Final report

Goatmeat quality – pathway to the future

Project code: B.GOA.0001

Prepared by: Liselotte Pannier, Jarrod Lees, David Miller

Murdoch University, University of New England

Date published: March 2021

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project aimed to map out and test pathways to address the issue of inconsistent goatmeat eating quality and product differentiation. Two processor surveys were conducted to assess critical control factors affecting goatmeat eating quality. The survey was based on the current Meat Standards Australia (MSA) sheepmeat pathways system. The survey reviewed if the application of the current sheep standards is sufficient, and whether improvements need to be made. Whilst the survey identified that many pre-slaughter animal practises are similar than those conducted in sheep, goat carcasses are typically not electrical stimulated, are not chilled for long periods of time and are not aged, which in turn may impact on the product eating quality.

Data analysis of the carcass phenotypic traits was carried out to understand the trait variation of hot carcass weight and pH decline for different subclasses such as sex, breed and weight class. The majority of the goats slaughtered were rangeland goats, and based on the historical data (from May to October), approximately half of the goats slaughtered are within the medium (12.9 – 18.2 Kg) and heavy (>18.3 kg) weight categories. Weight class played a role in the pH decline process, with the heavy weight category more inclined to have an ultimate pH > 6.0, medium weight class almost reaching pH 6, while light carcasses (< 12.8 kg) were prone to cold shortening. This indicates that a minimum weight may be required to ensure carcasses have enough weight to withstand chilling, and also shows that there is potential for particularly the rangeland goats to meet the pH temperature window, hence improvements in eating quality can be obtained with appropriate chilling regimes in combination with electrical stimulation. Both sex and breed did impact on the carcass weight range and the pH decline process, hence these animal factors may need to be accounted for when chilling and electrical stimulation configurations are further explored.

Milestones four, five and six of the project were not completed, as the project was terminated due to a lack of industry producer and processor engagement.

Table of contents

1. Background

Critical control factors affecting goatmeat eating quality are yet to be identified for the Australian goat production industry. As a result, there is inconsistency in goatmeat eating quality and product differentiation, which affects the productivity and efficiency of the industry.

2. Objectives

The overall project objectives of this project entail:
- Document current goat handling practices on-farm and at processing plants along with the impact of these practices on practicality, processing, plant markets and incentives, and eating quality
- Evaluate the current sheepmeat MSA guidelines for processors and producers for possible adaption to goatmeat
- Compile a comprehensive consultation with participating plants to document adoption incentives for a goatmeat eating quality program as well as likely barriers, and make recommendations for a potential adoption pathway
- Determine the eating quality of goatmeat of cuts of varying quality and assess factors affecting the eating quality including cooking method
- Develop producer and processor standards for the goat industry incorporating stakeholder feedback.

3. Methodology

The initial project proposal consisted out of three phases with the proposed planning for each phase outlined in milestone 1 report. These phases are:

Phase 1. Testing the sheep pathways

Phase 2. Assessing current producer standards

Phase 3. Preliminary Sensory testing

Phase 2 and 3 were not completed as the project was terminated early due to a lack of industry producer and processor engagement.

3.1 Phase 1. Testing the sheep pathways

After extensively searching and requesting numerous processing plants to participate (as outlined in milestone 1 report). Thomas Food International (TFI; Lobethal, SA) and Beaufort River Meats (BRM, WA) have been very accommodating and was willing to participate. An initial first visit was conducted in September 2019 and February 2020 at TFI and BRM respectively, to start building a relationship with the plant, and to undertake an initial survey about the on-plant animal handling prior to slaughter, processing strategy, market supply, and product differentiation. In addition, the team established the possibilities to conduct and measure the carcass phenotypic traits for the research slaughter that took place in November 2019 and March 2020.

The processing plant surveys were conducted on commercial herds (Boer, Diary and rangelands) to evaluate existing goat practices and carcass phenotypes. The survey was conducted by MSA sheepmeat trained staff, and the research group assigned to this project. Both TFI and BRM are domestic and international export plants and data was collected on the commercially goat herds that were available at the day of slaughter. Survey data collected included (and is addressed in detail throughout the report below);

- ultimate pH of the loin and eye round muscles
- pH temperature decline data to establish if cold or heat shortening occurs
- standard meat ageing times
- on plant animal handling prior to slaughter (pre-slaughter management) from arrival to slaughter (access to water, time in lairage, time off feed)
- carcass phenotypic variation (GR tissue depth, hot carcass weight, sex, breed)
- plant incentives to move forward to a goatmeat pathway system
- animal age (dentition) (collected and recorded according to Ausmeat categories)

The survey reviewed if the application of the current sheep standards are sufficient, and whether improvements need to be made. In addition, data analysis of the carcass phenotypic traits was carried out to understand the trait variation for different subclasses such as sex, breed and weight class. Key messages and recommendations are provided based on the data shown.

4. Project outcomes

4.1 Plant surveys completed, data and samples collected

In collaboration with Thomas Food International (TFI; Lobethal, SA) and Beaufort River Meats (BRM), two plant surveys and the carcass phenotypic data collections have been completed. Both plants, are both a domestic and international supplier of goat meat though the domestic proportion is very low. Detailed data has been collected on a maximum of 600 and 800 goat carcasses at TFI and BRM, respectively, and a detailed description of the traits collected and data analysis is presented below. In addition at TFI, historical data has been collected on 143,389 goat carcasses.

4.2 Data analysis completed and key messages/recommendations developed along with a value proposition for the plants

Plant survey description

The Meat Standards Australia Sheepmeat Abattoir Benchmark Assessment form (MSA plant survey; MSA Form 4.2.2; document version 2.0; see attached) was obtained and utilised to conduct a Palatability Analysis and Critical Control Points (PACCP) plant survey for TFI Lobethal plant (AUS-MEAT Accreditation number 0866) and BRM.

Thomas Foods Lobethal is a licenced Meat Standards Australia abattoir for sheepmeat and as such it is know that there are procedures in place to manage the critical control points for eating quality. As such; Sections 2: Review abattoir supplier / producer profile; 3: Assess abattoir lairage facilities; 4: Assess assembling area for pre-slaughter practices; 6: Assess voltage electrical stimulator (if applicable); 7: Assess slaughter floor practices; 9: Assess chiller operation, were modified to determine whether a PACCP approach could be applied to a goat meat pathway (where questions were appropriated for goats). The same approach was applied for BRM, although this plant is not a licenced Meat Standards Australia abattoir. These sections were determined to be the most important given data collection was focussed on the pathway to slaughter and its ability meet the pH temperature decline window. All existing sheep protocols may be applied to goat meat from supplier to load out documentation.

In brief, the current state at TFI reflects the following:

- Section 2: Goats are delivered with a National Vendor Declaration from regular suppliers, individual ear tags is not common and supply is highly variable
- Section 3: Goats are handled in the same way as sheep; all staff are trained for low-stress stock handling. Dogs are used to guide the sheep and goats.
- Section 4: Goats are handled in the same way as sheep
- Section 6: Goats are usually not electrically stimulated (MSA compliant sheep are)
- Section 7: Goats are handled in the same way as sheep; carcasses are not left in slaughter area during breaks, approximately 20min from stunning to chiller
- Section 9: Typically goat carcasses are not chilled, they are hot boned. However a subset might be held back in the chiller overnight for logistical reasons only. Furthermore, typically there are no aging practices in place.

In brief, the current state at BRM reflects the following:

- Section 2: Goats are delivered with a National Vendor Declaration from regular suppliers, individual ear tags is not common and supply is highly variable
- Section 3: Goats are handled in the same way as sheep, all staff are trained for low-stress stock handling.
- Section 4: Goats are handled in the same way as sheep, standard practices in place
- Section 6: No electrical stimulation is carried out
- Section 7: Goats are handled in the same way as sheep; carcasses are left in slaughter area during breaks, approximately 25min from stunning to chiller
- Section 9: Typically goat carcasses are chilled, they are boned the next day and frozen immediately. There are no aging practices in place.

Carcass phenotypic data – TFI Historical data

Additional to the research data that was collected, TFI has been very accommodating and have provided 6 months of goat carcass data (from May – October 2019). Majority of TFI's goat mobs are rangelands goats (almost 100%) and the data typical collected is kill date, time of slaughter (at weight scales), lot number (identified to the vendor), body number and hot carcass weight. Sex, dentition and a fat sore are also recorded, however sex is not really assessed in the plant and is based on the vendors details and might be inaccurate, whereas dentition is also not checked in the plant and is based on the operator who sets the setting. The plant's fat score is a crude visual assessment on the carcass fat score determined by the operator at the time.

Data analysis

Descriptive statistics was carried out to provide an overview of the data distribution for sex, dentition, fat score and hot carcass weight as recorded by TFI. To test the overall effect of slaughter month and sex on hot carcass weight, generalised linear models were analysed with hot carcass weight as dependent variable and month of slaughter or sex as fixed effect respectively. Additionally the effect of slaughter month across each hot carcass weight range category (explained below) was also tested by including the weight range category as fixed effect and its interaction with slaughter month.

