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Sensory evaluation of Australian and American briskets, striploins and ribs by Australian and American consumers utilising genomic tested cattle

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Abstract

With the increased utilisation of Meat Standards Australia (**MSA**) to underpin branded products in export markets, it is essential that the accuracy of the MSA models' predictions for international markets is quantified and the matrix is expanded to include key cooking styles in these countries. Australian and USA consumers were recruited for sensory testing of Australian beef briskets and ribs cooked using the low 'n slow cook method. Furthermore, USA consumers were recruited for sensory testing of striploins aged for up to 84 d with live cattle genomic information recorded.

This project provides the Australian industry with valuable insights into i) consumer perceptions of low 'n slow barbeque in the domestic market and a major export market, ii) the potential for using the low 'n slow barbeque method to improve the eating quality of secondary cuts, and iii) the effect of long ageing striploins on eating quality.

Executive summary

The low ‘n slow barbeque method for cooking beef briskets and ribs is well established in the United States of America (**USA**), however this method is only now gaining traction in the Australian domestic market. Therefore, this method of cooking highlights an area of increased returns for secondary cuts of traditionally low value. In an effort to maintain currency in today’s market, it is essential that the Meat Standards Australia (MSA) program continues to provide eating quality predictions that are both accurate and relevant to current practices and future trends.

Additionally, long ageing of meat under vacuum packaged conditions is a practice that is widespread in the Australian meat industry, providing a solution to storing chilled beef for the export and domestic market. However, the current MSA model does not account for the effect of long ageing periods on the eating quality of beef.

This project sought to answer i) the effect of long ageing of striploins on consumer sensory perceptions, as well as ii) the consumer acceptability of a new cook method (low ‘n slow barbeque) and iii) how Australian beef would be perceived in an export market with experience in this cook method.

Striploins were collected from carcases sourced from the United States Department of Agriculture’s MARC herd of genomically tested animals. Striploins were portioned and assigned to different ageing treatments (7 d increments from 21 – 84 d) before freezing down. Untrained consumer sensory testing was conducted and samples were scored for tenderness, juiciness, flavour and overall liking on a 100 point analogue scale. The outcomes from this portion of the project were inconclusive. It appears that eating quality decreased from 21 d to 84 d, an outcome that was not expected. It is unclear why this was the case and further work, or replication of this study, will need to be conducted in this space to determine how long ageing effects eating quality.

Australian briskets and ribs were collected from carcases (n = 90) with a wide range in eating quality, from a northern (low quality carcases) and southern abattoir (low – high quality carcases). Briskets and ribs from 60 carcases were sent to Texas Tech University to test the effect of serving brisket Hot, or as reheated beef. A further 30 briskets and 30 ribs (from one side of the remaining 30 carcases) were sent to Texas Tech University, with the matching side being stored at the University of New England for testing of Australian and USA consumers. All briskets were served as either a chopped, pulled or sliced sample; all three being considered relevant portioning methods for low ‘n slow barbeque brisket.

Briskets were considered acceptable by Australian and USA consumers, with estimated meat quality (MQ4) scores of 54.1 for the *M. pectoralis profundus* (BRI056) and 63.5 for the *M. pectoralis superficialis* (BRI057) from the entire sample. This places the majority of beef briskets in the Good Everyday category of the Meat Standards Australia program, with a large portion of the BRI057 muscles tested in the Better than Everyday category, if not Premium. Serve method (chopped, pulled or sliced) provided differing consumer sensory outcomes, with pulled being considered the least favourable, and chopped and sliced performing similarly.

Reheating brisket meat was shown to reduce the eating quality as measured by untrained consumer panels. The difference in MQ4 score was 4.1, with hot product averaging 69.3 as opposed to 65.2 for

reheated, across both BRI056 and BRI057. While this may not matter for freshly cooked and served product, this outcome has implications for value adding beef brisket into ready-to-heat meal solutions.

Overall, this project has provided valuable data on;

1. The acceptability of a new cook method within the Australian market,
2. Insights into the perceptions of USA consumers to Australian beef, cooked using a known and trusted local cook method,
3. The eating quality of beef briskets under a new cook method, not previously tested under MSA consumer sensory testing protocols, and
4. The eating quality of beef brisket when reheated, providing valuable outcomes for value adding a secondary cut into ready meal solutions.

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1 Background

1.1 Overarching project background

With the increased utilisation of Meat Standards Australia (MSA) to underpin branded products in export markets, it is essential that the accuracy of the MSA models' predictions for international markets is quantified and the matrix is expanded to include key cooking styles in these countries.

1.2 USDA Clay Center (MARC)

The project was initiated following a meeting and further discussion with USDA (United States Department of Agriculture) MARC (Meat Animal Research Center) meat scientists responsible for conducting extensive live animal and meat research at the centre. "Clay Center" (USMARC) has been at the forefront of genetic and genomic research for decades utilising a 7,000 cow herd to investigate cross and composite cattle breeding with associated evaluation of live animal performance and meat evaluation. While the meat evaluation has included extensive laboratory assessment and trained sensory panels, it has not included untrained consumer evaluation as utilised by MSA.

The MARC cattle are implanted with a hormonal growth Promotant (HGP) (Revalor® 200; 200mg trenbolone acetate, 20mg oestradiol) as a standard procedure. As current MSA data lacks any extended ageing of HGP treated cattle beyond 35 days the MARC cattle provided an opportunity to obtain data from an extremely well controlled and documented production system. Further significant benefits related to the opportunity to relate outcomes to genomic measures, as all the cattle scheduled for slaughter were genotyped with the F250 SNP chip (http://genomics.neogen.com/en/ggp-f-250-beef), which contains over 200,000 SNP that cause a change in gene function (either partial or complete loss of function). Additional value was offered through the opportunity to obtain E+V USDA grading images and data from each carcase over and above USDA and MSA grading inputs.

The strong interest and value for MSA in collecting and testing cattle from the MARC program was matched by enthusiasm from the USDA scientists who saw value in obtaining consumer data to align with their extensive genomic and phenotypic database. It was agreed that a striploin could be purchased from each carcase for consumer testing with data to be shared between all parties.

1.3 Australian briskets and ribs

Value adding of secondary cuts, and the desire to quantify international consumers, has been ranked as a high research priority by the MSA Beef Taskforce and MSA Beef Pathways Committees. This, and the interrelated projects, aim to simultaneously address multiple priorities including: 1) Increased cut x cook data to improve model accuracy and extend graded cooking options, 2) to address an agreed need to better understand beef flavour in a systematic manner - firstly, the mechanisms at play and later, application of this knowledge into product development, 3) the effect of packaging on the eating quality potential of the product, interactions with flavour and with re-heating and, 4) to quantify sensory responses to Australian product in key export markets with a particular view to opening new cooking pathways for two key secondary cuts.

To address this, Australian briskets and ribs, which currently have low MSA scores and are considered an underutilised cut with considerable potential for improved sensory outcomes, were targeted in this project. Both cuts have limited cut x cook data in the current MSA model and low consumer sensory score estimates. By contrast, in Texas, and much of the American South, briskets and ribs are regarded as premium cuts reflecting the considerable difference in cooking methods used between the two countries. Texas Tech University (TTU) made available commercial scale smoking, cooking and packaging equipment and provided extensive experience in the commercial production of these products.

A collection of American briskets, ribs, eye rounds, knuckles and striploins from Prime, Mid Choice and Select USDA quality grades was made available with samples tested at TTU in conjunction with the Australian product. The TTU based studies will connect multiple quality levels of Australian beef with the USDA MARC long ageing study and commercial USA cuts with alternative value adding treatments. There will be further connection through paired Australian product between Australian and USA consumer populations.

1.4 Project outcomes

Data from this project will greatly improve the accuracy of MSA prediction for briskets and ribs in domestic and export markets and extend grading outcomes to new cooking methods expected to deliver substantially higher consumer scores with a consequent value increase and potential for additional industry revenue.

The project also provides the first progressive ageing data beyond 35 days for striploins from HGP treated carcases.

New MSA cut x cook combinations for briskets and ribs will provide exporters and local value adders with a greater range of product opportunities targeted to specific markets where higher MSA grade outcomes can be aligned with premium branding and attract price premiums from traditionally lesser value commodity cuts.

Key benefits come from increased understanding and data on the sensory perception of Australian beef products by consumers in a key export market and by extension to increased accuracy of the MSA prediction model as well as scientifically based knowledge on how two undervalued secondary cuts (briskets and ribs) can be prepared and sold into a higher value market.

2 Project objectives

Progress on this research component will facilitate i) prediction accuracy within the MSA model, ii) increase knowledge of international consumer sensory response relative to Australian, iii) test limited cuts with new cook methods.

These outcomes will occur through consumer sensory testing with Australian and American consumers for the purpose of testing new cook methods and developing further accuracy on eating quality prediction of secondary cuts. The project will utilise cuts from cattle with genetic linkages and address key priorities of the MSA Beef Taskforce.

3 Methodology

3.1 Overview

3.1.1 Briskets

The BBQ brisket work aimed to establish basic muscle, position and cooking knowledge related to initial raw material quality together with a robust MSA BBQ protocol that may be used to benchmark further value added product development over time. As with other MSA protocols, such as slow cook/casserole, the protocol was designed to have minimal impact from added flavour; i.e. lightly seasoned using a 1:1 by volume salt and pepper blend pre-cooking. This design provided a realistic evaluation of meat differences arising from initial grading.

Key basic knowledge issues addressed under the trial design incorporate:

1. Systematic comparison of brisket muscles sourced from an extreme carcase quality range reflecting each of the 5 MSA based branding categories (Premium, High Quality, Base 3*, MSA Ungraded and Manufacturing) and primary USDA grade based categories (Prime, Mid Choice and Select).
2. Evaluation of the two primary brisket muscles, *M. pectoralis superficialis* (BRI057) and *M. pectoralis profundus* (BRI056).
3. Investigation of potential position effects within the two muscles.
4. Impact of basic “USA style” smoking and slow cooking on consumer ratings.
5. Evaluation of potential differences relative to serving directly after cooking, replicating a restaurant/BBQ pit experience, and serving after retail packaging, chilled display and re-heating prior to serving as would occur with a retail product for household use.
6. Balanced comparison of serving in sliced, chopped and pulled forms.
7. Comparison of USA and Australian consumer response.
8. Flavour chemistry interaction and potential for manipulation.

To ensure replication of commercial techniques, the design specified cooking of a full point end or navel end brisket with muscles separated and position based treatments to be applied after cooking.

3.1.2 Ribs

Both chuck and short ribs (3 ribs on each) were collected from an extreme grade category range from Australian and USA carcases. The initial objective was to establish a standard MSA protocol for BBQ ribs that is realistic however aimed at exposing raw material differences rather than producing an optimum consumer rating. The protocol utilised seasoning and cooking was identical to barbeque briskets.

Key basic knowledge issues to be addressed under the trial design incorporate:

1. Systematic comparison of rib muscles sourced from an extreme carcase quality range reflecting each of the 5 MSA based branding categories (Premium, High Quality, Base 3*, MSA Ungraded and Manufacturing) and primary USDA grade based categories (Prime, Mid Choice and Select).

2. Evaluation of the two primary rib locations – Chuck Ribs and Short Ribs.
3. Evaluation of principal muscles, *M. serratus ventralis thoracis* and *M. intercostales externus et internus* and commercial serving forms as ribs and rib fingers.
4. Potential further evaluation of cooking boneless and bone in pending analysis of recent MSA studies.
5. Impact of basic "USA style" smoking and slow cooking on consumer ratings.
6. Evaluation of potential differences relative to serving directly after cooking, replicating a restaurant/BBQ pit experience, and serving after retail packaging, chilled display and re-heating prior to serving as would occur with a retail product for household use.
7. Comparison of USA and Australian consumer response.
8. Flavour chemistry interaction and potential manipulation.

3.2 Product collection

3.2.1 USDA Clay Center (MARC)

MSA Cut Up Developer (CUD) software was utilised to develop a research plan and associated files to manage and document the collection and cut up. Further routines were used to produce individual carcase labels to be printed on coloured paper and laminated to assist in cut identification during the plant collection.

