number of head	200	200	400
Average weight per head	344.12	324.24	334.18

HAM	Rinsed		Non-rinsed		Primal value	Cut Values	
	Packed weight	Yield	Packed weight	Yield		Rinsed	Non-rinsed
BACK RIBS	630	0.92%	594	0.92%	$ 8.03	$ 25.28	$ 23.82
BRISKET	2,276	3.31%	2,145	3.31%	$ 6.15	$ 69.99	$ 65.95
CUBE ROLL	1,970	2.86%	1,857	2.86%	$ 27.00	$ 266.01	$ 250.64
OUTSIDE FLAT	2,617	3.80%	2,466	3.80%	$ 6.45	$ 84.39	$ 79.52
RUMP	1,791	2.60%	1,688	2.60%	$ 11.63	$ 104.13	$ 98.11
SHORT RIBS	1,247	1.81%	1,175	1.81%	$ 16.50	$ 102.92	$ 96.97
Spare Ribs	461	0.67%	435	0.67%	$ 5.10	$ 11.76	$ 11.08
STRIPLOIN	3,985	5.79%	3,755	5.79%	$ 17.25	$ 343.74	$ 323.88
TENDERLOIN SIDE STRAP OFF	802	1.17%	756	1.17%	$ 34.50	$ 138.33	$ 130.34
BLADE	3,137	4.56%	2,956	4.56%	$ 9.68	$ 151.75	$ 142.99
BOTTOM SIRLOIN TRIANGLE	342	0.50%	323	0.50%	$ 26.25	$ 44.95	$ 42.35
BRISKET NAVEL END	1,431	2.08%	1,349	2.08%	$ 6.53	$ 46.70	$ 44.00
CHUCK	3,862	5.61%	3,639	5.61%	$ 9.30	$ 179.58	$ 169.20
EYE ROUND	1,009	1.47%	950	1.47%	$ 8.93	$ 45.01	$ 42.41
FLANK STEAK	370	0.54%	348	0.54%	$ 4.95	$ 9.15	$ 8.62
HEEL MUSCLE	926	1.34%	872	1.34%	$ 8.72	$ 40.37	$ 38.04
INSIDE	2,732	3.97%	2,574	3.97%	$ 6.75	$ 92.21	$ 86.88
KNUCKLE	2,397	3.48%	2,259	3.48%	$ 6.90	$ 82.71	$ 77.93
SHIN	2,608	3.79%	2,457	3.79%	$ 5.10	$ 66.50	$ 62.65
TRIMMINGS	16,784	24.39%	15,815	24.39%	$ 5.93	$ 497.24	$ 468.51
Overall	51,379	74.65%	48,410	74.65%		$ 2,403	$ 2,264

Packed Weight increase	2,969	Yield benefit from R&C	$ 138.82
Increased packed weight per carcases	14.8		

Boning yields

The potential boning yield benefit has been excluded from the final value proposition due to limited dataset availability for non-rinsed animals. The yield gains were estimated as the trial animals were sold as carcases.

Table 21: Increase packed meat weight due to an increase in boning room yields resulting from an increased easy of boning rinsed products

Increased boning yield benefits - Normalised 400 head per day

	Rinsed	Non-Rinsed	Overall
Carcase weight	68,825	64,848	133,673
Number of head	200	200	400
Average weight per head	344	324	334.18

	Rinsed		Non-rinsed		Primal value	Cut Values	
HAM	Packed weight	Yield	Packed weight	Yield		Rinsed	Non-rinsed
BACK RIBS	1,224	0.92%	1,224	0.92%	$ 8.03	$ 24.55	$ 24.55
BRISKET	4,630	3.46%	4,421	3.31%	$ 6.15	$ 71.19	$ 67.97
CUBE ROLL	3,915	2.93%	3,827	2.86%	$ 27.00	$ 264.27	$ 258.32
OUTSIDE FLAT	5,221	3.91%	5,082	3.80%	$ 6.45	$ 84.19	$ 81.95
RUMP	3,586	2.68%	3,479	2.60%	$ 11.63	$ 104.21	$ 101.12
SHORT RIBS	2,402	1.80%	2,423	1.81%	$ 16.50	$ 99.08	$ 99.94
Spare Ribs	914	0.68%	896	0.67%	$ 5.10	$ 11.65	$ 11.42
STRIPLOIN	7,741	5.79%	7,741	5.79%	$ 17.25	$ 333.81	$ 333.81
TENDERLOIN SIDE STRAP OFF	1,564	1.17%	1,558	1.17%	$ 34.50	$ 134.88	$ 134.34
BLADE	6,360	4.76%	6,093	4.56%	$ 9.68	$ 153.84	$ 147.37
BOTTOM SIRLOIN TRIANGLE	697	0.52%	665	0.50%	$ 26.25	$ 45.72	$ 43.65
BRISKET NAVEL END	2,854	2.13%	2,780	2.08%	$ 6.53	$ 46.55	$ 45.35
CHUCK	7,673	5.74%	7,501	5.61%	$ 9.30	$ 178.41	$ 174.39
EYE ROUND	1,959	1.47%	1,959	1.47%	$ 8.93	$ 43.71	$ 43.71
FLANK STEAK	746	0.56%	718	0.54%	$ 4.95	$ 9.23	$ 8.88
HEEL MUSCLE	1,880	1.41%	1,798	1.34%	$ 8.72	$ 41.01	$ 39.21
INSIDE	5,306	3.97%	5,306	3.97%	$ 6.75	$ 89.54	$ 89.54
KNUCKLE	4,656	3.48%	4,656	3.48%	$ 6.90	$ 80.32	$ 80.32
SHIN	5,065	3.79%	5,065	3.79%	$ 5.10	$ 64.58	$ 64.58
TRIMMINGS	34,758	26.00%	32,599	24.39%	$ 5.93	$ 514.85	$ 482.87
Overall	103,150	77.17%	99,789	74.65%		$ 2,396	$ 2,333

Packed Weight increase	3,360
Increased packed weight per carcases	16.8

Yield benefit from RCT	$ 62.28

Light Cattle

Infeed weight increase

Table 22: Increase packed meat weight due to an increase in carcase weight entering the boning room for light cattle.