4.2.1 Hot carcass weight distribution

TFI's 6 month data consisted out of 143,389 goat carcasses with 143,013 carcasses having hot carcass weights recorded greater than zero, starting from 2 kg up to 47.8 kg. The typical trading weight range categories are:

1. Light weight: < 12.8 kg
2. Medium weight: 12.9 – 18.2 Kg
3. Heavy weight: > 18.3 Kg

The distribution of the data based on hot carcass weight categories is shown in Figure 1. The light weight group had an average weight of 10.3 kg (± 1.7 Stdev) and a weight range of 10.8 kg, with values lower than 5.5 kg statistically considered as outliers given they are outside the 1.5 times inner quartile range. Based on this 1.1% of the light weight carcasses could be considered as outliers. For the medium weight the average weight was 15.1 kg (± 1.5 Stdev) and a weight range of 5.3 kg. The data range for the heavy weight group (average 22.3 kg (± 3.4 Stdev), weight range 29.5 kg) is the biggest with values above 30.8 kg statistically considered as outliers because they are outside the 1.5 times inner quartile range. Based on this 2.4% of the heavy weight carcasses could be considered as outliers. The goat hot carcass weight distribution within each hot carcass weight category is shown in Figure 2.

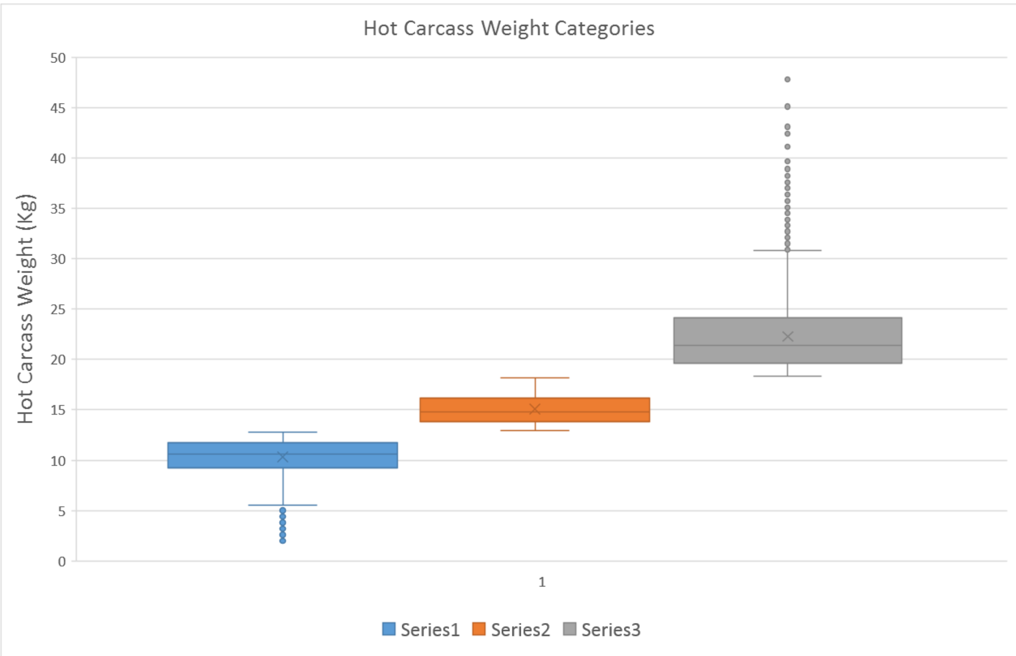

Figure 1. Goat hot carcass weight distribution according to light (series 1), medium (series 2) and heavy (series 3) weight category showing minimum, first quartile (Q1), median (-), mean (x), third quartile (Q3), and maximum hot carcass weight values.

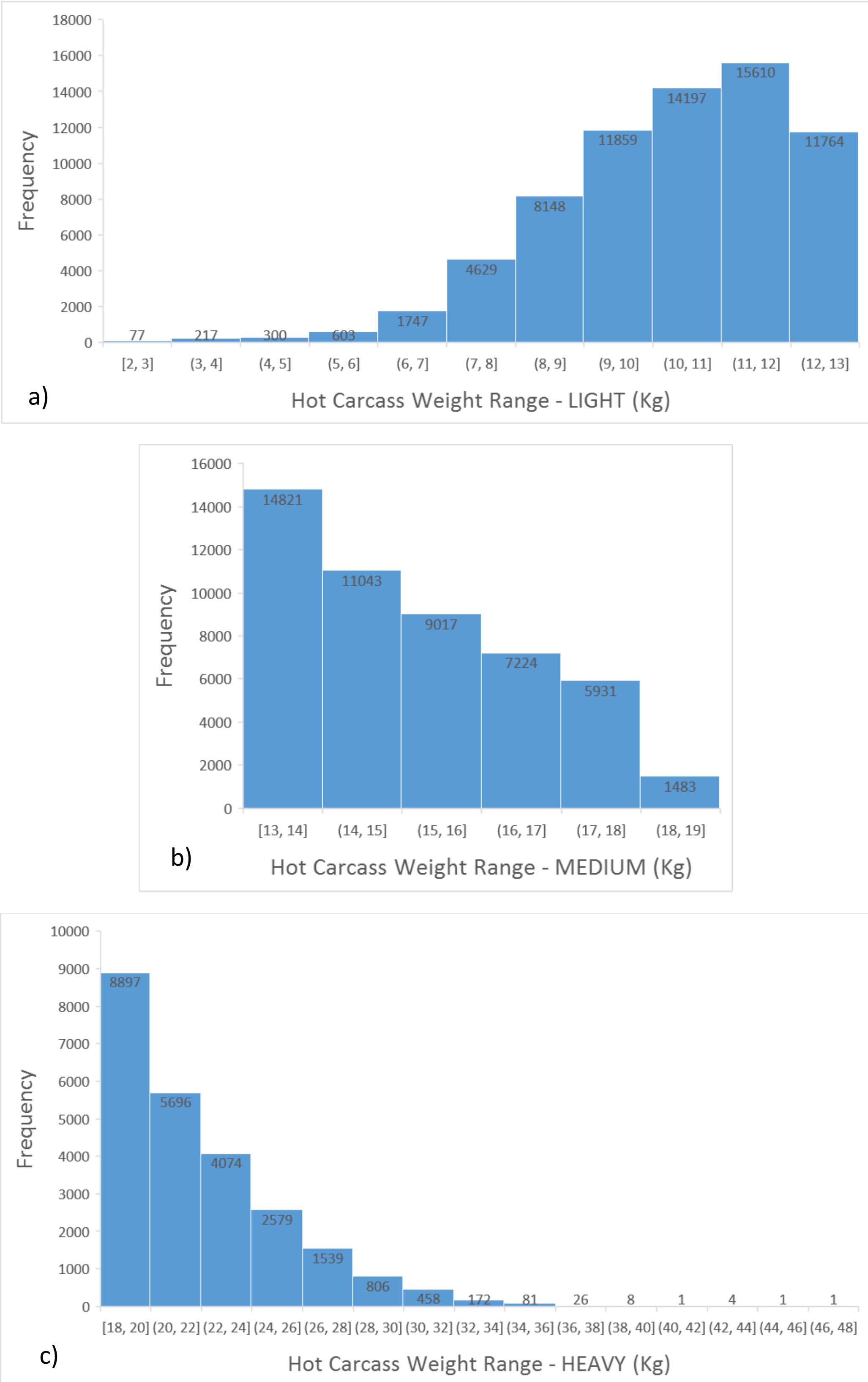

Figure 2. Goat hot carcass weight distribution within the light (a), medium (b) and heavy (c) weight category.

The proportion of the data within each hot carcass weight category is shown in Figure 3, and the proportion of data within in each weight category per month is presented in Table 1. The majority of all carcasses slaughtered are in the light weight category (n = 69,151), followed by the medium (n = 49,519) and heavy weight category (n = 24,343). This distribution remained fairly constant across all months (May to September), although the proportion of light weight carcasses decreased from May (58.2%) to September (35.5%). The medium weight proportion increased from May (27.9%) to August (38.4%), after which it relatively remained the same (September 36.4% and October 36.5%). The heavy weight proportion remained fairly unchanged across May to July, and increased from July (13.7%) to September (28.1%) after which it dropped again in October (18.6%).

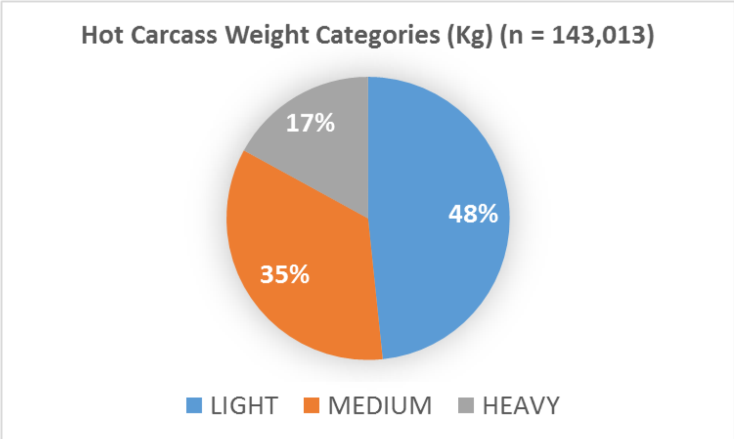

Figure 3. Proportion of goat carcasses within the light, medium and heavy weight category.

Table 1. Number, frequency (%) and unadjusted mean ± standard deviation (StDev) of the goat carcasses within the light, medium and heavy weight category across May to October.