One striploin was collected and tagged with a primal ID from each of 108 hd slaughtered at a commercial abattoir (Nebraska, USA) in August, 2017. The other striploin from each carcase was collected for MARC laboratory analysis. All carcases were chilled for 48 hours prior to ribbing at the 12/13th rib site for grading. Each carcase was assessed by three methodologies:

- E+V camera image analysis by Dr Steven Shackelford to generate USDA marbling scores, rib eye areas, meat colour and rib fat depth.
- Manual grading to USDA standards by TTU.
- Collection of MSA grading data by TTU.

Striploins were collected, vacuum packed at boning and shipped to the TTU Meat Laboratory in Lubbock Texas. Individual carcases were identified and data aligned with abattoir generated files of carcase weight, USDA quality and yield grade. Further animal data was provided by Dr Shackelford, including sire and dam ID, birth date, weight, implant details and codes to link to genomic output.

A further collection was conducted at a Nebraska, USA based plant to collect equivalent cuts to those collected in Australia (other than cube roll) from 16 head from each of USDA Prime, Mid Choice and Select grade carcases to facilitate direct comparison of Australian and USA product.

3.2.2 Australia

The Australian collection was conducted simultaneously with several other projects, all of which relate to cuts sourced from a wide quality range. To minimise plant disruption a single large collection was planned to obtain all cuts to be utilised in multiple R&D projects, with data from each to be interlinked

and consequently more valuable. Consequently, the trial design encompassed all cuts with their subsequent allocation to the component projects.

The combined projects required the collection of ribs, briskets, striploins, cube rolls, eye rounds and knuckles from an extreme range of grass and grain fed carcases. The briskets, ribs, eye rounds and knuckles, plus the lower quality striploins and cube rolls, provide direct USA and Australian consumer linkage across a wide variety of cooking and value adding treatments.

A core trial objective is a study of relationships between initial and final eating quality after various cooking methods and interventions. An extreme range of carcases was required to meet the design specification. As many of the background R&D questions relate to interactions between different muscles sourced from carcases of different inherent initial quality, a structured extreme range was planned as shown in *Table 1*.

Table 1 Cattle collection by quality category

Projected Carcase MSA Quality	**Feed Type**		**Total Number**
	Grain	**Grass**	
Premium	9	9	18
High	9	9	18
Base 3*	9	9	18
Non-MSA compliant	9	9	18
Manufacturing (< 3* MSA)	-	18	18

Table 2 lists the primal cuts collected from both sides of each carcase and the subsidiary muscles available for study with reference to individual Handbook of Australian Meat (HAM) coding.

Table 2 Cuts collected in Australia from all carcase sides

Primal (HAM[1])	Subprimal (HAM)	MSA Identifier	Muscle name
Chuck Short Ribs (1631) and Short Ribs (1694) – ribs 2 through 7	Chuck short ribs (1631) & 3-rib short rib (1688)	INT037	*M. intercostales externus et internus*
		RIB078	*M. serratus ventralis thoracis*
		BRI056	*M. pectoralis profundus*
Brisket (2323)	Navel End Brisket (2342)	BRI079	*M. serratus ventralis thoracis*
	Navel End Brisket (2342)	BRI092	*M. transversus abdominus*
Brisket (2323)	Point End Brisket (2332)	BRI056	*M. pectoralis profundus*
Cube roll (2244)	Point End Brisket (2332)	BRI057	*M. pectoralis superficialis*
	7 rib cube roll (2243)	CUB045	*M. longissimus thoracis*
Striploin (2140)	1 rib striploin (2142)	STR045	*M. longissimus lumborum*
Eye round (2040)	-	EYE075	*M. semitendinosus*
Knuckle (2070)	2067	KNU066	*M. rectus femoris*
	2069	KNU098	*M. vastus intermedius*
	2068	KNU099	*M. vastus lateralis*
	-	KNU100	*M. vastus medialis*

Table 3 presents the quality category and counts of cuts collected from the Northern and Southern collections. After removing the striploins and cube rolls, utilised in the packaging study, a standard pattern was followed with all cuts. From both sides of 6 bodies, within each category, one side of 3 were shipped to TTU and the other side of the 3 bodies were retained for consumer comparison in Australia. The 18 manufacturing carcases were treated as two sets of nine, with cuts from 6 sides retained in Australia. The greater numbers of briskets and ribs reflects collection of point and navel end brisket and chuck and short rib as separate primals from each body.

Table 3 Distribution and allocation of Australian cuts collected within quality category

Carcase Quality Category	FEED	No. Head	Australian Cuts Collected						Total Primals
			Cube Roll	Striploin	Eye Round	Knuckle	Brisket	Ribs	
Premium MSA Quality	Grain	9	*18*	*18*	18	18	36	36	144
	Grass	9	*18*	*18*	18	18	36	36	144
High MSA Quality	Grain	9	*18*	*18*	18	18	36	36	144
	Grass	9	*18*	*18*	18	18	36	36	144
Base 3* MSA Quality	Grain	9	*18*	*18*	18	18	36	36	144
	Grass	9	*18*	*18*	18	18	36	36	144
Ungrade MSA Quality	Grain	9	18	18	18	18	36	36	144
	Grass	9	18	18	18	18	36	36	144
Manufacturing non MSA Quality	Grass	18	36	36	36	36	72	72	288
	Total	**90**	180	180	180	180	360	360	1440
		** Italicised cube roll and striploins used in packaging study*							
Cut Allocation									
Australia - Packaging			108	108					216
- Value Adding			12	12	30	30	60	60	204
TTU - Value Adding			60	60	150	150	300	300	1020
			180	180	180	180	360	360	1440

3.2.3 United States of America collection

Paired U.S. briskets were collected in December, 2017 from a commercial abattoir in Omaha, NE to represent three distinct USDA Quality grades: USDA Prime, USDA average Choice, and USDA Select. Historically, USDA Select striploin (*M. longissimus lumborum*) or top sirloin butt/rump (*M. gluteus medius*) muscles have been included as link samples for grills, roasts, and other MSA cook methods as they have represented average eating quality over several years of eating quality research that has been conducted at TTU using MSA testing protocols. However, USDA Select briskets were already included as part of the proposed treatment design. Therefore, USDA Standard (No Roll) briskets were procured to be used as link samples. USDA Prime (n = 6), Choice (n = 6), and Select briskets (n = 6) were hand selected, and so carcase grade data was collected. However, Standard briskets procured and shipped to TTU due to logistical and time constraints, presented with no grade data available for

link briskets. All US briskets were aged 5 days post mortem, as the product could not be selected and delivered any faster. United States briskets were frozen immediately upon arrival.

3.3 Cut Up instruction and process

3.3.1 USDA Clay Center (MARC)

All striploins were fabricated into MSA consumer, flavour and objective samples 21 d post slaughter. Striploins were denuded of all surface fat and epimysium and reduced to the *M. longissimus lumborum* (LD) muscle, and primal ID was recorded. The tray with the denuded LD and ID label was then passed to a recording station. CutUpLabels were then assigned from the CutUp file as per Milestone 1 report. There were four portions for each striploin; Anterior 1 (A1), Anterior 2 (A2), Posterior 1 (P3) and Posterior 2 (P4).

An ageing period is designated for each position and a further objective sample is specified to align with the 4 EQSRef codes. The design included a standard 21 day aged treatment for all striploins and 3 further ageing treatments; i) 28, 35 or 42 days; ii) 49, 56 or 63 days; and iii) 70, 77 or 84 days (Table 4). These 3 ageing allocations were varied across the 108 muscles to provide data in 7 day increments from 21 to 84 days ageing. Muscle position was rotated within ageing treatment to ensure ageing and position was not confounded. The allocation of 4 ageing periods to individual muscles is shown in Table 1.

Table 4: Ageing treatments applied to individual striploin positions

Days Aged					Days Aged					Days Aged			
21	28	49	70		21	28	49	77		21	28	49	84
21	35	56	77		21	35	56	84		21	35	56	70
21	42	63	84		21	42	63	70		21	42	63	77
21	28	56	70		21	28	56	77		21	28	56	84
21	35	63	77		21	35	63	84		21	35	63	70
21	42	49	84		21	42	49	70		21	42	49	77
21	28	63	70		21	28	63	77		21	28	63	84
21	35	49	84		21	35	49	70		21	35	49	77
21	42	56	77		21	42	56	84		21	42	56	70

Once labels were assigned, striploins were sliced into 25 mm thick steaks progressively from the anterior muscle end. Three (3) steaks were used to make up samples designated by each pair of consumer and objective labels. Each steak was halved and fabrication of 6 approximately 38 x 65mm 25mm thick portions was achieved. Five of these were placed against the consumer EQSRef label and one against the objective label.

Once the four positions were accounted for, each set of samples were transferred to a vacuum bag. The objective sample placed in the bag and the bag vacuumed, sealed and sorted by freeze down date. The 5 consumer samples within each set were individually wrapped in freezer film then placed in a vacuum bag. The sealed bags were sorted on freeze down date codes.

The samples were stored at approximately 1˚C in a TTU chiller then frozen on the designated date (the cut up date for all 21 day samples) and transferred to -20˚C frozen storage.

3.3.2 Australia and United States

All briskets and ribs for this project were collected as whole primals and packed at the abattoir. There was no further processing conducted until post-cooking.

3.4 Development of cook protocols

Cook protocols were developed initially at Texas Tech University and refined by the University of New England and Texas Tech staff as cooking commenced. The protocols may be found in Appendix 8.1 and 8.2, however an abridged version follows.

Briskets – Point end and navel end

Point end and navel end briskets designated to a pick were selected based on primal ID and transferred from frozen storage (-20 °C) to chilled storage (1-3 °C) 72 h prior to cooking. Within 15 hours of cooking, point end briskets were trimmed of epimysium on the medial (internal) side of *M. pectoralis profundus*, and subcutaneous fat on the lateral (external) side of *M. pectoralis profundus* and *M. pectoralis superficialis*. Any large deposits of intermuscular fat present between *M. pectoralis profundus* and *M. pectoralis superficialis* were also removed. Navel end briskets were not trimmed.

Each brisket was identified with an ovenproof tag prior to cooking. Tag number was recorded against primal ID to maintain identification throughout the cook. Raw briskets were weighed, and weights were recorded on the pick cook sheet. Briskets were then lightly seasoned using a 1:1 by volume salt & pepper.

Briskets were placed fat (lateral) side down in a smoker (Jim Bowie, Green Mountain Grills, Nevada) after reaching the temperature set point of 121 ˚C. Internal brisket temperature was monitored regularly using the included smoker temperature probe in the smallest brisket within the smoker. Australian cooks utilised four Weber iGrill 2 units (Weber, Illinois), each including four individual temperature probes. Internal temperature was also monitored using an independent thermometer (Thermapen® Mk4, ThermoWorks, Utah).

When the internal temperature reached 65.6 ˚C briskets were removed and wrapped in heavy duty aluminium foil then returned to the smoker in the same orientation with time and temperature recorded. When the internal temperature of a brisket reached 93.3 ˚C the brisket was removed, left in the foil wrapping and placed in an insulated holding box with time and temperature recorded. Briskets were rested for minimum of 30 minutes. Ninety (90) minutes prior to the planned consumer taste panel start time, briskets were removed from storage, unwrapped, weighed, and processed.

After weighing the entire brisket, the two muscles were separated and individually weighed. Muscle identification and orientation was maintained and linked to specified preparation (chopped, pulled or sliced).

The source brisket ID was extended to individual consumer EQSRef ID with multiple EQSRef ID's specified per brisket. Preparation style (sliced, 6 mm x 70 mm x 40 mm; pulled, 70 mm x 10 mm; or chopped, 10 mm^2) were pre-assigned to the individual muscle and position. Positions for *M. pectoralis profundus* were navel end (caudal end; N) and point (cranial end; P); *M. pectoralis superficialis* were dorsal (D) and ventral (V); and *M. serratus ventralis* were navel (N) and point (P).

Once prepared, sufficient samples, to adequately serve 10 consumers, were transferred to a pre-heated 1/9th bain-marie 100mm deep pan. A laminated EQSRef ID was placed in the pan, with a further matched EQSRef sticker on the pan lid. The pan was then transferred to a specified serving bain marie pre-heated to 50˚C.

Samples were served utilising the Meat Standards Australia Roast service protocol (Watson et al., 2008a, Watson et al., 2008b).

Ribs

Both chuck and short ribs (3 ribs on each) were utilised as a single set of ribs (ribs 2 to 7), collected from an extreme grade category range from Australian and USA carcases. The preparation cooking method utilised was identical to that used on briskets.