Increase carcase weight benefit

	Rinsed	Non-Rinsed	Overall
Carcase weight	45,891	44,651	90,542
Number of head	200	200	400
Average weight per head	229.46	223.25	226.35

HAM	Rinsed		Non-rinsed		Primal value	Cut Values	
	Packed weight	Yield	Packed weight	Yield		Rinsed	Non-rinsed
BACK RIBS	420	0.92%	409	0.92%	$ 8.03	$ 16.85	$ 16.40
BRISKET	1,518	3.31%	1,477	3.31%	$ 6.15	$ 46.67	$ 45.41
CUBE ROLL	1,314	2.86%	1,278	2.86%	$ 27.00	$ 177.37	$ 172.58
OUTSIDE FLAT	1,745	3.80%	1,698	3.80%	$ 6.45	$ 56.27	$ 54.75
RUMP	1,195	2.60%	1,162	2.60%	$ 11.63	$ 69.43	$ 67.55
SHORT RIBS	832	1.81%	809	1.81%	$ 16.50	$ 68.62	$ 66.77
Spare Ribs	307	0.67%	299	0.67%	$ 5.10	$ 7.84	$ 7.63
STRIPLOIN	2,484	5.41%	2,417	5.41%	$ 17.25	$ 214.26	$ 208.47
TENDERLOIN SIDE STRAP OFF	535	1.17%	520	1.17%	$ 34.50	$ 92.24	$ 89.74
BLADE	2,092	4.56%	2,035	4.56%	$ 9.68	$ 101.19	$ 98.45
BOTTOM SIRLOIN TRIANGLE	228	0.50%	222	0.50%	$ 26.25	$ 29.97	$ 29.16
BRISKET NAVEL END	954	2.08%	929	2.08%	$ 6.53	$ 31.14	$ 30.29
CHUCK	2,575	5.61%	2,505	5.61%	$ 9.30	$ 119.74	$ 116.50
EYE ROUND	673	1.47%	654	1.47%	$ 8.93	$ 30.01	$ 29.20
FLANK STEAK	246	0.54%	240	0.54%	$ 4.95	$ 6.10	$ 5.93
HEEL MUSCLE	617	1.34%	601	1.34%	$ 8.72	$ 26.92	$ 26.19
INSIDE	1,822	3.97%	1,772	3.97%	$ 6.75	$ 61.48	$ 59.82
KNUCKLE	1,599	3.48%	1,555	3.48%	$ 6.90	$ 55.15	$ 53.66
SHIN	1,739	3.79%	1,692	3.79%	$ 5.10	$ 44.34	$ 43.14
TRIMMINGS	11,192	24.39%	10,889	24.39%	$ 5.93	$ 331.55	$ 322.58
Overall	34,086	74.27%	33,164	74.27%		$ 1,587	$ 1,544

Packed Weight increase	922
Increased packed weight per carcases	4.6

Yield benefit from R&C	$ 42.92

Increase boning yields

Table 23: Increase packed meat weight due to an increase in boning room yields resulting from an increased easy of boning rinsed products

Increased boning yield benefits - Normalised 400 head per day

	Rinsed	Non-Rinsed	Overall
Carcase weight	45,891	44,651	90,542
Number of head	200	200	400
Average weight per head	229	223	226.35

	Rinsed		Non-rinsed		Primal value	Cut Values	
HAM	Packed weight	Yield	Packed weight	Yield		Rinsed	Non-rinsed
BACK RIBS	829	0.92%	829	0.92%	$ 8.03	$ 16.63	$ 16.63
BRISKET	3,136	3.46%	2,994	3.31%	$ 6.15	$ 48.22	$ 46.04
CUBE ROLL	2,652	2.93%	2,592	2.86%	$ 27.00	$ 179.00	$ 174.97
OUTSIDE FLAT	3,536	3.91%	3,443	3.80%	$ 6.45	$ 57.02	$ 55.51
RUMP	2,429	2.68%	2,357	2.60%	$ 11.63	$ 70.59	$ 68.49
SHORT RIBS	1,627	1.80%	1,641	1.81%	$ 16.50	$ 67.11	$ 67.70
Spare Ribs	619	0.68%	607	0.67%	$ 5.10	$ 7.89	$ 7.74
STRIPLOIN	5,243	5.79%	4,901	5.41%	$ 17.25	$ 226.10	$ 211.36
TENDERLOIN SIDE STRAP OFF	1,059	1.17%	1,055	1.17%	$ 34.50	$ 91.36	$ 90.99
BLADE	4,308	4.76%	4,127	4.56%	$ 9.68	$ 104.20	$ 99.82
BOTTOM SIRLOIN TRIANGLE	472	0.52%	451	0.50%	$ 26.25	$ 30.96	$ 29.57
BRISKET NAVEL END	1,933	2.13%	1,883	2.08%	$ 6.53	$ 31.53	$ 30.72
CHUCK	5,198	5.74%	5,080	5.61%	$ 9.30	$ 120.84	$ 118.12
EYE ROUND	1,327	1.47%	1,327	1.47%	$ 8.93	$ 29.61	$ 29.61
FLANK STEAK	505	0.56%	486	0.54%	$ 4.95	$ 6.25	$ 6.02
HEEL MUSCLE	1,274	1.41%	1,218	1.34%	$ 8.72	$ 27.78	$ 26.56
INSIDE	3,594	3.97%	3,594	3.97%	$ 6.75	$ 60.65	$ 60.65
KNUCKLE	3,154	3.48%	3,154	3.48%	$ 6.90	$ 54.41	$ 54.41
SHIN	3,431	3.79%	3,431	3.79%	$ 5.10	$ 43.74	$ 43.74
TRIMMINGS	23,543	26.00%	22,081	24.39%	$ 5.93	$ 348.73	$ 327.07
Overall	69,867	77.17%	67,249	74.27%		$ 1,623	$ 1,566

Packed Weight increase	2,618
Increased packed weight per carcases	13.1

Yield benefit from R&C	$ 56.93

4.3 Industry Value Propositions

4.3.1 Sheep

The impact of OTH trim adjustments has been calculated and presented in this section. The processor loses money by rinsing OTH carcase purchases as they pay the additional weight gain and the rinse fees. Noted they do gain the offal benefit and increased throughput (kg/labour unit) through the boning room for boned out products.