	May			June			July			Augustus			September			October		
	n	Freq %	Mean ± StDev	n	Freq %	Mean ± StDev	n	Freq %	Mean ± StDev	n	Freq %	Mean ± StDev	n	Freq %	Mean ± StDev	n	Freq %	Mean ± StDev
LIGHT	10834	58.2	9.8 ± 1.9	13150	52.9	10.1 ± 1.7	17531	51.8	10.5 ± 1.7	16600	43.3	10.6 ± 1.6	4817	35.5	10.4 ± 1.7	6219	44.9	10.4 ± 1.7
MEDIUM	5190	27.9	15.1 ± 1.5	7926	31.9	15.1 ± 1.5	11698	34.6	14.9 ± 1.5	14714	38.4	15.1 ± 1.5	4935	36.4	15.3 ± 1.5	5056	36.5	15.1 ± 1.5
HEAVY	2580	13.9	21.9 ± 2.9	3765	15.2	21.7 ± 3	4624	13.7	21.9 ± 3	6996	18.3	22.6 ± 3.7	3808	28.1	22.8 ± 3.8	2570	18.6	22.5 ± 3.6
TOTAL	18604			24841			33853			38310			13560			13560		

Freq %: frequency percentage

4.2.2 Effect of slaughter month on hot carcass weight

On average across the three hot carcass weight categories, slaughter month had a significant effect on goat hot carcass weight ($P < 0.05$). Hot carcass weight increased across the months from May to September, after which it reduced in October (Figure 4). This effect varied when comparing the effect of slaughter month on weight within each hot carcass weight category ($P < 0.05$; Figure 5). For the light weight category, hot carcass weight increased from May (9.8 kg ± 0.02 se) to August (10.6 kg ± 0.02 se) ($P < 0.05$), after which it dropped in September (10.4 kg ± 0.03 se) ($P < 0.05$) and returned to the same July weight in October (10.4 kg ± 0.03 se) ($P > 0.05$). For the medium weight category there was less variation with hot carcass weight remaining the same for May, June, August and October (15.1 kg ± 0.03 se; $P > 0.05$). There was a slight decrease for the month July (14.9 kg ± 0.02 se) ($P < 0.05$) compared to the other months, and September had the highest weight with 15.3 kg ± 0.03 se) ($P < 0.05$). For the heavy weight category, hot carcass weight was the same for May and July (21.9 kg ± 0.04 se; $P > 0.05$), and increased across June (21.7 kg ± 0.03 se) to September (22.8 kg ± 0.03 se) ($P < 0.05$), after which it dropped in October (22.5 kg ± 0.04 se) ($P < 0.05$).

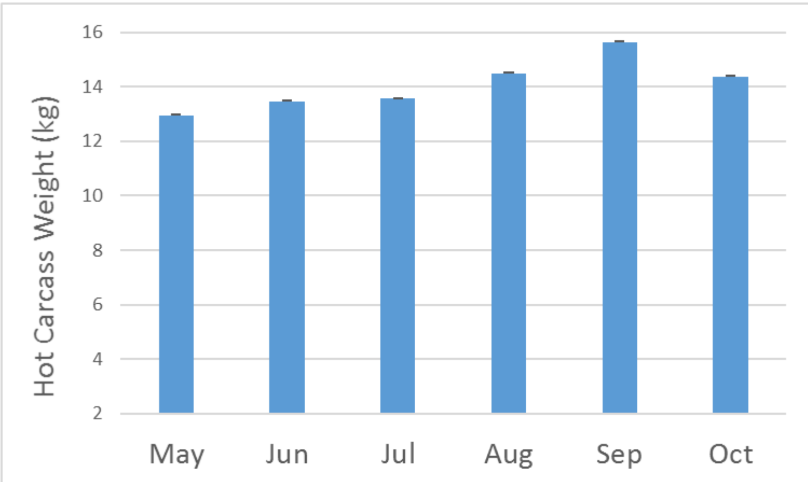

Figure 4. Effect of slaughter month on hot carcass weight + Standard Error (kg).

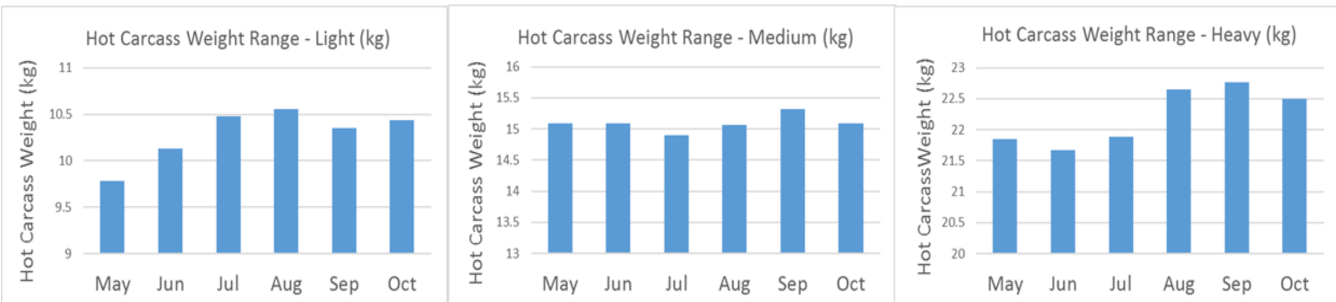

Figure 5. Effect of slaughter month on hot carcass weight + Standard Error (kg) within hot carcass weight category.

4.2.3 Fat score distribution

The fat score ranged from 3 to 20 units, with 99% of all goat carcass having a fat score of 3 (Table 2). The distribution of the fat scores across the full hot carcass weight range in shown in Figure 6, though as mentioned earlier the fat score is just a crude visual assessment.

Table 2. Number and frequency (%) of fat score.

Fat Score	n	Freq %
3	141930	99.24
5	75	0.05
6	873	0.61
9	49	0.03
10	2	0
12	72	0.05
15	11	0.01
20	1	0

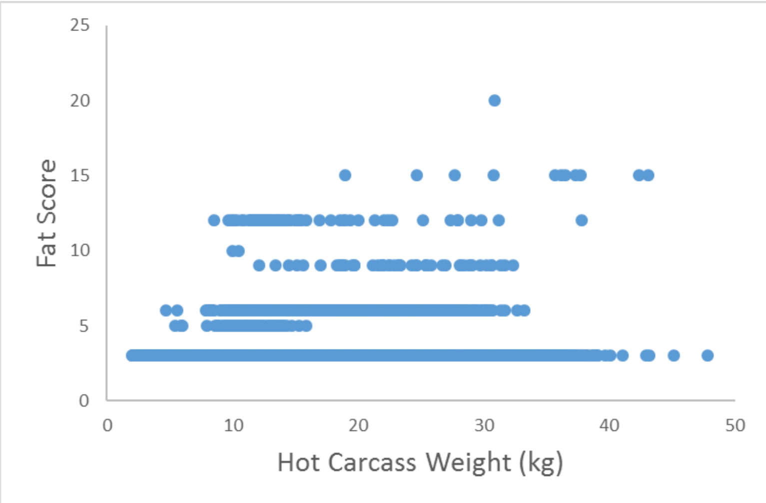

Figure 6. Effect of slaughter month on hot carcass weight + Standard Error (kg) within hot carcass weight category.

4.2.4 Sex and dentition distribution

The sex and dentition distribution are presented in Table 3. Of the total number of animals, there were 4 and 1 animal without dentition and sex records, respectively.

Table 3. Number of animals for sex and dentition.

	Dentition		Total
Sex	**2 Teeth (younger)**	**8 Teeth (older)**	
Female (Rangeland)	3	10036	10039

Female (Nanny)	114180	0	114180
Male	0	18789	18789
Total	114183	28825	143008

On average across the three hot carcass weight categories, sex had a significant effect on goat hot carcass weight ($P < 0.05$). Rangeland females had the lowest average weight (12.4 kg ± 0.05 se), followed by the female nannies (13.7 kg ± 0.01 se), with the males having the highest average weight (16.7 kg ± 0.03 se). Sex is based on the vendors details and is however not always correct.

4.3 Carcass phenotypic data – Research data

The research data collected at TFI and BRM comprised of a total of 600 and 800 goat carcasses, respectively. The data collected included time of slaughter, lot number (aligned to the vendor), body number, sex, dentition, hot carcass weight, GR tissue depth, rib count, pH decline and breed type. Sex and dentition were recorded straight after bleeding. Within 1 hour of slaughter, hot carcass weight, GR tissue depth (11cm from the midline to the lateral surface of the 12th rib) and rib count were measured on as many carcasses as possible before carcasses were being hot-boned at TFI, or remained in the chiller at BRM. pH and temperature decline were measured at 3 or 4 time points after slaughter on the M. *longissimus thoracis* et *lumborum* (LL). Ultimate pH was measured at 24h post-slaughter in the LL and the M. *semitendinosus* (ST). pH data was recorded on 160 and 186 carcasses from TFI and BRM respectively.

In addition at TFI, on the same slaughter day, a subset of carcasses was selected for the domestic market. Hot carcass weight was recorded on these carcasses but no further measurements were taken.

Data analysis

Descriptive statistics was carried out to provide an overview of the data distribution for hot carcass weight and GR tissue depth. To test the overall effect of lot, breed and sex on hot carcass weight, generalised linear models were analysed with hot carcass weight or GR tissue depth as dependent variable, and plant-lot-breed and sex within plant-lot-breed included as fixed effects. In case of GR tissue depth, the model was also corrected for hot carcass weight as covariate.