The ribs that were used in this study comprised the *M. serratus ventralis* and *M. intercostales externus et internus*. The *M. latissimus dorsi* was removed in the boning room upon cut collection. As such, there was no subcutaneous fat and minimal intermuscular fat to be trimmed prior to seasoning.

Processing and preparation for consumer sensory testing commenced with the separation and weighing of the two (2) primary muscles; *M. serratus ventralis* and *M. intercostales externus et internus*. The source primal ID was extended to individual consumer EQSRef ID with multiple EQSRef ID's specified per primal. Preparation styles of sliced (15 mm) for *M. serratus ventralis*, and chopped for *M. intercostales externus et internus* were pre-assigned to the individual muscle and position. Positions were only required for *M. serratus ventralis* as chuck rib (cranial or rib 2 end) and short rib (caudal or rib 7 end). No position was required for *M. intercostales externus et internus*.

Samples were served utilising the Meat Standards Australia Roast service protocol (Watson et al., 2008a, Watson et al., 2008b).

3.5 Consumer testing

The MARC consumer samples were held over, to allow testing in conjunction with Australian product, providing greater linkage between the Australian and USA meat and consumers.

Chilled and frozen cuts were sent from Australia to the USA by sea freight and were delivered to TTU in January, 2018. These cuts were prepared and paired with samples retained at UNE early in January 2018 for sensory testing in USA and Australia.

3.5.1 Striploins

Striploins were cooked and served utilising the Meat Standards Australia grill protocols as defined by Watson et al. (2008a).

3.5.2 Low 'n slow barbeque protocols

Briskets and ribs were served to consumers utilising the Meat Standards Australia Roast protocol (Watson et al., 2008a, Watson et al., 2008b).

Briefly, sensory samples were designated to a pick, which included 36 sets of 10 sensory samples, to be tested using a 6 x 6 Latin Square design across 60 consumers. Service was carried out over a 30 min period. Consumers rated each sample on tenderness, juiciness, flavour, and overall liking on a 100 point analogue scale. Overall satisfaction with the product was also recorded as either Unsatisfactory; Good every day quality; Better than every day quality; or Premium quality.

3.5.3 Low 'n slow barbeque - Comparison of hot and reheated product

To compare freshly cooked versus re-heated product the brisket from one carcase side was planned to be cooked one week prior (reheat treatment; RHT) to that from the other side (hot treatment; HOT) with both to be served to the same consumer sitting.

A full protocol for preparing reheat briskets may be found in Appendix 8.1 below. An abridged version follows.

Immediately post cooking the brisket was split into component muscles and nominated muscle positions used for sliced, chopped or pulled preparations for serving. Samples for RHT were vacuum packed and held chilled for seven days to simulate retail display. Three hours prior to retail testing the vacuum packs were heated by sous-vide procedure then opened and transferred to serving bain-maries.

The paired product cooked on the consumer test day was transferred to the bain-marie directly after being sliced, pulled or chopped replicating a food service environment. Samples were served utilising the Meat Standards Australia Roast service protocol (Watson et al., 2008a, Watson et al., 2008b).

3.6 Statistical analysis

Beef briskets were collected from MSA graded carcases (n = 90) in Australia. A further 108 striploins were collected from carcases that came from the USDA MARC herd.

3.6.1 USDA MARC striploins

The analysis of the striploin data was performed by Dr Angela Lees (University of New England) with guidance and input from Dr Jarrod Lees, University of New England, and Dr Garth Tarr, University of Sydney.

The overall eating quality score (**MQ4**) was determined from the consumer tenderness, juiciness, flavour and overall liking (Watson et al., 2008c). Tenderness, juiciness, flavour and overall liking scores were weighted by 0.3, 0.1, 0.3 and 0.3 respectively, providing a MQ4 score between 0 and 100,

modified from Watson *et al.* (2008c). The raw means of each sensory trait were calculated together with clipped means calculated by removing the highest and lowest 2 scores for each trait (Watson et al., 2008c).

All data exploration and statistical analyses were conducted in R (R Core Team, 2018). Data merging and manipulation, data visualizations and summary data were conducted using the 'dplyr' (Wickham et al., 2019b), 'ggplot2' (Wickham et al., 2019a) and 'table1' (Rich, 2018) packages respectively.

Initially correlations between raw and clipped consumer sensory scores for meat tenderness, juiciness, flavour, overall liking and MQ4 score were conducted. Raw and clipped consumer sensory scores for meat tenderness, juiciness, flavour, overall liking and MQ4 score were analysed using a linear mixed effects model in the 'lme4' package (Bates et al., 2015) and estimated marginal means were generated using the 'emmeans' package (Length, 2019).

Models incorporated number of days aged, position within muscle (Anterior 1, **A1**; Anterior 2, **A2**; Posterior 1, **P1**; and Posterior 2, **P2**) and their interactions as fixed effects. Additionally, an individual animal/carcase identification was incorporated as a random effect in all models, to account for individual animal variation. Models were refined to remove relevant insignificant interactions in a step-wise manner. Carcase traits including: carcase weight, hump height, eye muscle area, ossification, MSA marble score and pH ultimate were investigated as fixed effects. However there were no significant interactions, thus were dropped from the models. The final models for tenderness, juiciness, flavour, overall liking and MQ4 included days aged and position within muscle, the interaction between days aged and position was not significant, thus was removed from all models.

3.6.2 Low 'n slow barbeque briskets – Australian vs United States consumers

The analysis conducted for Australian vs USA consumers was performed by Dr Jarrod Lees (University of New England) and Dr Garth Tarr (University of Sydney).

A portion of the briskets collected from 29 carcases and were maintained at UNE. The paired brisket from the same carcase was sent to Texas Tech University (TTU), Texas, United States of America. Consumer sensory sessions (picks, n = 4) were developed for testing at TTU, and the briskets at UNE were paired into identical picks (n = 4); pick numbers were 1532 to 1539.

Consumer scores for all sensory measurements (tenderness, T; juiciness, J; flavour, F; overall liking, OL; and meat quality score, MQ4) were grouped by muscle, position and carcase number within each country and then the difference between the Australian and US consumer outcomes was calculated. This allowed for a comparison of the two countries on the same brisket positions within muscle, for the same serve method. Analysis was conducted using the 'lmer()' function from the 'lme4' package (Bates et al., 2015) in R (R Core Team, 2018). Initially, each sensory measurement was modelled with position within muscle as a fixed effect, and carcase ID as a random effect. This was to determine whether there was an effect of position on sensory measurements.

Position within muscle was significant, however only for the BRI079 Centre position when compared to the Navel and Point positions. This was due to muscle size and is further described in the results section of this report. This outcome led to the dropping of position within muscle as a fixed effect, with muscle being used as the fixed effect.

Serve method was modelled against consumer sensory outcomes using the 'lme4' package (Bates et al., 2015). Muscle, serve method (chopped, pulled or sliced) and country were fixed effects, and carcase number was the random term. All interactions were explored and higher order interactions that did not explain a portion of the variation were removed. Estimated marginal means were calculated to determine where differences were evident in serve method using the 'emmeans' package.

3.6.3 Low 'n slow barbeque briskets – Hot vs reheated product

The analysis conducted for the hot vs reheated product was performed by Dr Andrea Garmyn and Mr Justin Johnson (Texas Tech University).

Data analysis focused only on the BRI056 and BRI057, where sufficient comparisons existed to make inferences about serving form/time. Data were analysed as a completely randomized design including fixed effects of muscle, serve method (slice, chop, pull), serving time (reheat vs. hot), and their potential interactions. No interactions were significant ($P > 0.05$). Carcase was included as a random effect to account for animal variation. Treatment least squares means were separated with the PDIFF option at a significance level of $P < 0.05$. Pearson correlations were calculated between carcase and consumer sensory measurements using PROC CORR in SAS ($P < 0.05$). Data were analysed using the STEPWISE option of PROC REG of SAS to determine the influence of carcase traits on consumer eating quality traits and satisfaction. Variables had to meet a 0.15 significance level for entry and to remain in the model.

3.6.4 Low 'n slow barbeque briskets – Carcase characteristics

Further analysis was conducted on consumer sensory measurements from all briskets that were served hot to determine the effect of carcase characteristics. A base model was developed for tenderness, juiciness, flavour, overall liking and meat quality score using the lme4 package (Bates et al., 2015) with muscle and serve method as fixed effects and carcase number as the random term. Carcase characteristics were added to determine their effect on sensory outcomes. Carcase characteristics included sex, carcase weight, hump height, rib fat depth, ossification score, MSA marble score, ultimate pH, and HGP treatment status. These measurements were added as fixed effects and interactions were explored. Where a characteristic did not have an effect on the consumer sensory measurement it was removed and the model refined.

4 Results and Discussion

4.1 USDA MARC Striploins

Strong correlations between raw and clipped consumer sensory scores for tenderness (R^2 = 0.99, $P \leq$ 0.0001), juiciness (R^2 = 0.99, $P \leq$ 0.0001), flavour (R^2 = 0.99, $P \leq$ 0.0001), overall liking (R^2 = 0.99, $P \leq$ 0.0001) and MQ4 (R^2 = 0.99, $P \leq$ 0.0001) were identified (Figure 1). Furthermore there were no differences in the significant terms between models conducted on raw and clipped data, therefore data herein pertains to analysis conducted on the raw consumer sensory data.

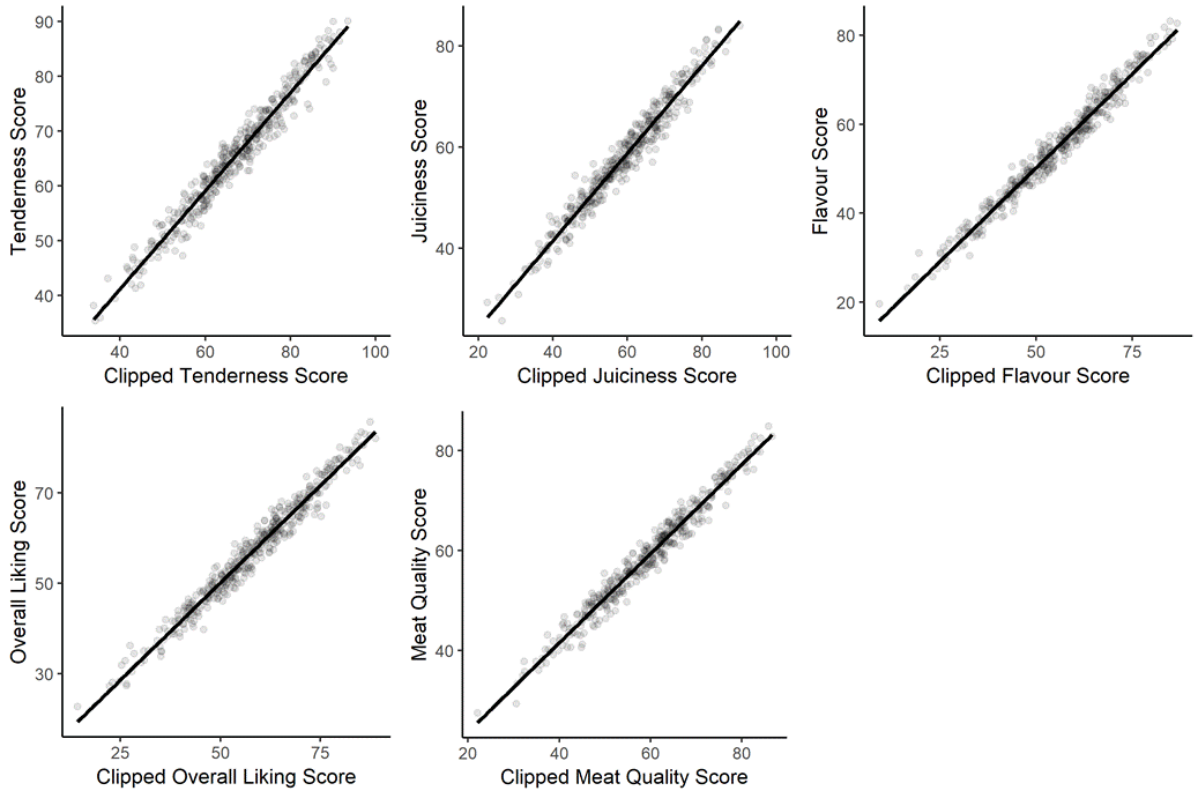

Figure 1: Linear relationship between clipped and non-clipped consumer sensory evaluations for tenderness (R^2 = 0.98; y = 5.4 + 0.9×; P ≤ 0.0001), juiciness (R^2 = 0.98; y = 7.0 + 0.86×; P ≤ 0.0001), flavour (R^2 = 0.99; y = 8.0 + 0.84×; P ≤ 0.0001), overall liking (R^2 = 0.98; y = 7.2 + 0.86×; P ≤ 0.0001) and meat quality score (MQ4; R^2 = 0.98; y = 5.8 + 0.89×; P ≤ 0.0001)

4.1.1 Carcase characteristics

Cattle were processed at a single abattoir on one day. All 108 carcases were graded by a single grader, this was done to reduce between grader variability and bias. A summary of the carcase characteristics, as evaluated during grading, are summarised below in *Table 5*. Please note that rib fat and p8 fat were not recorded within this dataset.