Table 24:Current value proposition without OTH trim adjustments for livestock purchased through live animal or vertically integrated supply chains

Benefit Calculations	
Producer Benefit	
Processor benefit	$ 2.55

Input	From
Increased dressing percentage	
Increased value of offal	$ 0.28
Throughput Benefit	$ 0.12
Increased packed weight due to heavier carcases	2.15

Table 25:The benefit of a processor rinsing OTH livestock

Benefit Calculations	
Producer Benefit	$ 3.18
Processor benefit	-$ 0.64

Input	From
Increased dressing percentage	$ 3.18
Increased value of offal	$ 0.28
Throughput Benefit	$ 0.12
Increased packed weight due to heavier carcases	2.15

4.3.2 Beef

The value proposition presented in Table 27 is understated as the following benefits have not been included due to a lack of data:

- Increase boning room yields on specific primals due to easier boning and different products groups absorbing more rinse solution that others (Meat, bone and fat).
- Throughput increase resulting from an increase in the kilograms slaughtered, boned, through chillers without any additional cost.
- Meat colour differences between rinsed and non-rinsed animals could not be obtained as the trial animals were sold as entire carcases.
- It is important the cost of rinsing animals is considered. For lighter cattle the producer would gain the most value for a processor purchasing rinsed animals over the hooks as per Table 28. Whereas with heavy cattle the benefit would be evenly shared on cattle that have been

purchased over the hooks. This makes the decision to rinse or not rinse for a processor complex as the following needs to be considered:

- What is the mix of livestock processed?
- If we install the system, what animals should we rinse and what should we not rinse. This if further exacerbated by the variation in dressing percentage increase in cattle from different producers. As the light cattle from different vendors in this trial had between a 0.82% and 2.98% increase in HSCW.

In summary, there are benefits for the supply chain. The impact of Rinse and Chill® on profitability for the processor depends on variables which include carcase weight and type among unknown influencing factors as shown in graphs by vendor (Figure 34 and Figure 35).

The impact of OTH rinsing is negated by processors which own vertically integrated supply chains (already own the cattle at slaughter) and live animal purchasing methods to utilise the technology prior to the development of the AusMeat trim accreditation. The only limitation that is currently on these supply chains is if they are currently selling into Korea. For individual processes this market access constraint requires a detailed benefit cost analysis to compare the financial benefits of RCT to the financial gain of selling products sold into Korea compared to other markets for specific carcase types.

Table 26: Value creation by carcase category for beef

Benefit Areas		Beef					
		% improve	$/kg	Weight (kg)	$/hd benefit	% of Pdn	Beef $/Hd
Validated	Carcase Yield Improvement (350kg)	3.60%	$ 2.93	350	$ 36.92	100%	**$ 36.92**
	Carcase Yield Improvement (230kg)	1.57%	$ 3.16	230	$ 11.41	100%	**$ 11.41**
	Heart gain (350kg HSCW)	30%	$ 9.00		$ 8.64	100%	**$ 8.64**
	Liver gain (350kg HSCW)	27%	$ 1.73		$ 4.46	80%	**$ 4.46**
	Quantified Benefit From (230kg) - To (350kg)					**$ 19.96**	**$ 50.02**
Further research needed	Increased MSA compliance	5%	$ 0.85		$ 234	64%	**$ 7.48**
	Reduced Dark cutting (Saleyard) (OTH's)*	85%			$ 31.36	2.8%	**$ 0.88**
	Reduced Shrink (w/o spray chill)	0.2%	$ 8.64		$ 1,634.40	40%	**$ 1.90**
	Improved Blood capture	40.0%	$ 3.00		$ 18.00	50%	**$ 9.00**
	Boning Yield Improvement	0.5%	$ 12.00		$ 16.50	60%	**$ 9.90**
	Easier Boning (Throughput increase)	5%	$ 0.01		$ 2.1	60%	**$ 1.26**
	Increased shelf life				$ 13.39	50%	**$ 6.70**
	Chilling Energy Reduction				$ 27.81	10%	**$ 2.78**
	Processing Capacity (carcase chilling)						$ -
	Carbon Footprint reduction						$ -
Additional estimated benefit							**$ 39.90**

**Direct Producer benefit*

Table 27: Overall value proposition for the utilisation of RCT for cattle purchased through saleyards or out of the paddock

Gross Benefit		
	Heavy Cattle (Grass & Grain fed)	Light grass finsished cattle
Benefit Calculations		
Total Benefit ($/Head)	**$ 166.44**	**$ 61.06**
Processor benefit	**$ 166.44**	**$ 61.06**
Input	**From**	**From**
Increased dressing percentage		
Increased value of offal	**$ 27.62**	**$ 18.14**
Hearts	$ 8.64	$ 5.17
Tail		
Kidney		
Tongue		
Lung		
Liver	$ 18.97	$ 12.97
Thick Skirt		
Thin Skirt		
Increase boning room yeilds	**$ -**	**$ -**
Increased packed weight due to heavier carcases	**138.82**	**42.92**
BACK RIBS	1.46	0.46
BRISKET	4.04	1.26
CUBE ROLL	15.37	4.80
OUTSIDE FLAT	4.88	1.52
RUMP	6.02	1.88
SHORT RIBS	5.95	1.86
Spare Ribs	0.68	0.21
STRIPLOIN	19.86	5.79
TENDERLOIN SIDE STRAP OFF	7.99	2.49
BLADE	8.77	2.74
BOTTOM SIRLOIN TRIANGLE	2.60	0.81
BRISKET NAVEL END	2.70	0.84
CHUCK	10.38	3.24
EYE ROUND	2.60	0.81
FLANK STEAK	0.53	0.16
HEEL MUSCLE	2.33	0.73
INSIDE	5.33	1.66
KNUCKLE	4.78	1.49
SHIN	3.84	1.20
TRIMMINGS	28.73	8.97