For the pH analysis, goats were grouped by lot, breed, sex, sex within breed, and weight category to determine if there were factors that effected the pH decline. pH declines were conducted on 160 goats from the research data collected. Each carcase had up to five readings in total, up to four conducted on the day of slaughter at 1 to 1.5 hour intervals and an ultimate pH the following morning, approximately 20 hours post mortem. For the purpose of this report a mean pH and temperature were calculated for each reading across a group of animals to provide an overview of the pH decline. This is in accordance with the MSA procedure for pH decline in sheep. Additionally, plant-lot-breed and sex was tested for its impact on pH. The model included plant-lot-breed, reading number (i.e. 1, 2, 3, 4 or ultimate pH), hot standard carcase weight, GR fat, and the interaction between hot standard carcase weight and GR fat and sex with non-significant terms removed.

4.3.1 Vendor, lot and breed distribution

The research data consisted of goats obtained from 12 different vendors ranging from 70 km to approximately 1000km distance away from the processing plant (Table 4). Breed distribution according to each vendor is also presented in Table 4. Majority of the goats obtained were rangeland goats, which is the typical category being slaughtered at both plants. Available animal numbers for sex by breed are presented in Table 5.

Table 4. Vendors with distance located from the processing plant, and breeds represented in each lot for both Thomas Foods International (TFI) and Beaufort River Meats (BRM).

Vendor			Breed			
Owner	distance (km)	Lot Number	Boer	Dairy	Rangelands	Total
TFI						
Cotabena	388	333674			118	
Jericho & Sons	494	333624			4	
Miller	185	333672	24	1		
Moolooloo	497	333681			96	
		333690			64	
Oksbjerg	70	333671		13		
Paulco	497	333680			119	
		333668			25	
		333689			23	
Warwick	405	333676			43	
Total			24	14	492	530
BRM						
Davidson BF & HM	597	10327			36	
Coulson LR	162	10328	28			
Carpenter	405	10329	50			
Bird Agri	120	10330	8		1	
Gabor Holdings	1003	10331			677	
Total			86	0	714	800

Table 5. Number of animals per sex and breed in the research data for both Thomas Foods International (TFI) and Beaufort River Meats (BRM).

Sex	Breed			
	Boer	Dairy	Rangelands	Total
TFI				
Female	1	11	224	
Male	24	4	324	
Total	25	15	548	588
BRM				
Female	84	0	9	
Male	2	0	705	
Total	86	0	714	800
Total				1388

4.3.2 Hot carcass weight distribution

The TFI research data consisted out of 600 goat carcasses with 530 carcasses having hot carcass weights recorded. For BRM this consisted out 800 carcasses with 738 carcasses having hot carcass weights recorded. Each processing plant has different trading weight range categories in place which were the following for TFI; Light weight: < 12.8 kg, Medium weight: 12.9 – 18.2 Kg, Heavy weight: > 18.3 Kg and for BRM; Light weight: < 15.9 kg, Medium/Heavy weight: > 16.0 kg.

The TFI distribution of the data based on the three hot carcass weight categories was fairly evenly spread and as shown in Figure 7. The light weight group had an average weight of 10.0 kg (+ 2.2 Stdev) and a weight range of 10.5 kg. For the medium weight group the average weight was 15.3 kg (+ 1.6 Stdev) with a weight range of 5.3 kg. The data range for the heavy weight group (average 24.7 kg (+ 4.6 Stdev)) was 26.2 kg which was the biggest ranging from 18.3 to 44.5 kg. For BRM, the majority of carcasses are classified under the light weight category (Figure 7) with an average weight of 11.9 kg (+ 1.9 Stdev) and a weight range of 7.6 to 15.9 kg. For the medium/heavy weight group the average weight was 21.3 kg (+ 4.5 Stdev) with a weight range of 22 kg.

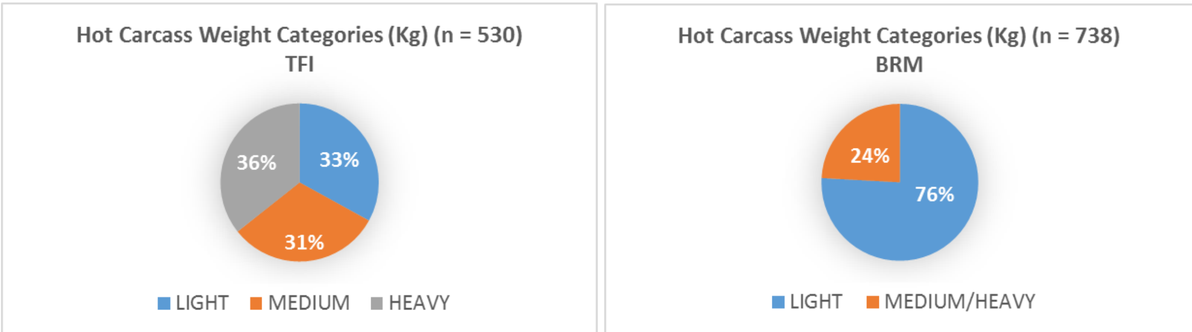

Figure 7. Proportion of goat carcasses within the trading weight categories for both Thomas Foods International (TFI) and Beaufort River Meats (BRM) of the research data collected.

At TFI, of the total 600 carcasses, a subset of carcasses (n = 50) were selected based on hot carcass weight for the domestic market. These consisted of 29 light weight (average 11.5 kg ± 0.9 StDev) and 21 medium weight (14.0 kg ± 0.8 StDev) carcasses. Typically, around 50 carcasses each week are selected for the domestic market.

The proportion of the data available, according to breed and sex within each hot carcass weight category is shown in Table 6. Predominantly most dairy goats were classified in the heavy weight category and where only present at TFI. Approximately 58% and 57% of the Boer goats were classified in the medium and light weight category at TFI and BRM, respectively. The rangeland goats were fairly evenly spread across the three hot carcass weight categories at TFI, whereas for BRM the rangeland goats made up 78% of the light weight category. As for the female goats, 59% and 60% were classified in the light weight category at TFI and BRM, respectively, whereas the male goats were predominantly (48%) heavy weight goats at TFI and light weight goats (78%) at BRM.

Table 6. Number and unadjusted mean + standard deviation (StDev) of the goat carcasses within the weight categories by breed and sex for both Thomas Foods International (TFI) and Beaufort River Meats (BRM).

	Boer		Dairy		Rangeland		Female		Male	
	n	Mean ± StDev	n	Mean ± StDev	n	Mean ± StDev	n	Mean ± StDev	n	Mean ± StDev
	TFI									
LIGHT	3	10.5 ± 2.7	1	11.1	171	9.9 ± 2.2	111	10 ± 2.3	63	10 ± 2
MEDIUM	14	16.0 ± 1.2	1	16.9	151	15.3 ± 1.6	51	14.9 ± 1.6	113	15.6 ± 1.6
HEAVY	7	21.7 ± 2.2	12	29.1 ± 8.1	170	24.5 ± 4.1	27	25.7 ± 6.5	161	24.5 ± 4.2
TOTAL	24		14		492		189		337	
	BRM									
LIGHT	48	13.0 ± 2.0			512	11.8 ± 1.9	55	12.9 ± 1.9	505	11.8 ± 1.9
MEDIUM/HEAVY	37	21.5 ± 4.1			141	21.3 ± 4.6	37	21.1 ± 4.0	141	21.4 ± 4.6
TOTAL	85				653		92		646	

4.3.3 Effect of lot, breed and sex on hot carcass weight

On average across all hot carcass weight categories, plant-lot-breed and sex within plant-lot-breed had a significant effect on goat hot carcass weight ($P < 0.01$). There was no consistent variation across the lots, or within one breed type, and when comparing the lots containing mainly rangeland goats (Table 5), there was significant variation amongst them. On average across all lots, dairy goats (24.2 + 1.6) had 6.2 kg and 8.4 kg heavier carcasses than Boer goats (18.0 + 2.1) and rangeland goats (15.8 + 1.1), respectively. On average, across all breeds and all lots male goats (18.2 + 1.4) were 3.0 kg heavier than female goats (15.2 + 1.6), however within a breed group males remained heavier than females for the Boer and rangeland goat whereas the opposite was seen for the Dairy goats.