Table 5: Mean (± SEM), minimum and maximum carcase characteristics for the 108 carcases that striploins were collected from MARC carcases

Carcase Trait	Mean	Min	Max
Carcase weight, kg	364.8 ± 3.1	285.7	436.6
Hump height, mm	89.7 ± 0.9	64	120
Eye muscle area, cm^2	94.7 ± 1.1	66.1	125.2
Ossification	119.9 ± 1.7	110	250
MSA Marble Score	327.2 ± 4.5	200	560
pH ultimate	5.61 ± 0.01	5.49	6.08

4.1.2 Consumer Sensory Outcomes

The number of days striploins were aged for tended to influence consumer evaluations for tenderness (P = 0.08; Fig 2). Of interest, tenderness scores decreased as days ageing increased. Increased days aged from 21 days to 84 days decreased tenderness by 3 points (P = 0.59; Fig 2). However, consumer evaluations suggest that position within muscle influenced tenderness scores (P < 0.0001; Fig 3). Consumer sensory evaluations suggest that anterior positions (A1, 69.0 ± 1.0; A2, 67.7 ± 1.0) were evaluated to be more tender, when compared with posterior (P3, 62.2 ± 1.0; P4, 62.1 ± 1.0) portions (P < 0.0001; Fig 3). These results do not appear to make any sense, given that as meat ages, tenderness historically increases. The level of tenderisation is driven by the initial levels of calpastatin, μ- and m-calpains, and cysteine and serine proteinase inhibitors (Zamora et al., 1996). Large gains in tenderness occur within three to seven days post mortem, however this may extend out to 28 days in muscles that have high intrinsic toughness, for example *M. longissimus lumborum* (Kim et al., 2018). Thus, decreases in tenderness, i.e. meat becoming tougher, appear nonsensical.

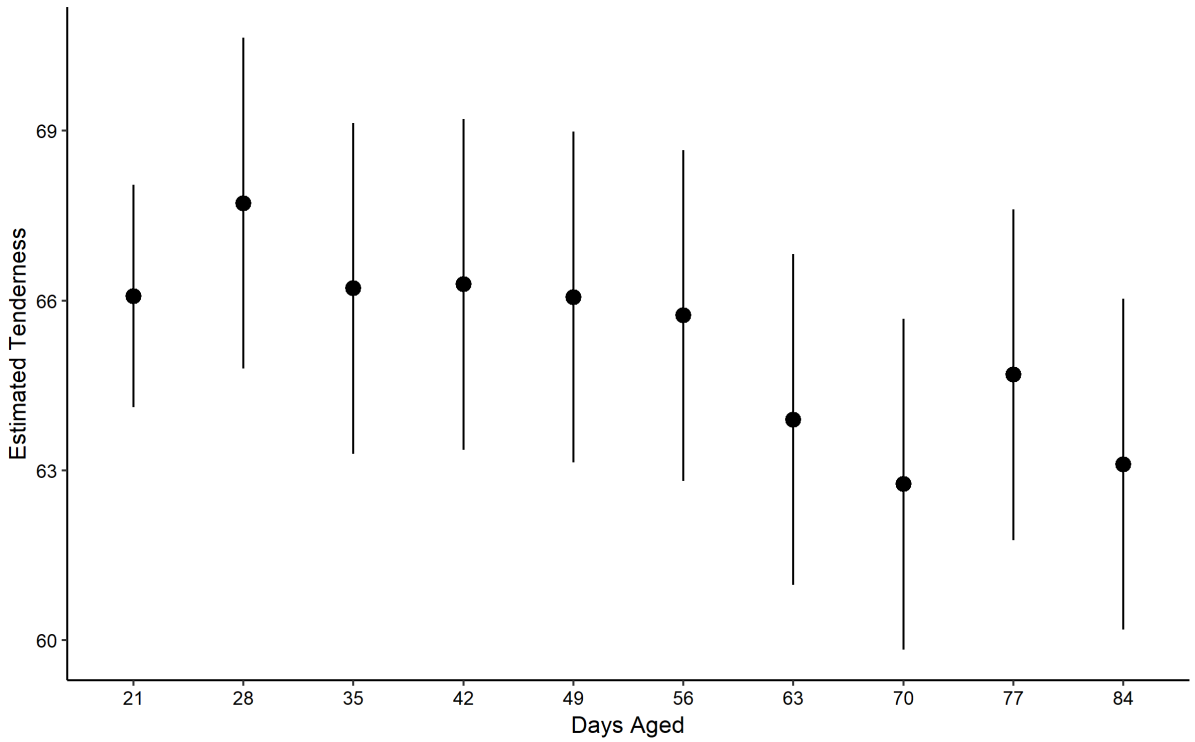

Figure 2: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for tenderness of striploins (M. longissimus lumborum) aged between 21 and 84 days

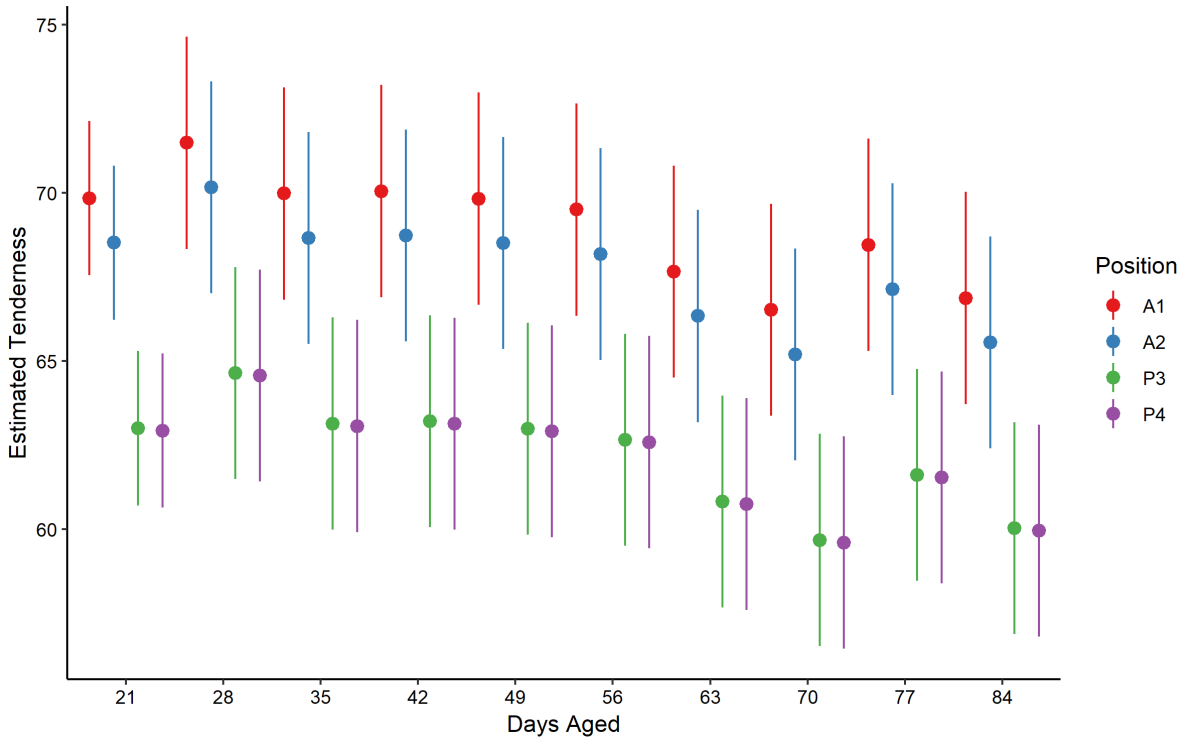

Figure 3: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for tenderness of anterior and posterior portions of striploins (M. longissimus lumborum) aged between 21 and 84 days

Consumer juiciness scores were influenced by days aged ($P < 0.0001$), as days ageing increased from 21 days to 84 days juiciness scored decreased by 6.2 points ($P = 0.0027$; Fig 4). Position within the striploin also influenced consumer evaluations of juiciness ($P < 0.0001$). Anterior portions (A1, 58.6 ± 1.0; A2, 60.6 ± 1.0) of the muscle had higher juiciness scores when compared with posterior (P3, 55.9 ± 1.0; P4, 53.7 ± 1.0) samples ($P \leq 0.03$; Fig 5).

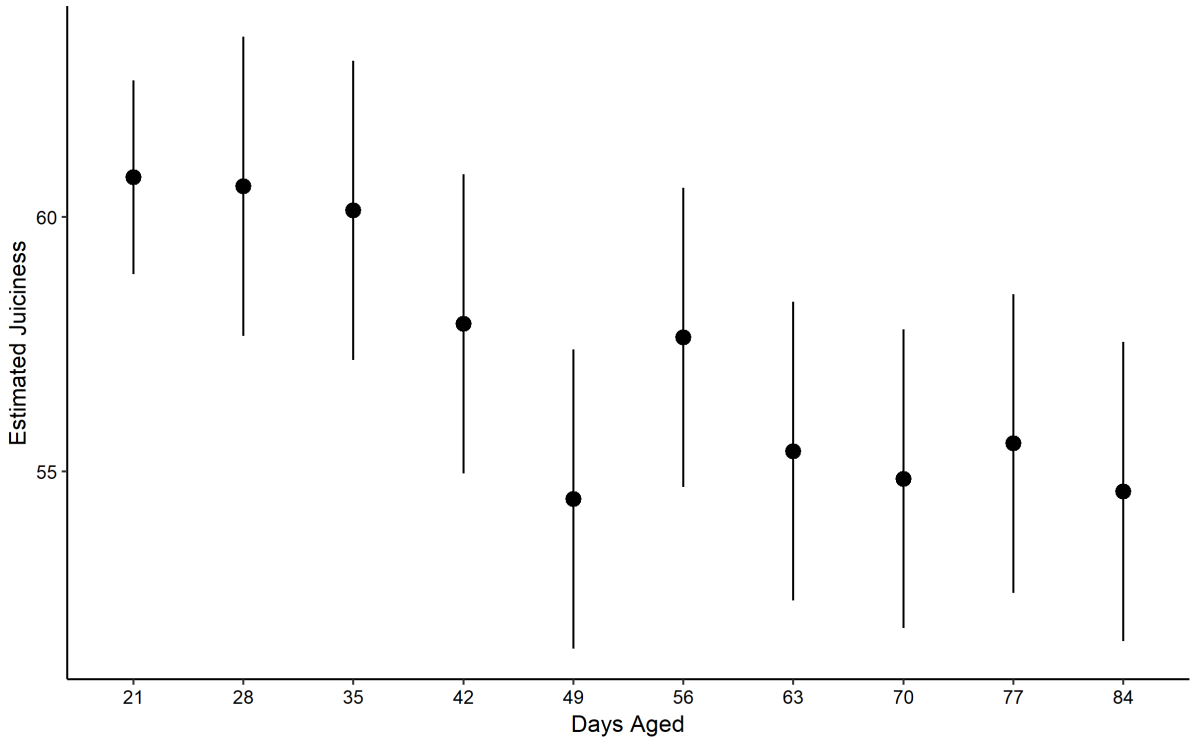

Figure 4: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for juiciness of striploins (M. longissimus lumborum) aged between 21 and 84 days