Table 28: OTH purchase benefit to processor

Gross Benefit		
	Heavy Cattle (Grass & Grain fed)	Light grass finished cattle
Benefit Calculations		
Producer Benefit ($/hd)	**$ 58.17**	**$ 19.62**
Processor Gross benefit	**$ 108.27**	**$ 41.43**

Input	From	From
Increased dressing percentage	**-$ 58.17**	**-$ 19.62**
Increased value of offal	**$ 27.62**	**$ 18.14**
Increase boning room yields	**$ -**	**$ -**
Increased packed weight due to heavier carcases	**138.82**	**42.92**
BACK RIBS	1.46	0.46
BRISKET	4.04	1.26
CUBE ROLL	15.37	4.80
OUTSIDE FLAT	4.88	1.52
RUMP	6.02	1.88
SHORT RIBS	5.95	1.86
Spare Ribs	0.68	0.21
STRIPLOIN	19.86	5.79
TENDERLOIN SIDE STRAP OFF	7.99	2.49
BLADE	8.77	2.74
BOTTOM SIRLOIN TRIANGLE	2.60	0.81
BRISKET NAVEL END	2.70	0.84
CHUCK	10.38	3.24
EYE ROUND	2.60	0.81
FLANK STEAK	0.53	0.16
HEEL MUSCLE	2.33	0.73
INSIDE	5.33	1.66
KNUCKLE	4.78	1.49
SHIN	3.84	1.20
TRIMMINGS	28.73	8.97

4.3.3 Lost opportunity for industry

It was identified there were a number of areas of lost value for the red meat industry. Unrealised value exists due to (1) plants with the Rinse & Chill® Technology installed that are not rinsing OTH purchased animals and (2) plants which currently have not invested in the technology due to the constraints with purchasing animals OTH. The choices on offer to the processor are to either not rinse or pay the producer for the heavier HSCW from the use of RCT when processed.

The lost opportunity to the red meat industry due to not having an OTH trim adjustment is over $10 million based on existing plants with RCT installed and 2023 rinsing data.

Table 29: Beef rinsing data for plants with RCT installed 2023

	Percentage non-rinsed	Annual Kill	Number of head non-rinsed	Lost benefit for industry
Plant 1	20%	73,451	14,457	$ 1,644,401
Plant 2	5%	72,033	3,418	$ 388,781
Plant 3	25%	70,105	17,815	$ 2,026,378
Plant 4	6%	71,773	4,388	$ 499,111
Total	14%	287,362	40,077	$ 4,558,671

Table 30: Sheep rinsing data for plants with RCT installed 2023

	Percentage non-rinsed	Annual Kill	Number of head non-rinsed	Lost benefit for industry
Plant 1	14%	956,667	134,198	$ 858,954
Plant 2	8%	1,501,894	113,682	$ 727,639
Plant 3	1%	121,379.27	1,156	$ 7,400
Plant 4	7%	849,005	57,725	$ 369,481
Plant 5	53%	1,296,831	689,123	$ 4,410,841
Total	21%	4,725,776	995,884	$ 6,374,315

RCT is operating in 4 beef plants in Australia. Due to processors being reluctant to rinse due to OTH yield gains and cost of rinse fees there were 40,000 head which weren't rinsed in 2023.The value of lost benefit to industry due non-rinsing based on the carcase and offal yield gains that could be immediately realised was $4,558,671 based on averaged benefit of $113.74 per head.

5. Conclusion

Research trials were conducted on mutton and with Angus and Angus cross cattle to investigate the financial implications of using Rinse & Chill®. The trials measured surface temperatures of offal for the first time providing valuable data on temperature differentials. The data collected allowed financial implications per carcase type to be calculated and modelled for heavy and light Angus and Angus cross animals and mutton based on benefits and buy and sell prices of livestock from the National Livestock Reporting Service.

In conclusion, the research trials measured yield benefits per carcase type and offal benefits particularly for liver and hearts for both sheep and beef. The boning room yield benefits were not measured in this trial for beef and sheep, as the animals involved in the research trials were sold as carcases. Future research is required to access boning room data to undertake analysis and calculate the value proposition using cut level data.

Rinse & Chill® provides financial gains which are currently captured by the processors when rinsing their own stock. The financial gains are attributed to increase in saleable meat, heart and liver yields and increase in boning room throughput (kilogram per labour unit per hour). The value of improved presentation of carcases was identified but not included in financial monetary gain for the supply chain. Other benefits of RCT included a decrease in offal temperatures which removed the need for ice water baths and or improved product quality due to the temperature reduction prior to packing.

Through the trial research it was identified for the mutton processing plant individual RFID hook tracking was required as a minimum of 10% of animals went through the retain rail. Inline scales are required for accurate individual carcase assessments to take into account variable pelts and digesta. It is recommended the minimum data requirements for sheep are liveweight/deadweight, pre and post rinse, post evisceration and carcase scales.

The value proposition per carcase per animal type for lamb, mutton, light and heavy beef animals (Angus and Angus cross) were calculated. The financial gain is animal type, purchase price and saleable product dependent. The saleable meat yield and boning room gains of rinsed beef products means it is economical for the processors on heavier boned out carcases to utilise RCT on own stock and OTH purchased animals.

The cost to rinse compared to the monetary gain for mutton sold as 6-way when margins are tight (between buy and sell price) is not always financially beneficial. A mutton processor noted they continued to rinse even when margins were tight due to rinsed carcases having increased blood removal and improved carcase presentation. The value of improved carcase presentation was not valued and included in the financial implications of using Rinse & Chill®. The loss in industry value due to existing MPSC customers in Australia not rinsing due to OTH purchases was calculated and estimated at $10.8 Million per year based.

5.1 Key findings

Through the use of RCT the optimisation of carcase homeostasis resulted in increased dressing percentage for mutton of 0.95% ($3.18) with an increased saleable heart (13%, $0.15) and liver (6.8%, $0.13) with total financial benefit of $3.46 per head.

The boning room benefit includes increase in saleable meat yield worth $1.94 per head and a decreased cost per kilogram boned due to an increase in boning room output valued at $0.12 per head with a total boning room benefit of $2.06 per head.