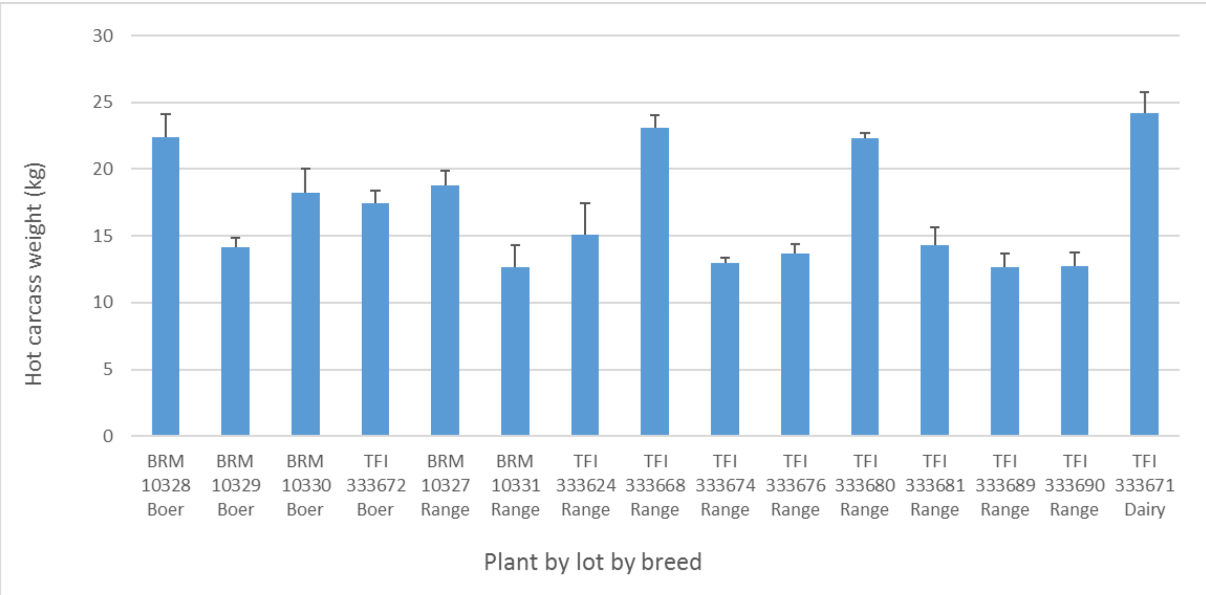

Figure 8. Effect of plant-lot-breed on hot carcass weight (kg).

4.3.4 Effect of lot, breed and sex on GR fat depth distribution

The fat score ranged from 2 to 18 mm and 0 to 13 mm for TFI and BRM goat carcasses, with majority of all goat carcass between 4 and 8 mm (average 6.0 $\pm$ 2.0 Stdev;) for TFI, and 1 and 3 mm (average 2.4 $\pm$ 1.8 Stdev) for BRM (Table 8). Sex did not impact of the GR level ($P > 0.05$), whereas plant-lot-breed was significantly different ($P < 0.05$). When corrected for hot carcass weight, the overall mean scores across all lots demonstrated the Dairy breed had 2.4 and 1.5 mm GR tissue depth more than the Boer and rangeland goats (Figure 9). Within both the Boer and rangelands lots some variation was observed (Figure 10), and particularly the lot with the Dairy breed at TFI had the highest GR tissue depth. As hot carcass weight increased, GR tissue depth increased by 4.2 mm across a 28 kg hot carcass weight range (from 5kg to 33 kg).

Table 8. Number of animals for GR fat depth distribution for both Thomas Foods International (TFI) and Beaufort River Meats (BRM).

	TFI	*BRM*
GR tissue depth (mm)	**n**	**n**
0		16
1		235
2	7	245
3	29	100
4	90	47
5	82	34
6	87	23
7	88	20
8	51	6
9	28	3
10	6	1
11	2	1
12	4	1
13	1	2
18	1	
Total	476	734

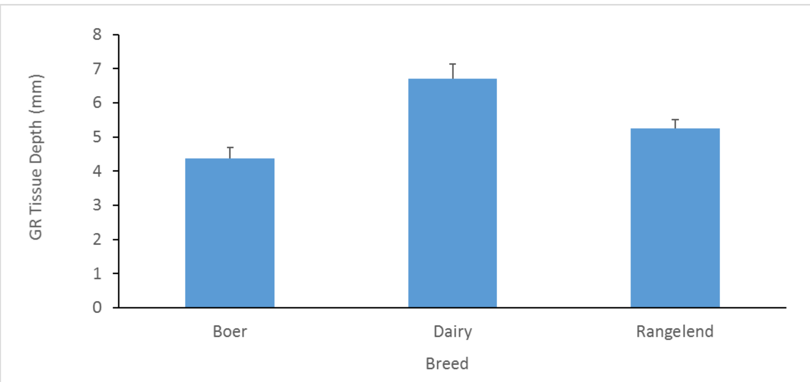

Figure 9. Effect of breed on GR Tissue Depth (mm).

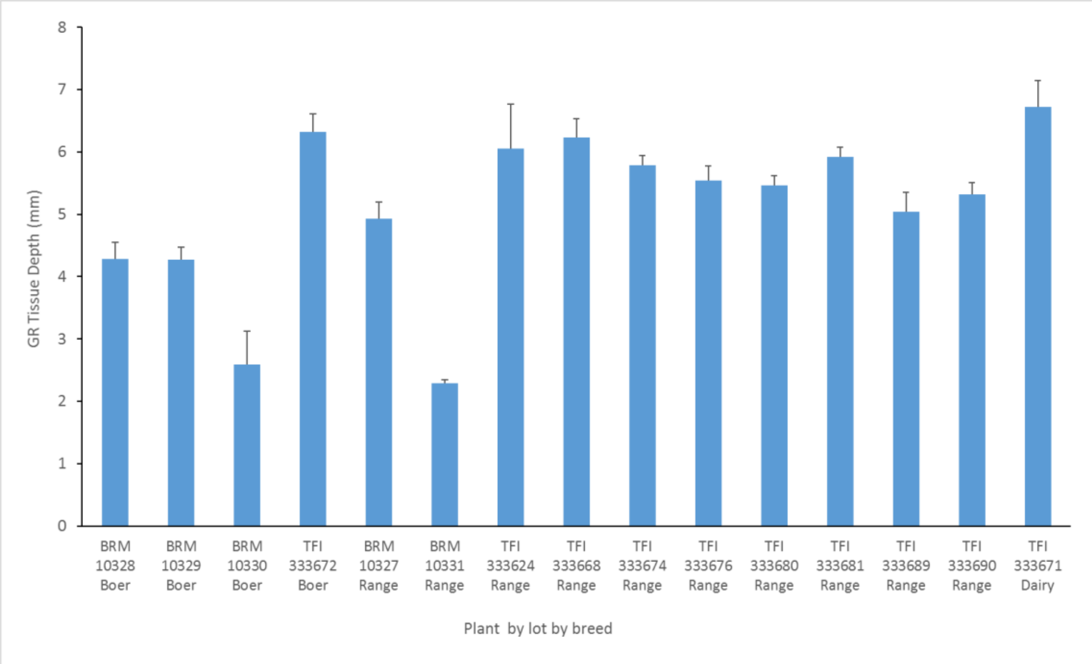

Figure 10. Effect of plant-lot-breed on GR Tissue Depth (mm).

4.3.5 Dentition distribution

As a proxy for age group, dentition was recorded which is presented in Table 9. This represents the number of permanent incisors teeth.

Table 9. Number of animals for dentition for both Thomas Foods International (TFI) and Beaufort River Meats (BRM).

Dentition	*TFI* n	*BRM* n
0	162	101
1-2	127	372
3-4	161	165
5-6	116	125
8	17	37
10	6	
Total	**589**	**800**

4.3.6 pH Decline

The goat pH decline was compared to the Meat Standards Australia reference pH temperature window for an unstimulated sheep, where pH should fall below 6.0 between 35 and 8 °C in order to avoid cold shortening. This window can be seen as a solid black line on each graph.

It must be noted that the goats at TFI had electrical stimulation applied, whereas the goats at BRM did not. This will have a significant impact on the pH decline and this is evident in the results. The pH decline for all goats measured may be seen in Figure 9 below. It shows that on average, under current industry protocols, goat carcases are not meeting the pH temperature window that is required to ensure a minimum standard of eating quality.

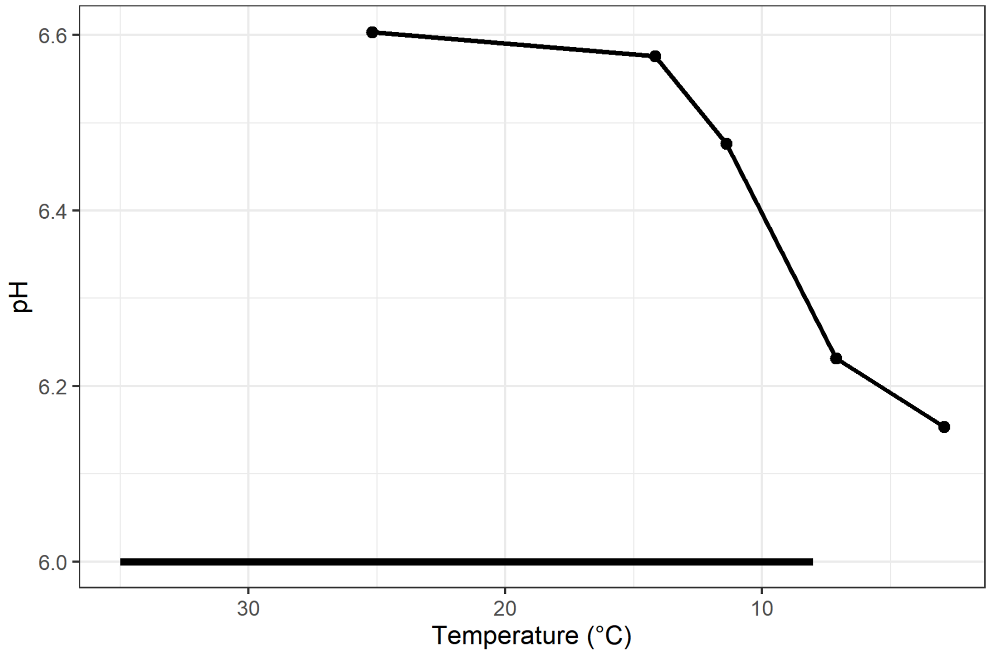

Figure 9. pH temperature decline for all goats measured at TFI and BRM

In order to determine if there were factors that effected the pH decline, goats were grouped by plant, lot within plant, breed, sex, and weight class. Simple figures were generated to show the general trends in the data and to inform the statistical modelling. These figures merely show the trends observed and must not be relied upon to make informed decisions.