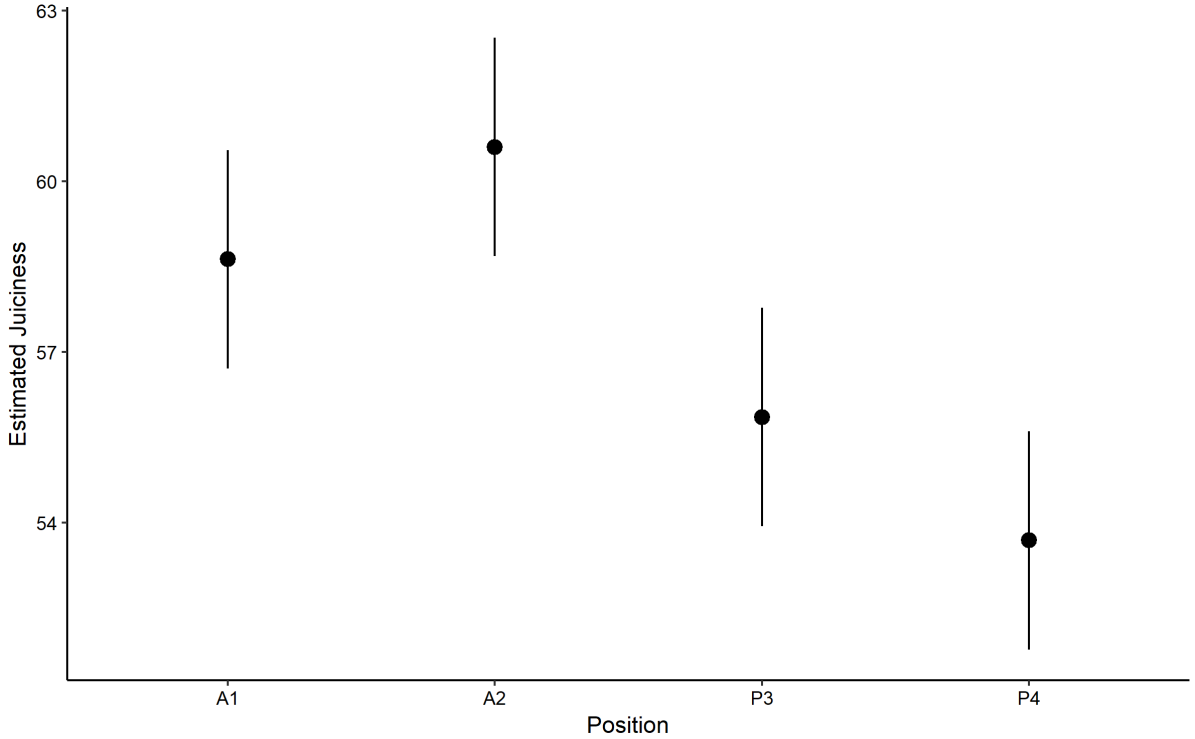

Figure 5: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for juiciness of anterior (A1, A2) and posterior (P3, P4) portions of striploins (M. longissimus lumborum)

Flavour of the striploins was influenced by both days aged (*P* = 0.0001) and position within muscle (*P* = 0.01). Flavour exhibited a steady decrease in consumer evaluations from 21 days, regardless of sample position within the striploin (Fig 7). Increasing days aged from 21 days to 84 days was associated with an 18.5 point decrease in consumer evaluations of flavour (*P* < 0.0001; Fig 6).

These findings are also inconsistent with the literature. Kim et al. (2018) outlines that flavour should improve over time, with the release of flavour related compounds and sugar compounds that improve the Maillard reaction. They also noted that prolonged ageing (>28 d) led to an increase in volatile compounds that are important to aroma development. The steady decline in flavour from 21 d indicates that this may be the case for the striploins used within this experiment and brings to question whether or not there may have been contamination of the fresh product at boning or during portioning.

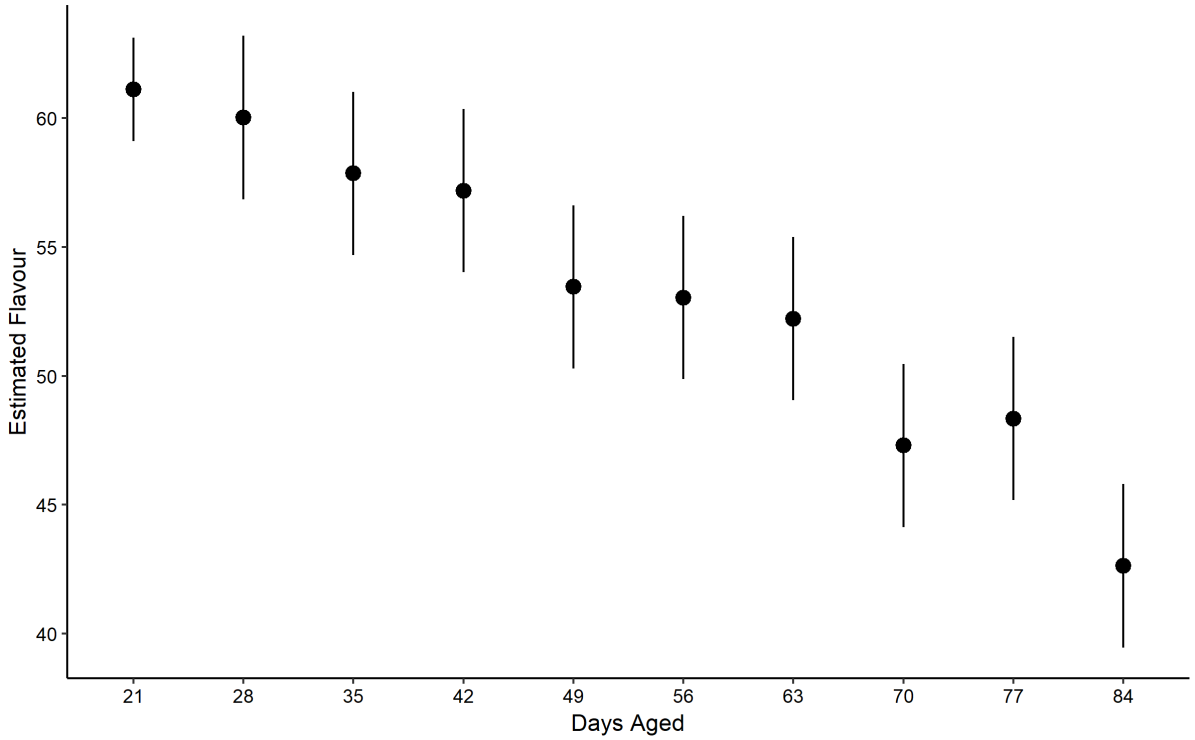

Figure 6: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for flavour of striploins (M. longissimus lumborum) aged between 21 and 84 days

The model suggests that position within the muscle influenced consumer sensory evaluations of flavour. Generally, anterior samples had numerically greater flavour scores when compared with posterior samples (Fig X), however this was not consistent across the four positions. Samples from A2 had flavour scores that were 3.13 ± 1.1 points greater than P3 scores (*P* = 0.03) and a tendency between A1 and P3 (*P* = 0.09). However, there were no differences in flavour scores between A1 and A2 (*P* = 0.92), P3 and P4 (*P* = 0.97), A1 and P3 (*P* = 0.14), or A1 and P4 (*P* = 0.33).

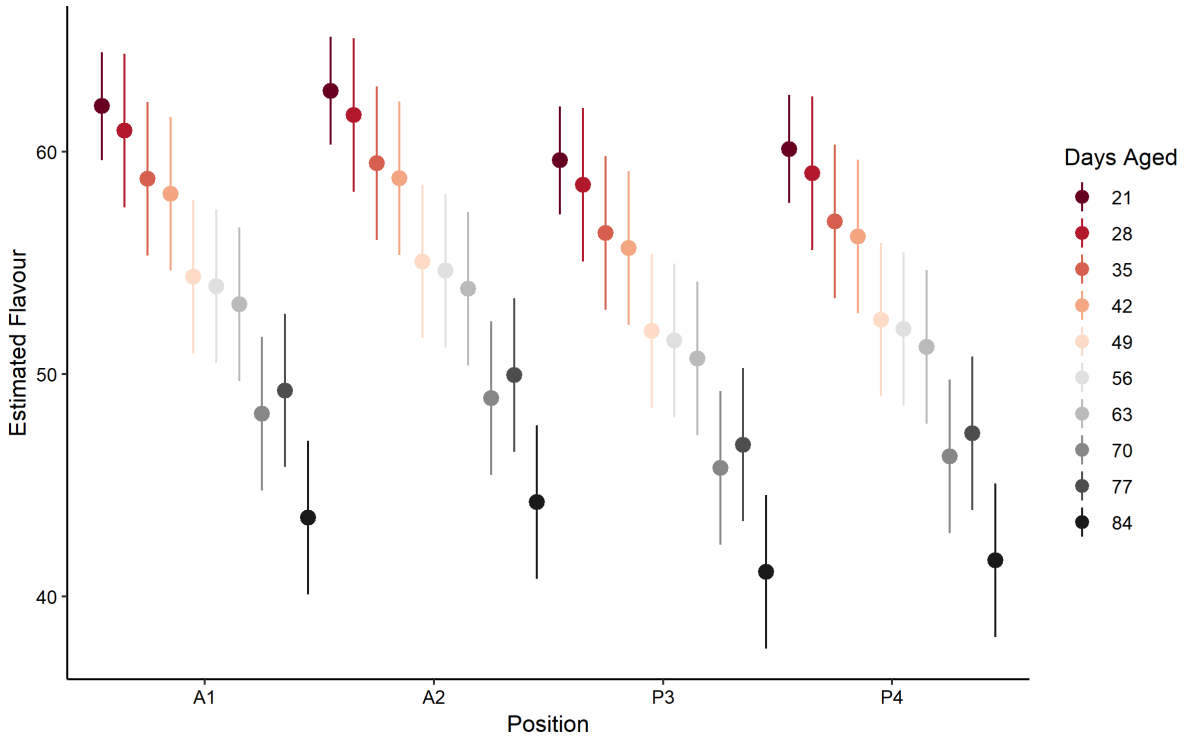

Figure 7: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for flavour of anterior (A1; A2) and posterior (P3; P4) portions of striploins (M. longissimus lumborum) aged between 21 and 84 days

Overall liking of the striploins exhibited a decreasing trend as days aged increased (Fig 8). There was a 14.7 point decrease in overall liking scores between 21 days aged (62.5 ± 1.0) and 84 days aged (47.8 ± 1.6; $P < 0.0001$; Fig 8). The decreasing trend in consumer overall liking scores occurred regardless of sample position within the striploin (Fig 9). Anterior (A1, 62.2 ± 1.2; A2, 64.2 ± 1.15) and posterior (P3, 59.4 ± 1.15; P4, 57.3 ± 1.15) both exhibited a 6 point decrease ($P < 0.0001$) in overall liking scores between 21 days aged and 84 days aged, albeit from differing initial consumer evaluations at 21 days (Fig 9).