The overall supply chain benefit of using RCT for a mutton plant is $5.52 based on the data collected during the trial undertaken in this project. When lamb and mutton are purchased OTH with the processor paying the increased dressing percentage value to the producer plus the rinse fee to MPSC, the processor was making a net loss from 2015 to 2021 based on the differential between the buy price of livestock and sell price of red meat.

Beef cattle trials undertaken in this project included grassfed Angus and Angus X steers and heifers categorised as light (400kg liveweight) and heavy (587kg liveweight). Raw data from previous beef cattle trials on cull cows were also analysed. Dressing % increase ranged from 1.57% for light animals through to 3.58% for heavy animals given a benefit of $33.82 and $71.71 per head in red meat and offal sales. The range of increase in value for hearts averaged from $5.50 for light animals to $8.65 for heavy stock and $3.04 to $4.46 for livers. Boning room benefits were not able to be calculated as product in the trial was sold as whole carcases.

It is financially viable for processors to rinse larger (well muscled) animals purchased OTH (paying MPSC the rinse fee plus the producer the HSCW gain) due to the financial gain on the hearts, liver and increase in saleable meat yield post hot carcase scales.

Rinsed sheep and beef heart surface temperatures were more than 7°C colder for both species. Rinsed beef liver was 5°C cooler than the control while sheep livers were 2.4°C cooler.

The benefit of using RCT varied between lot (vendor) and carcase type. To understand when it is financially viable for processors to rinse OTH purchased animals the following weights are required for individual carcase type cost benefit analysis:

- ‘Liveweight’ or post exsanguination weight
- Pre-rinse weight
- Post rinse weight
- Post evisceration weight
- Hot standard carcase weight

Not all financial benefits of using RCT could be easily modelled with the data available. Benefits observed by the researchers and not included in the cost benefit modelling included:

- Improved presentation of carcases
- Improved presentation of 6-way product
- Less trimming required in the neck and forequarter regions
- Packing colder livers and hearts (reduced energy draw on plate or blast freezers)

5.2 Benefits to industry

Industry and processors were wanting to understand the financial implications of not rinsing OTH purchased animals as well as documenting value propositions. This project facilitated the collection and analysis of data from sheep (mutton) and from grassfed Angus X steers and heifers on the financial impact of using Rinse & Chill® for OTH purchases. The variables impacting the financial implications of using RCT was documented to support each processor being able to make a decision based on the livestock buy and sell differential, livestock types, carcase attributes, type of products sold, market outlets.

The variables which need to be considered when looking at each individual processing plant's value proposition includes:

1. Animal ownership and carcase type: OTH verses owned animals
    a. The full benefits of rinsing are retained by the processor for owned animals.
    b. The financial viability (not considering carcase appearance attributes) of rinsing OTH in smallstock is dependent on the buy – sell price differential.
    c. It is financially beneficial to rinse OTH heavier cattle based on individual carcase cost benefit analysis undertaken.
2. Offal processing and packing
    a. Pre-chilled offal improves flow of product in the offal room.
    b. Cooler livers start the cold chain earlier and supports improved temperature decline in the freezers.
3. Product sales
    a. Carcase sales – benefit gain is carcase presentation and increase in saleable product
    b. 6-way – benefit gain is cut presentation and increase in saleable product
    c. Boned product – Easier to bone according to boning room managers. Less trimming required in the neck region and increase in saleable product. Rinsed beef products can be sold in all markets except Korea. Rinsed sheep products can be sold in all markets and countries.
4. Labour availability
    a. One to two people are required to operate RCT on plant.

Through the research project it enabled documentation and validation of the data requirements to better understand what is possible and what is required regarding an OTH trim adjustment. To facilitate an OTH trim adjustment it needs to take into pregnancy status, digesta weight and pelt weight for sheep. The data points are described in the previous section which take into consideration these variables. The sheep trial documented the order of carcase flow from rinsing through the retain rail and to the hot scales. This analysis identified a minimum of 10% of the carcases were out of order for the mob involved in the trial. For smallstock plants with a separate retain rail RFID gambrel tracking would be required to enable individual carcase OTH trim adjustments.

This research was the first time the surface temperature differentials were quantified between rinsed and control hearts and livers. Measuring and quantifying the significantly cooler surface temperature of the beef hearts (32°C down to 24°C) and livers (32°C down to 27°C) was important to help processors understand the benefits of Rinse & Chill® relevant to each processing plant's offal operations. The cooling of the liver's pre-evisceration provides energy and water saving opportunities.

6. Future research and recommendations

Future research

- The beef trial animals were sold as whole carcases. Future research programs to quantify the processing plant and supply chain benefits should include boned out carcases to measure meat colour, boning room efficiencies and boning room throughput at an MSA accredited plant.
- The sheep trials were mutton from one vendor. Future trials should include lamb and multiple vendors to measure boning room efficiencies, boning room throughput and impact on saleable meat yield across vendors.
- Data points were identified which could support OTH trim adjustment however research trials are needed to identify commercially viable ways collect the data and link the data to individual carcases.

Recommendations

- The value of Rinse & Chill® is processing plant dependent. The variables to calculate the cost benefit analysis for individual processing plants has been documented to enable an informed decision.
- An OTH trim adjustment where value created is shared between processors and producers would facilitate greater industry adoption and rinsing of OTH owned animals in processing plants where RCT is currently installed.

7. References

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Li, Z., Warner, R. D., & Ha, M. (2023). Rinse and chill®, frozen storage and retail packaging influence the quality of lamb loins. *Meat Science*, *195*, doi.org/10.1016/j.meatsci.2022.109000

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Yancey, E. J., Dikeman, M. E., Addis, P. B., Katsanidis, E., & Pullen, M. (2002). Effects of vascular infusion with a solution of saccharides, sodium chloride, and phosphates with or without vitamin C on carcass traits, Warner–Bratzler shear force, flavor-profile, and descriptive-attribute characteristics of steaks and ground beef from Charolais cattle. *Meat science*, *60*(4), 341-347. doi.org/10.1016/S0309-1740(01)00141-3