Table 10. Number of goats from each breed sampled for pH temperature decline from each lot by plant

	Lot Number	Boer	Dairy	Rangeland
BRM	10327	-	-	6
	10328	28	-	-
	10329	50	-	-
	10330	3	-	-
	10331	-	-	99
TFI	333624	-	-	2
	333668	-	-	7
	333671	-	3	-
	333672	10	1	-
	333674	-	-	38
	333676	-	-	12
	333680	-	-	39
	333681	-	-	29
	333689	-	-	6
	333690	-	-	13

	Total	**91**	**4**	**251**

Figure 10 (below) outlines the pH declines for each breed type measured and shows that the Boer goats from TFI and Dairy goats were more inclined to have an ultimate pH lower than 6.0. Furthermore, these groups tended toward meeting the lower end of the pH temperature window. This may be due to the application of electrical stimulation on these carcases, causing a faster rate of decline

Unfortunately, there were no dairy goats at BRM and there were only 4 dairy goats pH declined, (three females and one male), therefore the data are not overly valuable. There is an interesting relationship occurring with the rangeland goats at BRM where the pH appears to rise again after the third reading. Figures 10, 11 and 12 identify that the rangeland males at BRM are the cause for the interesting pH decline. These carcases (n = 105) came from two different lots, with 99 head coming from one lot.

Sex was discovered to play a role in the outcome of the pH decline, with males tending to have a faster pH decline on kill day (Figure 11). This is particularly apparent at TFI. Ultimate pH was similar for both sexes at TFI as well, but less so for BRM. Furthermore, when sex and breed were taken into consideration (Figure 12) it may be seen that males generally have a faster initial pH decline when compared to females. This is not the case for Boer males at BRM, however there were only two males decline as opposed to 79 Boer females.