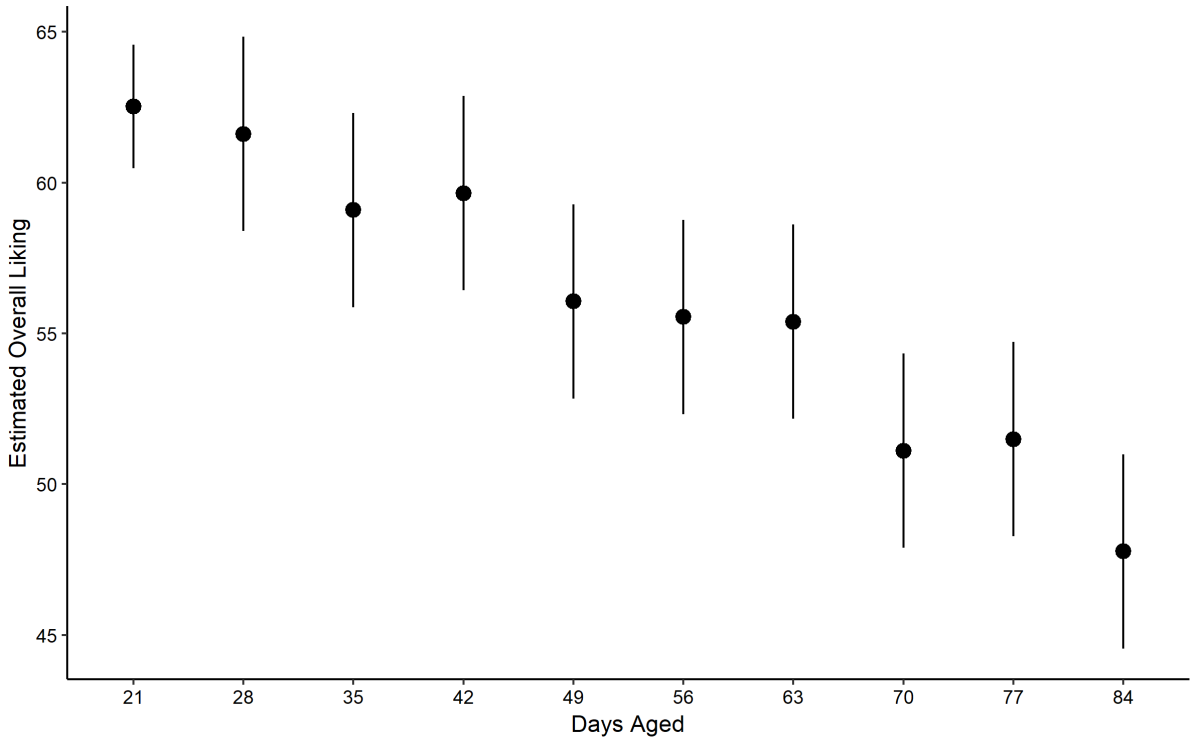

Figure 8: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for flavour of striploins (M. longissimus lumborum) aged between 21 and 84 days

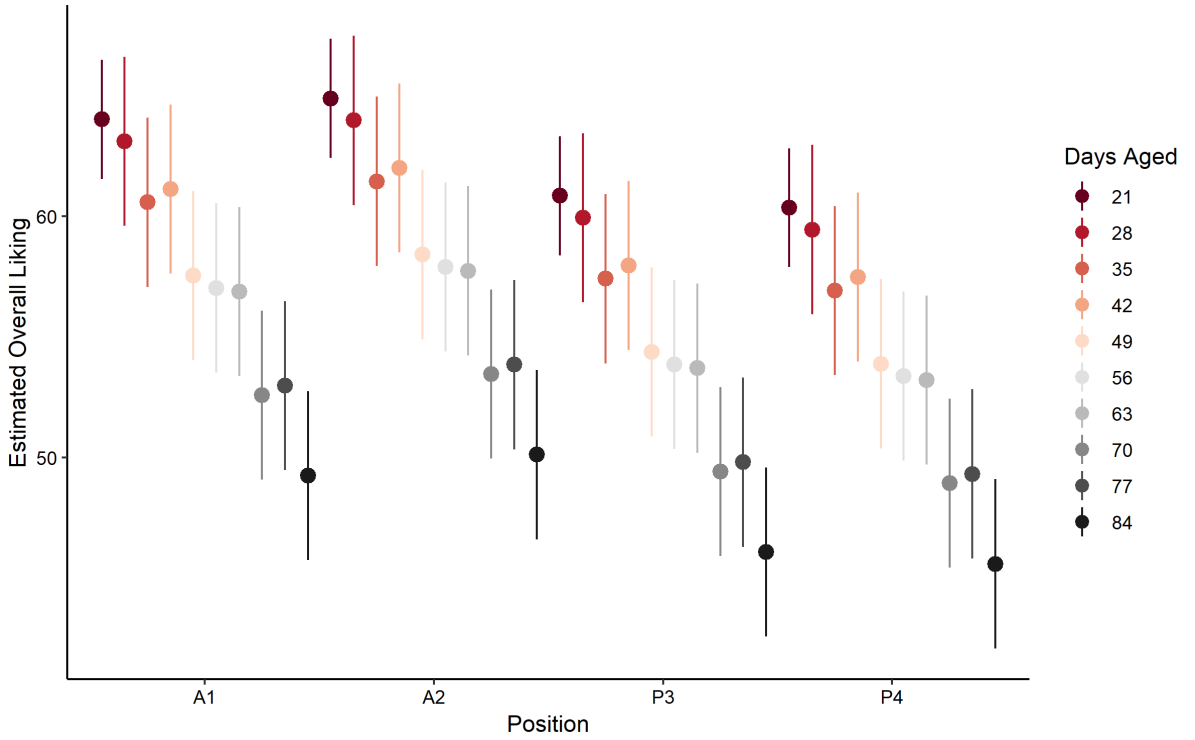

Figure 9: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for overall liking of anterior (A1; A2) and posterior (P3; P4) portions of striploins (M. longissimus lumborum) aged between 21 and 84 days

Consumer sensory outcomes for the MQ4 unsurprisingly exhibited a decreasing trend as the number of days aged increased, regardless of sample position within the striploin (Fig 10). As the number of days aged increased from 21 days to 84 days there was a 11.5 decrease in MQ4 scores ($P < 0.001$; Fig 11). There were no differences in the MQ4 scores between A1 and A2 or P3 and P4, however A1 MQ4 scores were 4.0 and 4.2 points greater than P3 and P4, respectively ($P < 0.0002$; Fig 10). Similarly, the MQ4 scores of A2 were 4.2 and 4.4 points greater than P3 and P4 respectively ($P < 0.0001$; Fig 10).

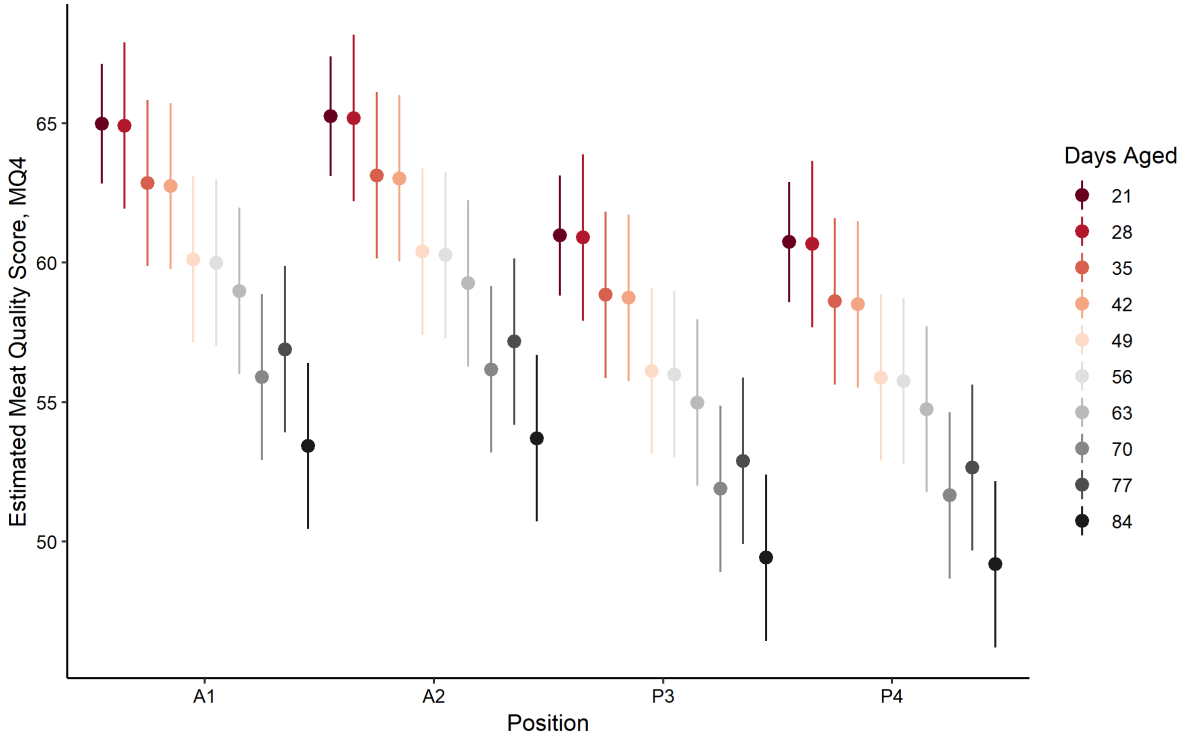

Figure 10: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for meat quality score (MQ4) of anterior (A1; A2) and posterior (P3; P4) portions of striploins (M. longissimus lumborum) aged between 21 and 84 days

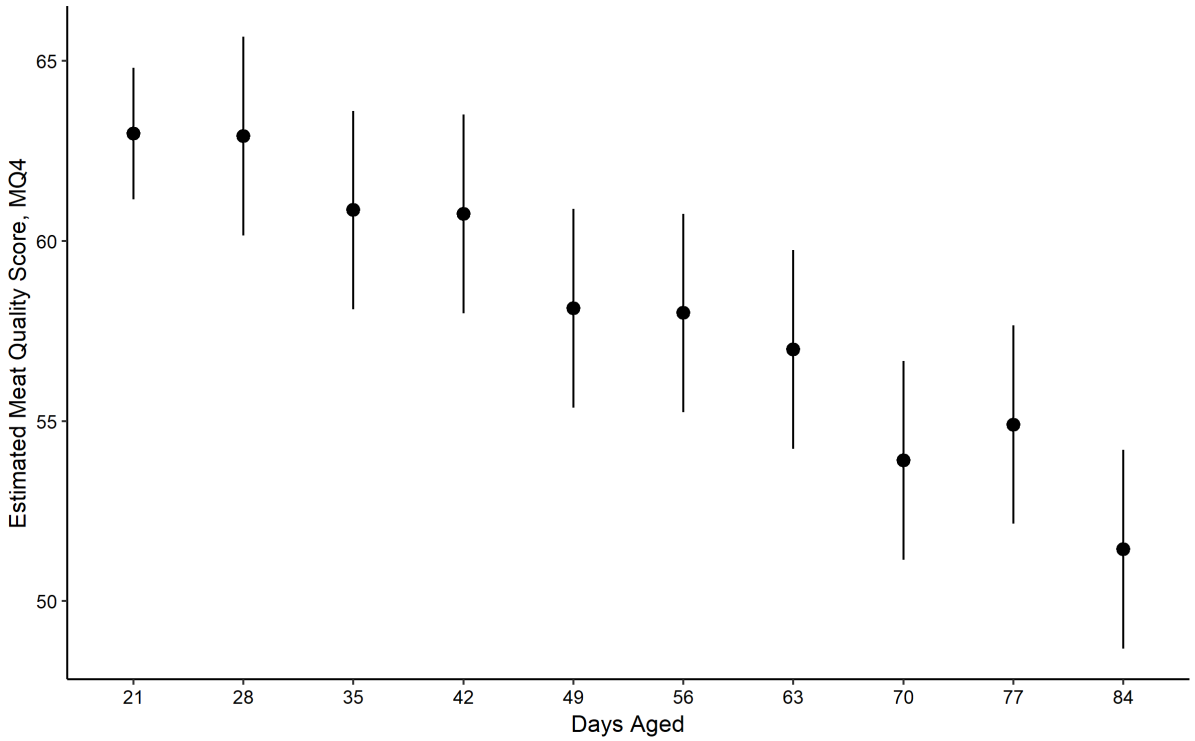

Figure 11: Estimated marginal means with 95 % confidence intervals for consumer sensory scores for meat quality score (MQ4) of striploins (M. longissimus lumborum) aged between 21 and 84 days

4.2 Low 'n slow barbeque briskets – Australian vs USA consumers

4.2.1 Carcase characteristics

The carcases utilised in this experiment were varied in their carcase attributes. The section outlines this carcase variation.

Ten (10) carcases were HGP treated, with the remaining 18 HGP free. Furthermore, there were 10 females and 18 males. Table 6 outlines the descriptive statistics for the main carcase traits (below).

Table 6: Mean carcase data ± standard deviation of carcases utilised in comparing Australian and USA consumers

Trait	Mean
Hot standard carcase weight (kg)	354.9 ± 49.7
Hump Height (mm)	86.61 ± 16.8
MSA Marble Score	394.41 ± 128.6
Ossification score	230.28 ± 129.3
Ultimate pH	5.51 ± 0.1
Rib Fat (mm)	9.73 ± 4.2

Figure 12 outlines the variation in ossification score between all carcases. It should be noted that there were no carcases with an ossification score between 200 and 400. Furthermore, MSA Marble Score showed a distinct population with a marble score between 300 and 450 (Fig 13). Hot Standard Carcase

Weight (HSCW) ranged from 200-450kgs and Rib Fat (RFT) ranged from 2 – 22mms indicating a wide range in cattle physical make up.