8. Appendix

8.1Rinse & Chill® Value propositions

Benefit Areas		Beef						Sheep				
		% improve	$/kg	Weight (kg)	$/hd benefit	% of Pdn	Beef $/Hd	g gain	$/kg	$/hd	% of Pop.	Sheep $/Hd
Validated	Carcase Yield Improvement (350kg)	3.60%	$ 2.93	350	$ 36.92	100%	**$ 36.92**	700	$ 4.64	$ 3.20	100%	**$ 3.20**
	Carcase Yield Improvement (230kg)	1.57%	$ 3.16	230	$ 11.41	100%	**$ 11.41**					
	Heart gain (350kg HSCW)	30%	$ 9.00		$ 8.64	100%	**$ 8.64**	30	$ 5.43	$ 0.16	100%	**$ 0.16**
	Liver gain (350kg HSCW)	27%	$ 1.73		$ 4.46	80%	**$ 4.46**	50	$ 2.68	$ 0.13	70%	**$ 0.13**
	Quantified Benefit From (230kg) - To (350kg)					**$ 19.96**	**$ 50.02**	**Quantified Benefit $**				**$ 3.50**
Further research needed	Increased MSA compliance	5%	$ 0.85		$ 234	64%	**$ 7.48**					
	Reduced Dark cutting (Saleyard) (OTH's)*	85%			$ 31.36	2.8%	**$ 0.88**					
	Reduced Shrink (w/o spray chill)	0.2%	$ 8.64		$ 1,634.40	40%	**$ 1.90**					
	Improved Blood capture	40.0%	$ 3.00		$ 18.00	50%	**$ 9.00**					**$ -**
	Boning Yield Improvement	0.5%	$ 12.00		$ 16.50	60%	**$ 9.90**			$ 0.48	20%	**$ 0.10**
	Easier Boning (Throughput increase)	5%	$ 0.01		$ 2.1	60%	**$ 1.26**	5%	$ 0.01	$ 0.17	20%	**$ 0.03**
	Increased shelf life				$ 13.39	50%	**$ 6.70**			$ 1.46	20%	**$ 0.29**
	Chilling Energy Reduction				$ 27.81	10%	**$ 2.78**			$ 2.22	10%	**$ 0.22**
	Processing Capacity (carcase chilling)						**$ -**					**$ -**
	Carbon Footprint reduction						**$ -**			$ 0.01	100%	**$ 0.01**
Additional estimated benefit							**$ 39.90**	Estimated benefit		**$ 4.33**		**$ 0.65**

**Direct Producer benefit*

Beef Benefit Area Assumptions:

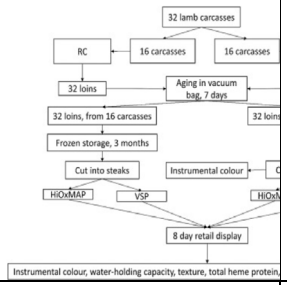
- Carcase yield improvement (350kg): data from research trial on heavier Angus and Angus X steers
- Carcase yield improvement (230kg): data from research trial on lighter (younger) Angus X steers and heifers
- $/kilogram value: average for grass and grainfed prime carcases ex plant: $3.16/kg light, $2.93 heavy
- Heart weight gain: 0.96 kilograms for averaged 350kg HSCW, 0.61 kilograms for averaged 230kg HSCW
- Liver gain: 2.58 kilograms (calculated for averaged 350kg HSCW), 1.82kg for averaged 230g HSCW
- % of Pdn: Percentage of production: assuming only 80% of livers are sold
- Quantified Benefit from (230kg) to (350kg): takes into account carcase weight plus liver and heart gain for the two carcase sizes. From is the 230kg carcase and to equates is the 350kg carcase.

Sheep Benefit Area Assumptions:

- Mutton carcase trial – 700g on average per animal that was sold as frozen six way from one animal type
- Liver % of Pop.: assumed 70% of livers are sold with calculations pro-rated to a per head value.

8.2Rinse & Chill® Reviewed published research

Lamb and Sheep research

Reference	# in experiment	What measured	Method	What found
Li, Z., Warner, R. D., & Ha, M. (2023). Rinse and chill®, frozen storage and retail packaging influence the quality of lamb loins. *Meat Science*, *195*, 109000. doi.org/10.1016/j.meatsci.2022.109000	N=16:16 lamb loins 	• RC v control • Frozen thawed v fresh • VSP v HiOxMAP • Lipid oxidation • Shear force • Water holding capacity • Colour • pH • Texture • Total heme protein	Loins were aged for seven-days (fresh), and then allocated to fresh or freezing-thawing (frozen-thawed). After storage completion loins were cut into steaks then packaged in high oxygen modified atmosphere packaging (HiOxMAP) or vacuum skin packaging (VSP) and into 8-days simulated retail display.	RC samples had lower heme protein content and lipid oxidation ($p < 0.05$ for both) compared to control samples. In frozen-thawed lamb samples, VSP resulted in lower lipid oxidation, higher red values (a^*), and lower Warner-Bratzler shear force compared to those in HiOxMAP ($p < 0.05$ for all). RC no effect on purge loss or cooking loss ($p < 0.05$ for both). RC had no effect on pH or WBSF.
Wilesmith, B., Fowler, S., Rutley, D. (2022). P.PSH.1327 Lamb meat yield benefit of Rinse and Chill. Online report https://www.mla.com.au/contentassets/7aed7e6f6fd94e038b45347d60d7c3c9/P-PSH-1327-Final-Report.pdf	Lamb N=1324, 702 Control, 697 RC, Chiller shrink for 346 carcases. Square cut shoulders - 72	• pH temp decline • hot weight • cold weight (24hrPM) • GR tissue depth • Purge for square cut shoulder (72 samples) in vacuum pack -14 day	Square cut shoulders aged for 14 days before measuring purge.	HSCW increased by 3.2%, 700g. Chiller shrink and purge no significant difference.
Ha, M., Vaskoska, R., Warner R. (2020). Shelf life and quality of Rinse & Chill lamb meat in extended chilled storage, University of Melbourne. Online Report https://mpscinc.com/wp-content/uploads/2020/11/MPSC-lamb-shelf-life-final-report_v3.pdf	30:30 lambs, 24: 24 selected. total 48 loin and topsides	• pH • weight • lipid oxidation • protein oxidation, • colour, • purge loss • bacterial counts (SPC) were measured at days 0, 60, 70, 85, 95, 105, 115 and 140	Compare the loin (*longissimus lumborum et thoracis*) and topside (*semimembranosus*) with vacuumed chilled storage over 140 days. Chilled 24 hours then processed at Uni of Melb.	Initial similar weight. Higher yield 105d in storage. pH initially higher, then went lower or the same. Colour lighter. Lipid oxidation and protein oxidation the same in loins. Total heme content, oxymyoglobin and metmyolobin were similar in the RC and control carcasses, suggesting similar level of protein oxidation. RC muscles had greater lightness and redness, greater hue angle of the loins and the chroma of the topsides. SPC better in RC product until 140d.