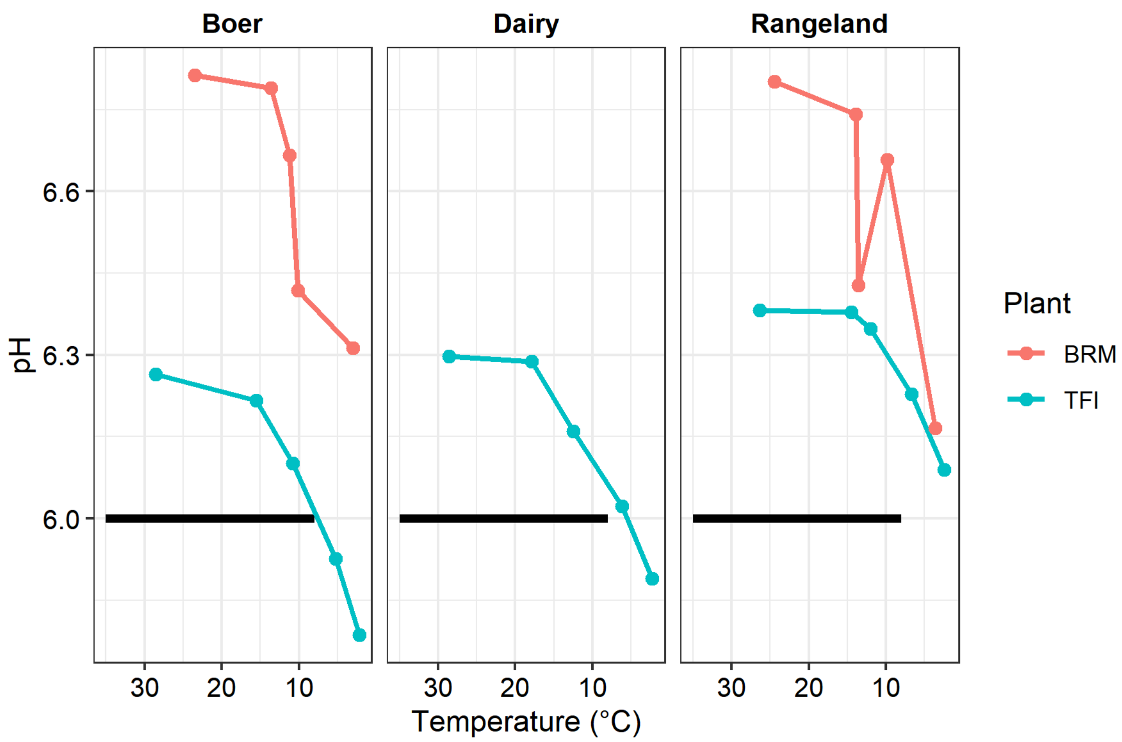

Figure 10. pH decline by breed type

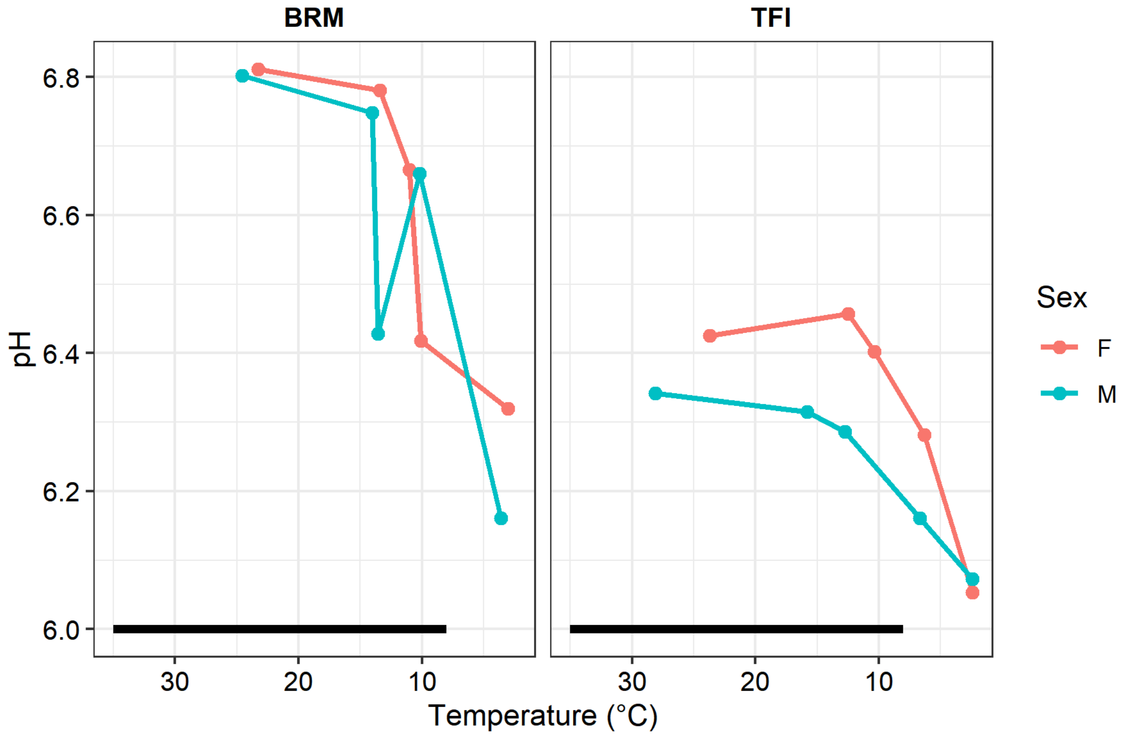

Figure 11. pH decline by sex

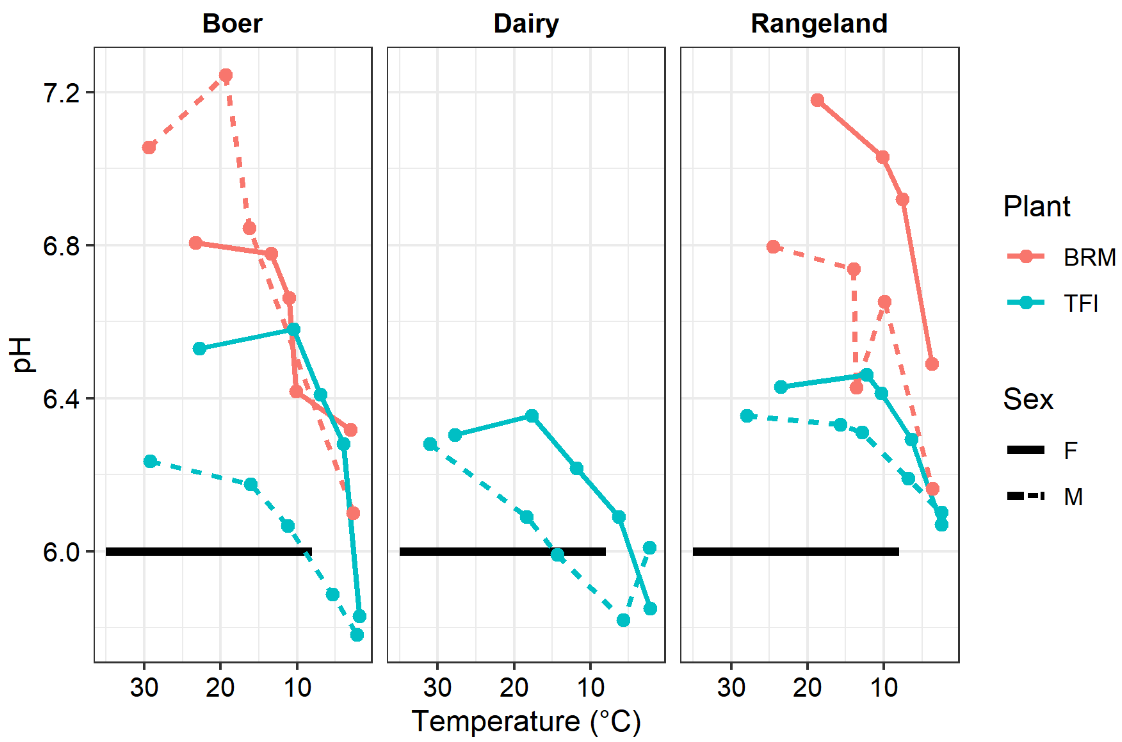

Figure 12. pH decline by sex within breed

Weight class played a role in the pH decline process (Figure 13). Heavier carcases (> 18.2 kg), while not meeting the window on average, were more inclined to have an ultimate pH < 6.0, while light carcases (< 12.8 kg) were prone to cold shortening and high pH. This is not unsurprising. Lighter carcases lose heat much quicker than heavier carcases due and as such are more inclined to chill quicker. The stimulated medium and heavy weight carcases from TFI both appear to have a similar pH and temperature decline. The goats from BRM failed, on average, to meet the pH temperature window regardless of size. Furthermore, the ultimate pH remained high indicating a lack of energy in the muscles at the time of slaughter.

The pH temperature decline is managed in sheep and beef carcases through altered stimulation and chilling regimes based on the carcase weight, fatness, feed type and pathway to slaughter. This allows for tailored solutions for each animal type and is an integral part of an eating quality program.

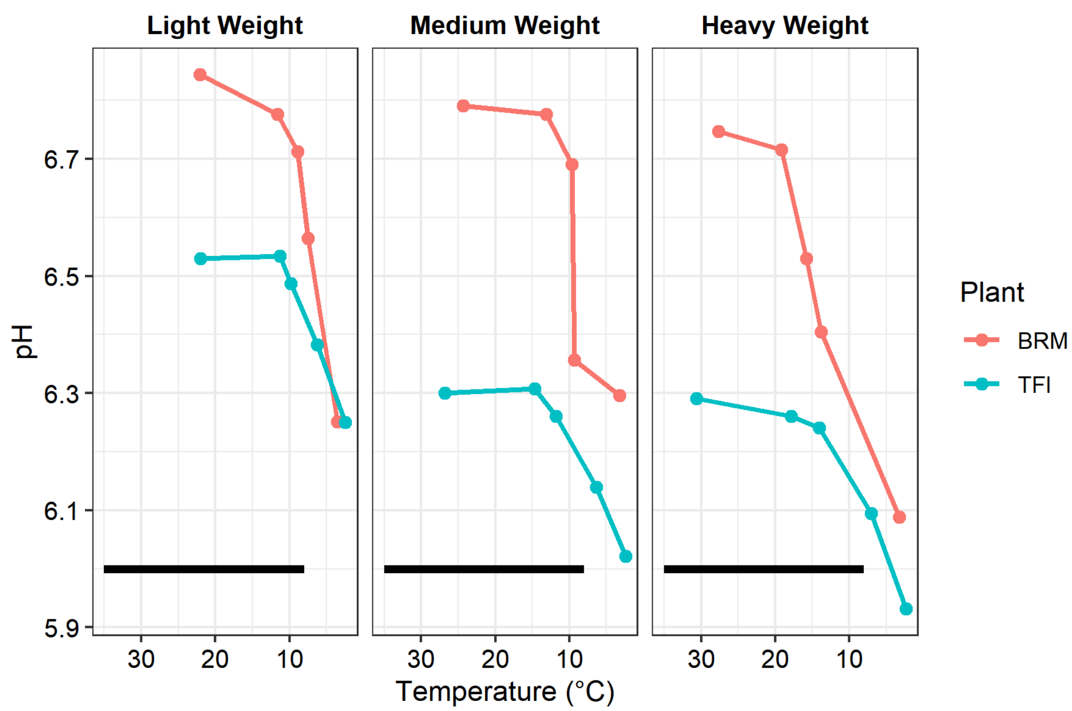

Figure 13. pH decline by weight class (light < 12.8 kg, medium 12.8 – 18.2 kg, heavy > 18.2 kg)

Sex did not appear to have an impact in heavy carcases, however there appeared to be an advantage for electrically stimulated females reaching an ultimate pH < 6.0 in light and medium weight classes (Figure 14). It is unclear if there was an effect of unstimulated carcases.

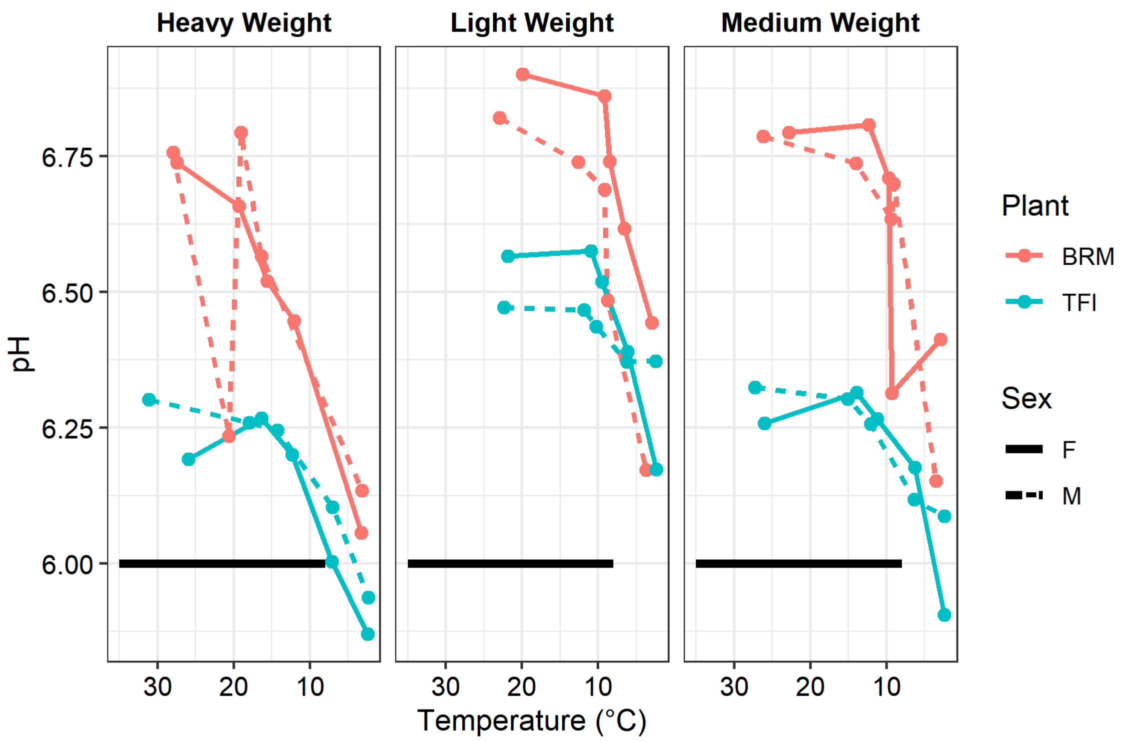

Figure 14. pH decline by sex within weight class

The above trends were utilised to assist in selecting an appropriate model to investigate the measurements that might predict pH throughout a pH decline. Due to the difference in the plants, goats within each lot, and breed within each lot, there was a requirement for these three terms to be brought together into a single term; plant-lot-breed. The subsequent model included plant-lot-breed, reading number (i.e. 1, 2, 3, 4 or ultimate pH), hot standard carcase weight, GR fat, and the interaction between hot standard carcase weight and GR fat. Sex was included in the model, but did not affect the outcome and was removed.

Estimated marginal means were calculated for readings to determine the estimated pH value at any particular reading for each lot of goats. Table 11 and figure 15 present the outcomes of the model and clearly display that at each reading the pH does steadily decline. This outcome is in agreeance with results noted from beef and sheep pH declines.