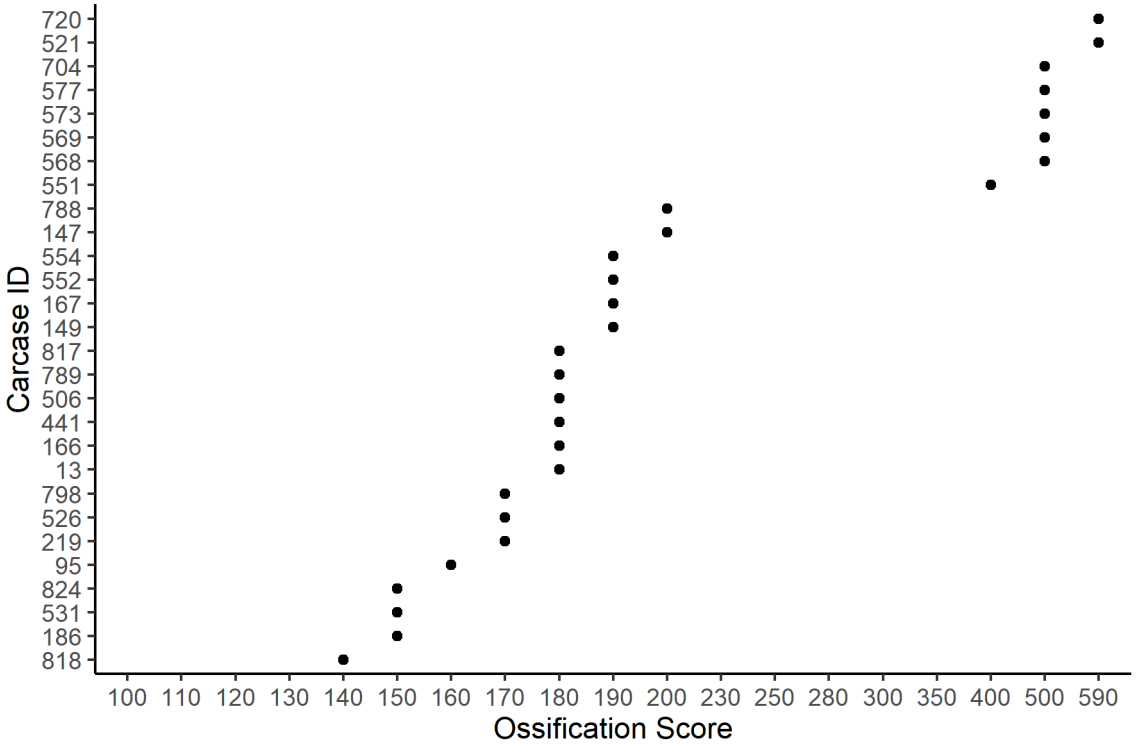

Figure 12: Ossification score of carcases utilised in the Australia vs US consumer testing

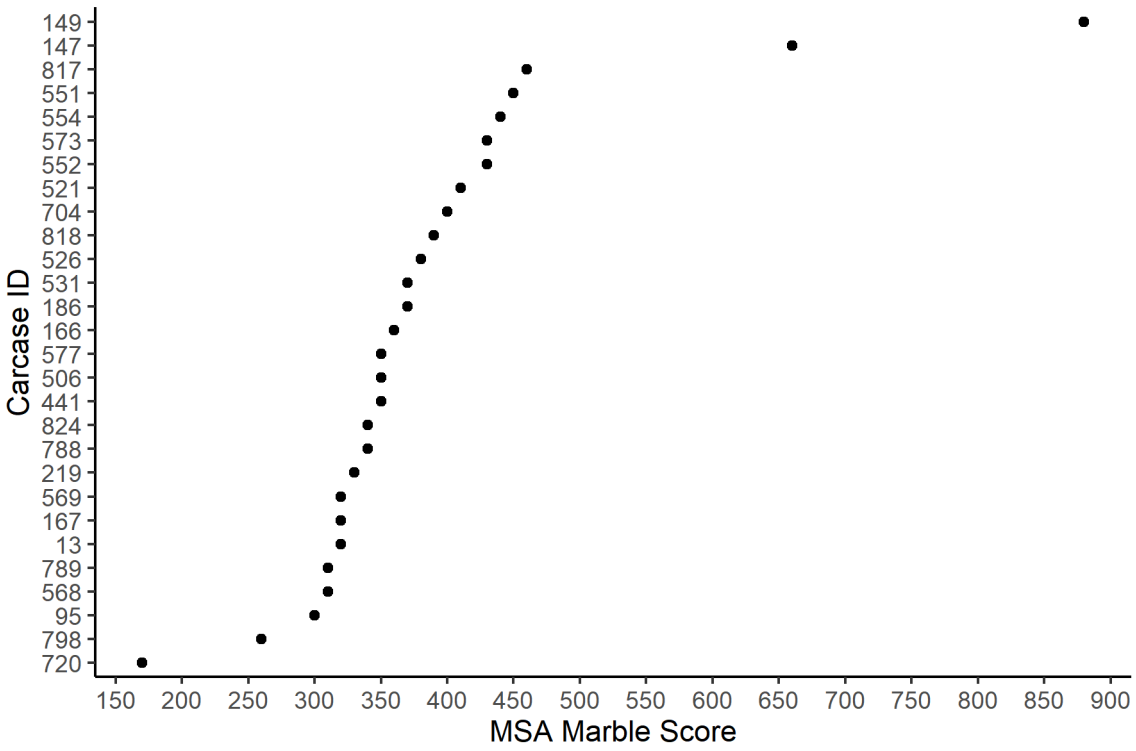

Figure 13: Meat Standards Australia Marble Score of carcases utilised in the Australia vs US consumer testing

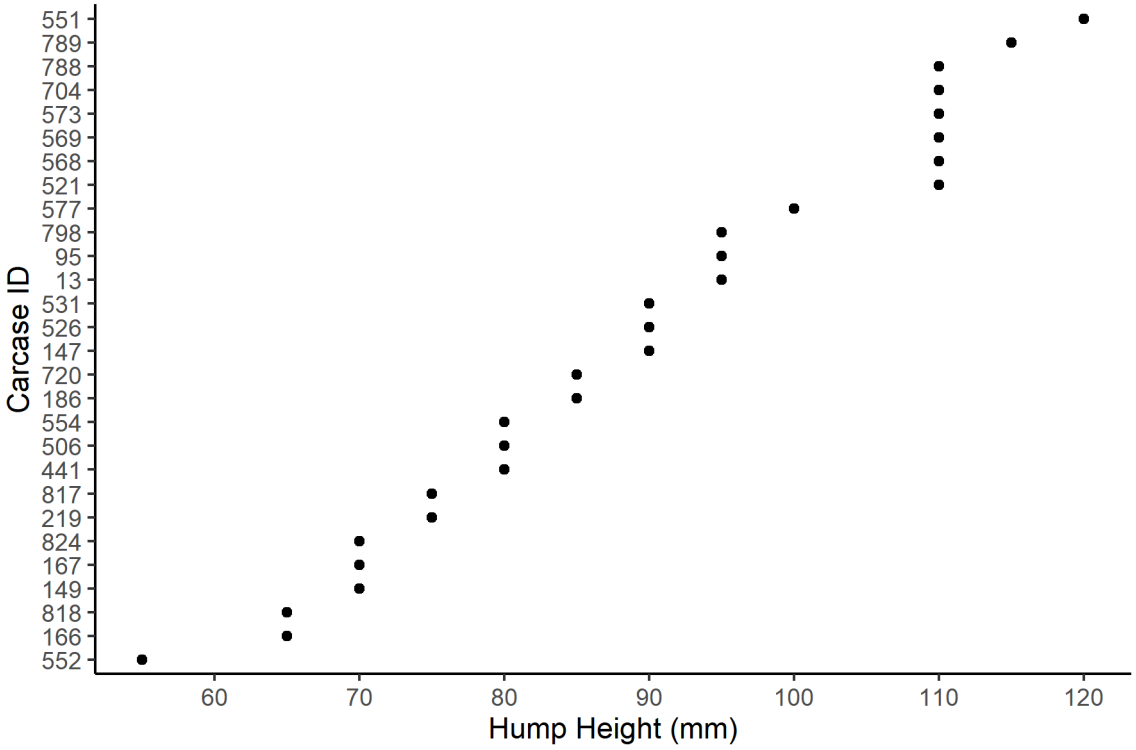

Figure 14: Hump height (mm) of carcases utilised in the Australia vs US consumer testing

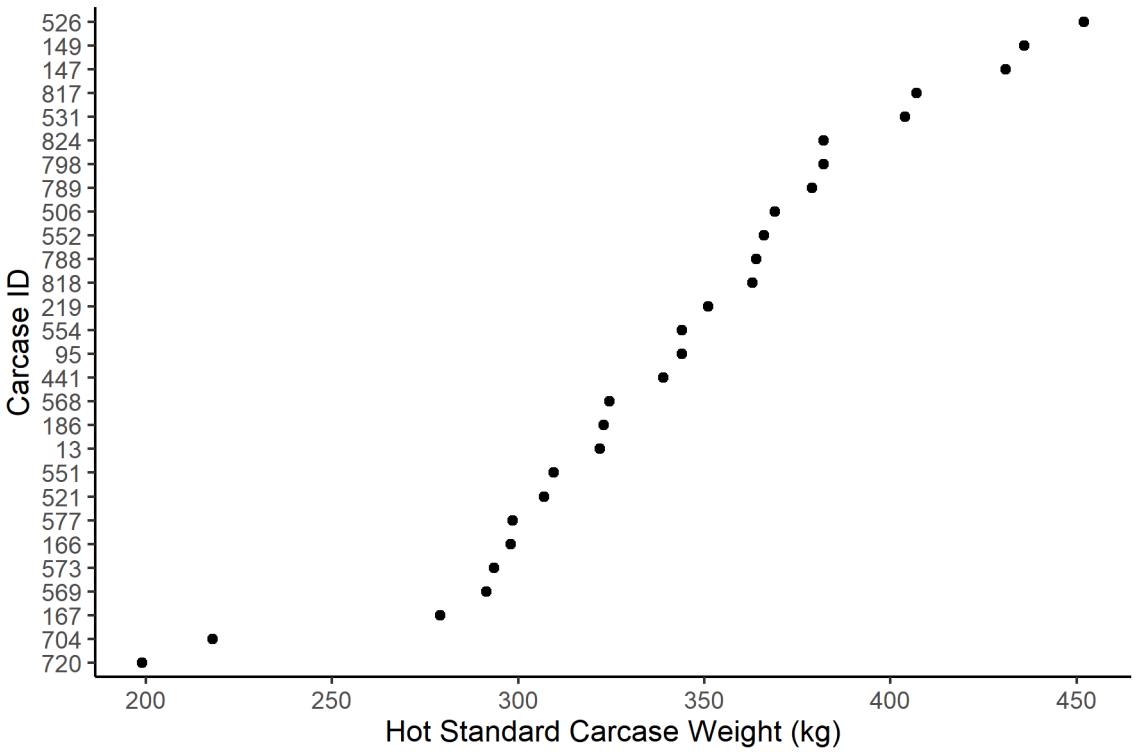

Figure 15: Hot standard carcase weight (KG) of carcases utilised in the Australia vs US consumer testing