Rutley, D., Wilesmith, B., Baeck, A., Miller, M., Marlett, J. (2019). Small stock high speed application machine yield trial with University of Melbourne. MPSC report.	2103 Control: 2173 RC Lamb+Mutton 1900 livers 2200 hearts 3900 kidneys 2000 spleens 2000 skirts	• Shear force, • Yield carcase + offal • Meat colour		Mob average increase in dressing 1.1% for lambs, 1.5% for mutton. Heavier animals gained 2.2%, lightest animals 0.9% Shear force reduction – 18% - 22 to 18N Meat colour – 2 units lighter 34 to 36 Yield gain: 19% for kidneys 14% for livers 11% for thick skirt and 10% for hearts
Fowler, S. M., Claus, J. M., & Hopkins, D. L. (2017). The effect of applying a rinse and chill procedure to lamb carcases immediately post-death on meat quality?. *Meat science*, *134*, 124-127. doi.org/10.1016/j.meatsci.2017.07.015	N=15:15 *M. longissimus thoracis et lumborum* (LL) Left side loin Carcase 23.6kg, 9mm GR fat	• RC v control • Shear Force • Cooking loss • Purge loss • Sarcomere length • pHu • Particle size • Colour	Carcases chilled for 24 hours. pH taken. Loin boned out. Colour measurements taken. Aged 7 days in vacuum packaging. Purge loss calculated. Shear force measured.	No significant difference for cooking loss, purge loss, sarcomere length, pHu or particle size. >50% reduction in toughness (lower shear force) due to RC. Lighter (L*), yellower (b*) due to RC. No impact on redness (a*) due to RC. No impact lipid oxidation.

Beef & Bison Research				
Reference	**# in experiment**	**What measured**	**Method**	**What found**
Kethavath, S. C., da Cunha Moreira, L., Hwang, K. E., Mickelson, M. A., Campbell, R. E., Chen, L., & Claus, J. R. (2022). Vascular rinsing and chilling effects on meat quality attributes from cull dairy cows associated with the two lowest-valued marketing classes. *Meat Science*, *184*, 108660. DOI: 10.1016/j.meatsci.2021.108660 https://go.openathens.net/redirector/uq.edu.au?url=https://doi.org/10.1016/j.meatsci.2020.108409	Total N=64 Cull dairy cows Lean LE n= 16 Control:18RC Light LI n= 16 Control n=13RC Older than 42 months based on ossification of vertebrae.	• pH Temp decline • pHu • Sarcomere length • Shear Force • Colour • Moisture Fat Free (MFF) • Purge loss	*Longissimus lumborum* (LL) and *Triceps brachii* (TB) muscles were processed (steaks, ground). 7d aged before shear force testing.	RC lower pH, longer sarcomeres, lower shear force than control LE58% lower, LI 55% lower. RC greater redness, oxymyoglobin, greater total pigments and less purge. No difference between treatment and control for cooking loss. LE cows greater cooking loss compared to LI.
Hwang, K., Claus, J. R., Jeong, J. Y., Hwang, Y. H., & Joo, S. T. (2022). Vascular rinsing and chilling carcasses improves meat quality and food safety: a review. *Journal of Animal Science and Technology*, *64*(3), 397. doi.org/10.5187/jast.2022.e29				Effects of Rinse & Chill® • Enhanced blood removal • Lower internal temp by 5'C • pH decline- glycolysis complete by 6 hours lamb • Tenderness (improved shear force) • Improved meat colour & stability • Greater oxygen consumption ability • Lower hemoglobin and non-heme iron • MFF control 72.3%, RC 72.64%
Hwang, K., Claus, J. R., Jeong, J. Y., Hwang, Y. H., & Joo, S. T. (2022). Physical and biochemical mechanisms associated with beef carcass vascular rinsing effects on meat quality: a review. *Food Science of Animal Resources*, *42*(3), 389. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9108954/	Review of research using raw data of other research undertaken.		Relationship between quality attributes (CIE L*, a*, b*; chemical states of myoglobin; oxygen consumption and sarcomere length) and muscle metabolic response to various substrate solutions (Rinse & Chill®, fructose, sodium phosphate, and dipotassium phosphate).	MPSC RC stimulates the rate of glycolysis early postmortem that facilitates the decline in pH.
Australian Fresh Meat Group, (2021). Grading Advantages in Wagyu Cows. MPSC report	168 cow MSA graded carcases 85 RC, 83 control	• HSCW • meat colour • fat colour • pHu		HSCW (P=0.02), 8.5 kg, 4%.- Av 213.8 (range 153-275)