Table 11: Estimated mean pH ± SE for each reading by plant-lot-breed

plant_lot_breed	Reading 1	Reading 2	Reading 3	Reading 4	Ultimate pH
BRM_10327_Rangeland	6.69 ± 0.06	6.66 ± 0.06	6.58 ± 0.06	6.45 ± 0.06	6.24 ± 0.06
BRM_10328_Boer	6.76 ± 0.03	6.73 ± 0.03	6.65 ± 0.03	6.52 ± 0.03	6.31 ± 0.03
BRM_10329_Boer	6.8 ± 0.02	6.77 ± 0.02	6.7 ± 0.02	6.56 ± 0.03	6.35 ± 0.02
BRM_10330_Boer	6.63 ± 0.07	6.6 ± 0.07	6.52 ± 0.07	6.39 ± 0.07	6.18 ± 0.07
BRM_10331_Rangeland	6.63 ± 0.02	6.6 ± 0.02	6.52 ± 0.03	6.39 ± 0.03	6.18 ± 0.02
TFI_333624_Rangeland	6.3 ± 0.08	6.27 ± 0.08	6.19 ± 0.08	6.06 ± 0.08	5.85 ± 0.08
TFI_333668_Rangeland	6.48 ± 0.05	6.46 ± 0.05	6.38 ± 0.05	6.24 ± 0.05	6.03 ± 0.05
TFI_333672_Boer	6.26 ± 0.04	6.24 ± 0.04	6.16 ± 0.04	6.03 ± 0.04	5.81 ± 0.04
TFI_333674_Rangeland	6.41 ± 0.02	6.39 ± 0.02	6.31 ± 0.02	6.17 ± 0.03	5.96 ± 0.02

TFI_333676_Rangeland	6.55 ± 0.04	6.52 ± 0.04	6.44 ± 0.04	6.31 ± 0.04	6.09 ± 0.04
TFI_333680_Rangeland	6.44 ± 0.03	6.41 ± 0.03	6.33 ± 0.03	6.2 ± 0.03	5.99 ± 0.03
TFI_333681_Rangeland	6.54 ± 0.03	6.51 ± 0.03	6.44 ± 0.03	6.3 ± 0.03	6.09 ± 0.03
TFI_333689_Rangeland	6.34 ± 0.05	6.31 ± 0.05	6.24 ± 0.05	6.1 ± 0.05	5.89 ± 0.05
TFI_333690_Rangeland	6.68 ± 0.04	6.65 ± 0.04	6.57 ± 0.04	6.44 ± 0.04	6.22 ± 0.04

Figure 15 shows some promise for the ability of goats to meet a pH temperature decline. Where reading 4 sits on or near the black horizontal line situated at pH 6.0, there is evidence that the lot has the ability to meet the pH temperature window. Admittedly, the temperature of the meat at the fourth reading was usually below 8 degrees. As such these goats sit within the cold shortening end of the window. However this provides evidence that with the right chilling and stimulation regime, the ph temperature window may be met.

Plant (or stimulation status) appeared to have the most effect over the pH decline of the goats, with the BRM goats not presenting below pH 6.0. However, the stimulated goats which came near to or met the pH temperature window included both Boer and Rangeland goats. This indicates that there are goats among the Rangeland population that have the ability to meet a minimum eating quality standard. The lot differences would in part reflect the distances the goats travelled however due the confounding nature of the data, the distance travelled and the other factors impacting each lot cannot be separately analysed.

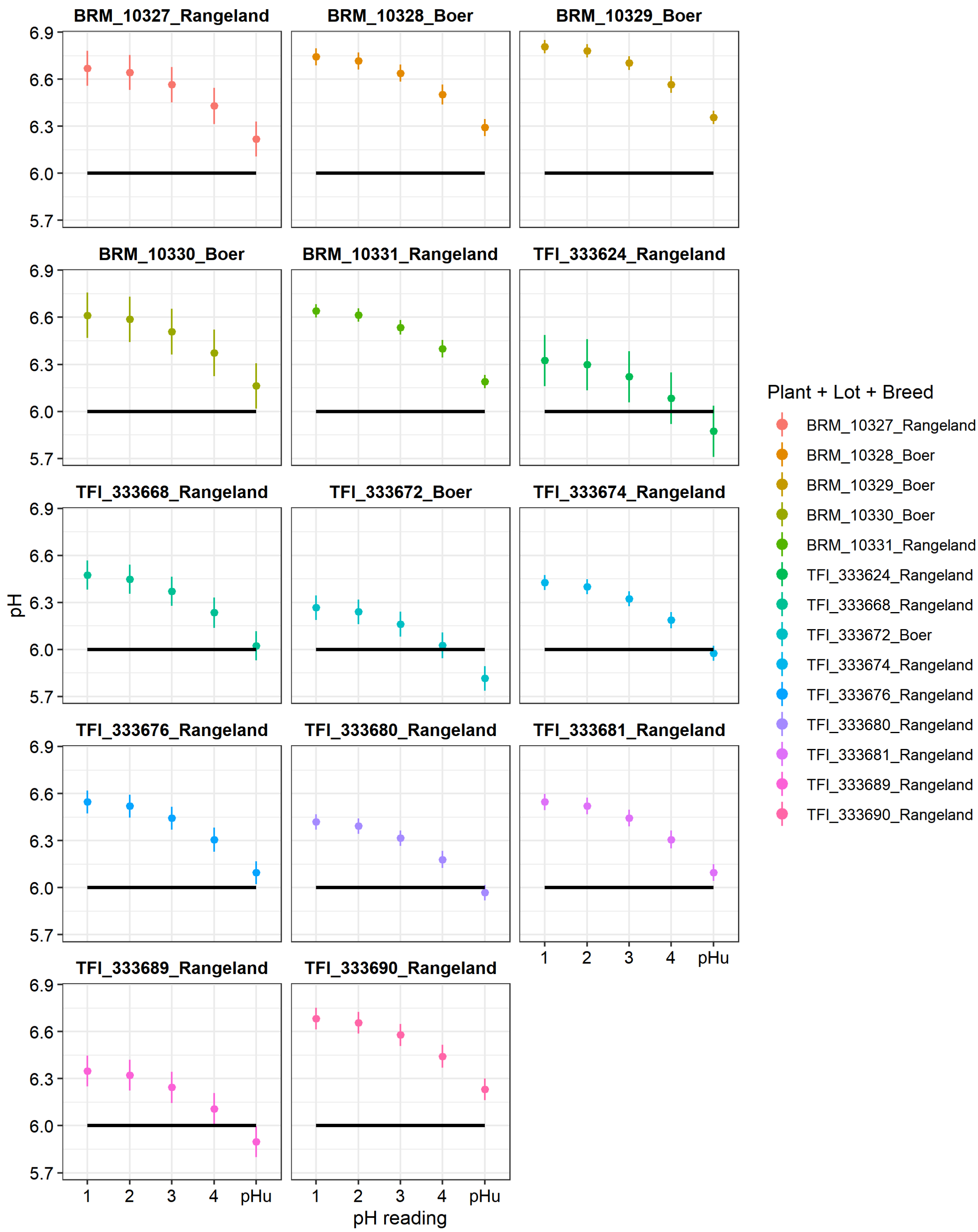

Figure 15. pH temperature decline for each individual lot of goats

5. Key messages/recommendations

Based on the obtained data and the data analysis, some key messages and recommendations can be retrieved.

- Currently there are no specific goat classification systems in place, except selection is based on hot carcass weight. No other selection measurements are taken at the processor level.
- The goat domestic market is approximately 10% of production, and there are no obvious, direct incentives from a processor point of view to increase this, when demand remains low.
- A minimum weight may be required, similar to the MSA minimum weight of 18 kg for lamb, and 16 kg for young lamb. This will assist in ensuring carcases have enough weight to withstand chilling. What the minimum weight would be dependent on further pH declines across multiple mobs and varied chilling regimes.
- Further to the above point, chilling and electrical stimulation configurations must be explored to determine the best chilling regime for goats. Moreover, these regimes would need to be specific of the breed type, weight class, fat class, and management background. It is clear from this research that electrical stimulation is non-negotiable.
- At a later stage if goat meat quality proves to be very acceptable to consumers when tested through MSA eating quality protocols, a proposition could be made to electrically stimulate goat carcasses and implement chilling regimes to provide a more consistent product.
- Many goats, including rangeland goats, met an ultimate pH < 6.0, highlighting that the carcases measured had enough glycogen to drop pH post slaughter. This indicates that improvements in eating quality can be obtained with appropriate chilling regimes. The goatmeat from these carcases have met a similar pathway to MSA sheepmeat and met the basic requirements for eating quality.
- Management of goats prior to slaughter is an area that needs further investigation to determine what is required for a goat to meet basic eating quality requirements.
- So far, data has been collected in two plants. Though a substantial amount of data was collected in these plants, they does not represent the entire industry. Specifically, they do not represent the smaller abattoirs that may be supplying to the domestic market; an obvious area for the development of an eating quality program.
- Dairy goats are the heaviest and had the highest GR tissue depth, though only a small proportion of the data collected was Dairy.
- The rangelands goats, which show to be the greatest goat category for slaughter, provided a wide distribution in weights, but may need to be restricted to a medium and high weight category to obtain the ultimate pH. This weight range could be affected by the months the supply came through.
- Further plant surveys could be conducted on rangelands goats when potential weight specifications, and right chilling and stimulation regime are introduced.

5.1 Meetings conduced with participating plants to assess implementation, incentives, adjustments to be made to the draft standards and barriers to adoption

Whilst the development of industry standards is a huge undertaking including all industry partners, meetings with TFI and BRM have taken place twice mainly to understand their position in the goat market. This is still ongoing, and it is early days to set up draft standards as this fully relies on the industry's participation. The survey reviewed if the application of the current sheep standards are sufficient, and whether improvements need to be made. Key messages and recommendations are provided based on the data shown, however before moving forward with drafting new and improving existing processor standards, more meetings with MLA and the processor need to be conducted to determine:

1. If the analysis and data collected is sufficient
2. If any additional work is required
3. If the key messages and recommendations are reasonable
4. Where there is room for possibility for changes to be made to processing practices
5. If the processors are willing to take up any change

After discussions and approval with MLA regarding the content of this report, the research team will discuss this report with TFI and BRM.