				•Meat Colour (P=0.00), 0.49 units, 19%.(2.59 to 2.1 for RC (less variation)) •Fat Colour (P=0.01), 0.28 units, 7%, reduced fat colour score by 28 units. RC3.27, Control 3.51 •ultimate pH (P=0.00), 0.05 units, 1%.from 5.64 to 5.58
K.E. Hwang & J.R. Claus 2020 Vascular Rinsing and Chilling carcasses improves meat quality and food safety	Cull dairy cows 12 control, 28 RCT	• Phosphorus & Sodium & Glucose concentration		Phosphorus and Sodium – no difference, Glucose – lower but not significantly different
Mickelson, M. A., & Claus, J. R. (2020). Carcass chilling method effects on color and tenderness of bison meat. Meat science, 161, 108002.	Bison RC=9 Control = 9 HCW -232kg	• Colour • Myoglobin • Purge • pH • sarcomere length • Shear force • Cooking loss	Muscles (*Longissimus lumborum*, LL; *Triceps brachii*, TB) were processed (LL, steaks; TB, ground), packaged (polyvinyl chloride, PVC; vacuum, VAC), and displayed or stored dark. Measurements included colour, purge, pH, sarcomere length, shear force, and cooking loss.	RC increased ($P < .05$) cooking loss 1.7% but decreased shear force 24% (C, 42.5 N; $P < .05$) in steaks. RC ground bison packaged in PVC and VAC had greater ($P < .05$) CIE L^*, a^*, and b^* values than C. RC VAC bison steaks had greater ($P < .05$) oxymyoglobin, deoxymyoglobin and decreased ($P < .05$) metmyoglobin than C VAC steaks. RC positively impacted bison steak tenderness and color in ground bison and steaks.
Claus, J. R., & Hwang, K. E. (2019). Assessment of Potential Residues in Beef Associated with Application of Beef Carcass Vascular Rinse & Chill®. https://mpscinc.com/wp-content/uploads/2020/11/RC-Residue-White-Paper-Y19M12D23-Claus-and-Hwang.pdf	108Con:108 RC 63:63: 45:45 11:28 cull cows 42 months or older	• Dextrose • Phosphorus • Phosphate	Longissimus dorsi (LD) samples (15x3 groups) were collected from the fourth lumbar vertebra, 5 cm from the dorsal midline. Samples (~300 g each) were trimmed of all visible fat	No significant difference for dextrose and phosphorus between control and RC. Pre-rigour muscles are metabolising the glucose and phosphorus.
Moreira, L. D. C., Hwang, K. E., Mickelson, M. A., Campbell, R. E., & Claus, J. R. (2019). Vascular rinsing and chilling carcasses: Effects on quality attributes and metabolic changes in beef. *Meat and Muscle Biology*, *3*(2). doi.org/10.22175/mmb.10816	Cull dairy cows Lean LE n= 10 Con:12RC Light LI n= 10 Con n=12RC	• pH decline, • shear force, • sarcomere length • cooking losses	Shear force and cooking losses were measured on *Longissimus dorsi* steaks aged (7 d). Sarcomere length (SL) was determined by a laser diffraction method.	RC reduced (P < 0.05) shear force by 51.9% (6.79 kgf CC) and 55.8% (8.50 kgf CC) for LI and LE cows. LI cows were more tender than LE for CC (6.79 vs. 8.50 kgf; P < 0.05). RC compared to CC had longer SLs (LE: 1.80 vs. 1.44µ; P < 0.05) and LI (1.80 vs. 1.40µ; P < 0.05). Purge and cooking losses were not impacted.
da Cunha Moreira, L., Connolly, C. & Claus, J. R., (2018). Vascular Rinse and Chill Effects on Meat Quality and Shelf Life of Cull Cows,	Cull cows N=10 control:12RC Lean cows (LC)	• pH temp decline • pHu • Aerobic plate count • Shear force	pH and temperature of each carcass were taken at 1, 4, 8, 12, and 24 h postmortem. Shear force and cooking loss on	RC lower CFU. No effect on moisture or fat. Age and cow type impacted results for shear force. LC no difference d7, GF RC

Meat and Muscle Biology 2(2). doi.org/10.221751/rmc2018.094	N=6 control: 5RC Grain finished cows (GF) Control: Electrically stimulated RC: Vascular rinse only	• Cooking loss • Colour • Microbial analysis • Myoglobin	steaks. Moisture, fat & colour on mince.	more tender. Cooking loss LC no different, GF RC higher.
Hunt, M. C., Schoenbeck, J. J., Yancey, E. J., Dikeman, M. E., Loughin, T. M., & Addis, P. B. (2003). Effects of postexsanguination vascular infusion of carcasses with calcium chloride or a solution of saccharides, sodium chloride, and phosphates on beef display-color stability. Journal of Animal Science, 81(3), 669–675. https://doi.org/10.2527/2003.813669x	36, 3 treatments Grainfed Hereford X Angus steers MPSC RC =12 $CaCl_2$ = 12 Contol = 12	• pH decline 1,2,4,8,16,24 • Colour • Colour stability	At 48 h postmortem, the quadriceps muscles and subcutaneous fat were removed from the carcasses, frozen, and later made into ground beef (18 to 20% fat). The longissimus lumborum (LL), semimembranosus, and psoas major (PM) also were removed, vacuum packaged, aged until 14 d postmortem, and then one steak was sliced from each muscle for visual and instrumental color evaluations.	LL and OSM steaks from MPSC-infused carcasses had a lighter red ($P < 0.05$) initial appearance than steaks from other treatments. Infusion with MPSC increased ($P < 0.05$) hue angles in the LL and OSM. No differences ($P > 0.05$) due to infusion were found for any colour traits for the PM muscle and ground beef. MPSC solution lightened loin and inside round colour in a desirable way, but the colour stability was slightly less compared to muscle from noninfused carcasses. MPSc RC muscles had a faster initial pH decline than control (hour 1-4). No pH difference 48h PM.
M. E. Dikeman, M. C. Hunt, P. B. Addis, H. J. Schoenbeck, M. Pullen, E. Katsanidis, and E. J. Yancey 2003 Effects of postexsanguination vascular infusion of cattle with a solution of saccharides, sodium chloride, and phosphates or with calcium chloride on quality and sensory traits of steaks and ground beef, J. Anim Sci 81: 156-166	36, 3 treatments Grainfed Hereford X Angus steers	• pH decline x muscles • Shear Force • Sensory panel	12 steers infused at 10% of live weight Declines in pH for three muscles were measured.	pH decline was more rapid for CaCl2- and MPSC RC-infused carcasses than for CON carcasses, but there were no differences in 24-h pH. Warner-Bratzler shear force values were much higher ($P < 0.05$), and descriptive attribute sensory panel tenderness scores much lower ($P < 0.05$), for the LL from CaCl2-infused carcasses than for MPSC RC-infused and CON carcasses. There were no distinct meat quality advantages for infusing cattle with a solution of saccharides, sodium chloride, and phosphates Dressing percentage of steers infused with the MPSC RC solution was about 4 percentage points higher ($P < 0.05$) than for CON steers, No impact on flavour.