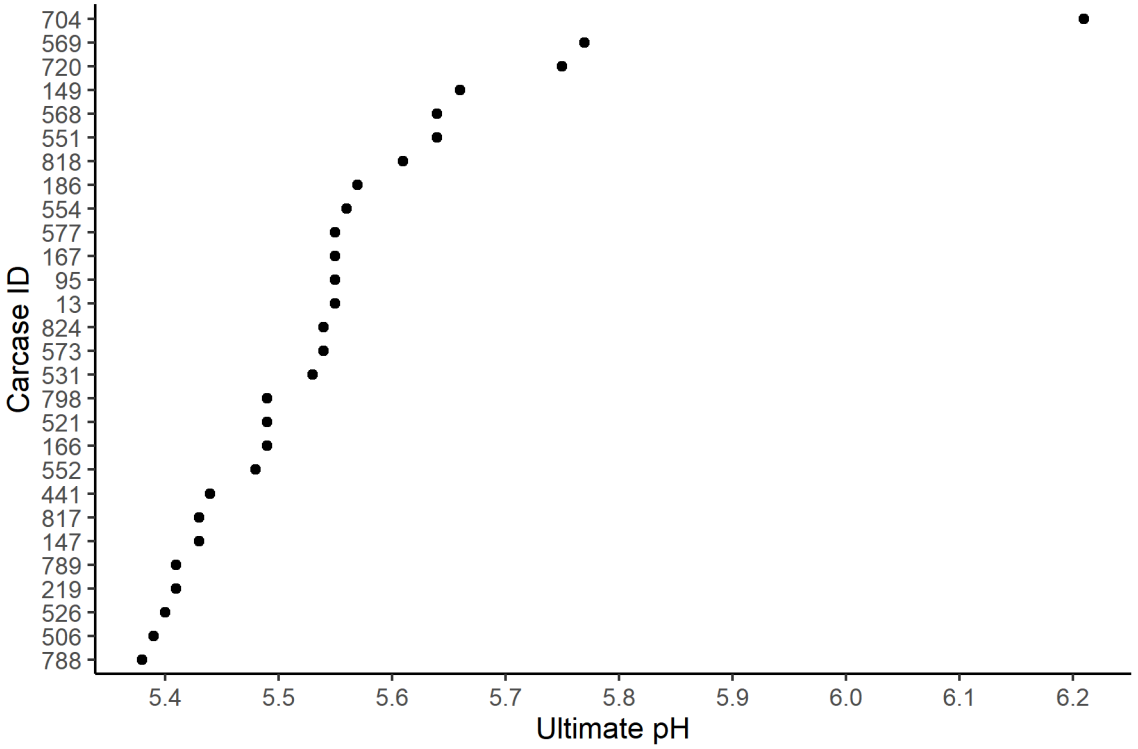

Figure 16: Ultimate pH of carcases utilised in the Australia vs US consumer testing

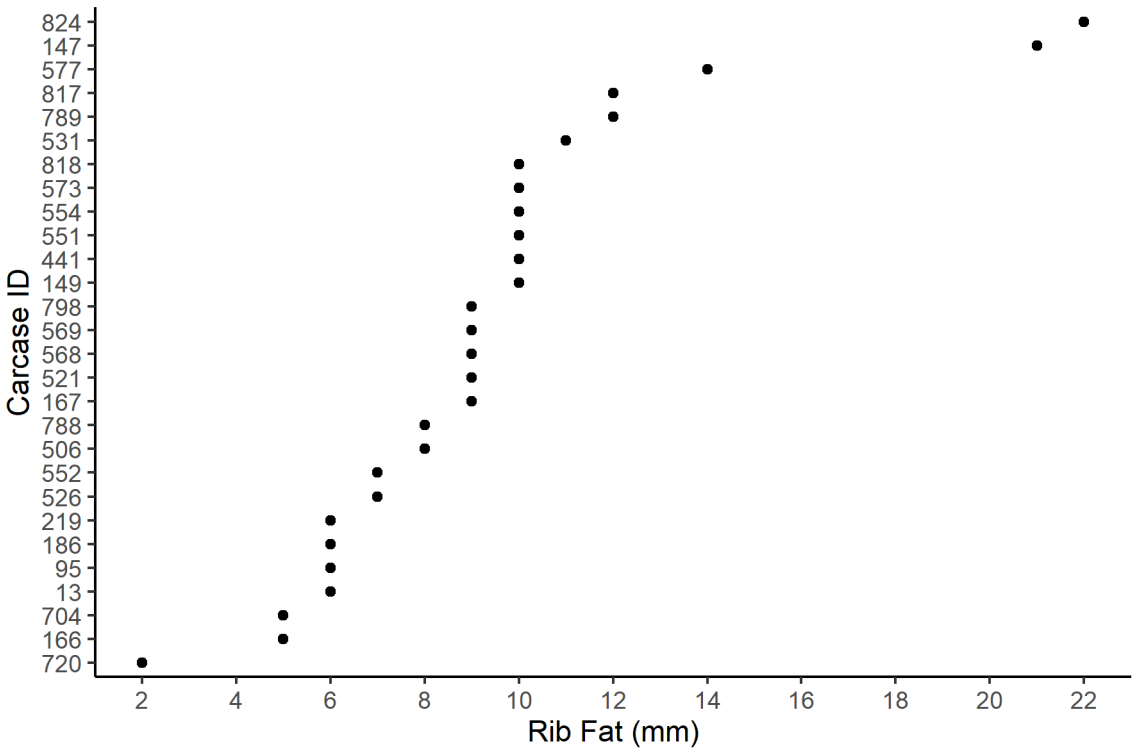

Figure 17: Rib fat (mm) of carcases utilised in the Australia vs US consumer testing

4.2.2 Consumer origin

Consumer origin, Australia or the USA, was analysed by calculating the difference in consumer sensory scores for each paired brisket. This calculation allowed for the serve type; chopped, pulled or sliced; to be accounted for within the pair. Furthermore, the difference was calculated by subtracting the Australian score from the USA score.

Table 7 (below) utilises estimated marginal means to identify the areas where differences were noted. It is evident that the BRI079 displayed the most consistent differences for consumer sensory measurements, except flavour where no distinct differences were found ($P > 0.05$). This is possible due to the method employed to prepare samples for sensory testing. Australian consumers were provided with the meat only from specifically BRI079, whereas USA consumers may have been provided with a sample that included some connective tissue. This would explain the extreme difference in the tenderness scores, which appear to be driving the overall liking of the BRI079 muscle.

Table 7: Estimated difference (± 95 % confidence interval) in consumer Australian and US sensory scores of tenderness, juiciness, flavour, overall liking and meat quality score (MQ4) for M. pectoralis profundus (BRI056), M. pectoralis superficialis (BRI057) and M. serratus ventralis (BRI079)

Muscle	Tenderness	Juiciness	Flavour	Overall Liking	MQ4
BRI056	6.73 ± 2.14^{a}	6.04 ± 1.94^{c}	-5.17 ± 1.82	-0.72 ± 1.91^{e}	0.82 ± 1.74^{g}
BRI057	2.77 ± 2.14^{a}	2.96 ± 1.94^{cd}	-5.19 ± 1.82	-3.36 ± 1.91^{e}	-1.41 ± 1.74^{g}

BRI079	-7.88 ± 2.15[b]	-2.49 ± 1.96[d]	-9.33 ± 1.83	-11.44 ± 1.92[f]	-8.72 ± 1.75[h]

[a, b] Different superscripts within row denote a difference in the estimated difference between muscles ($P < 0.001$)
[c, d, e, f, g, h] Different superscripts within row denote a difference in the estimated difference between muscles ($P < 0.01$)

Figures 18 – 22 outline the differences between the two country consumer groups for tenderness, juiciness, flavour and overall liking by muscle.

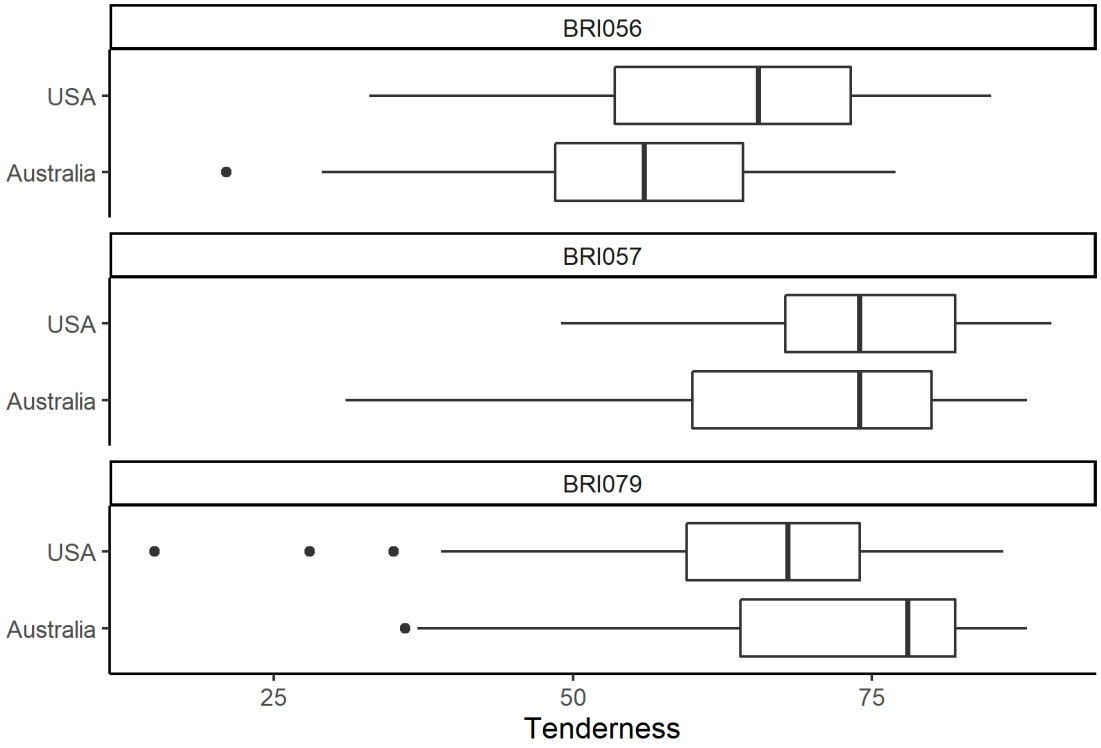

Figure 18: Tenderness scores from Australian and USA consumers on paired briskets (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

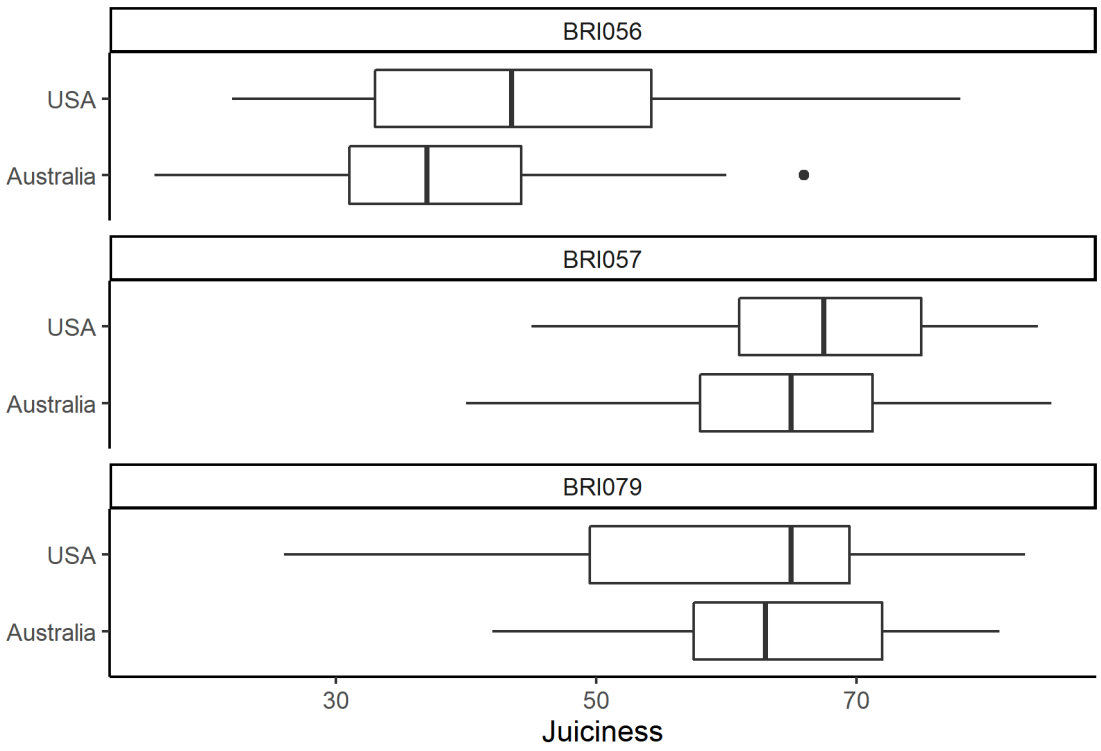

Figure 19: Juiciness scores from Australian and USA consumers on paired briskets (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

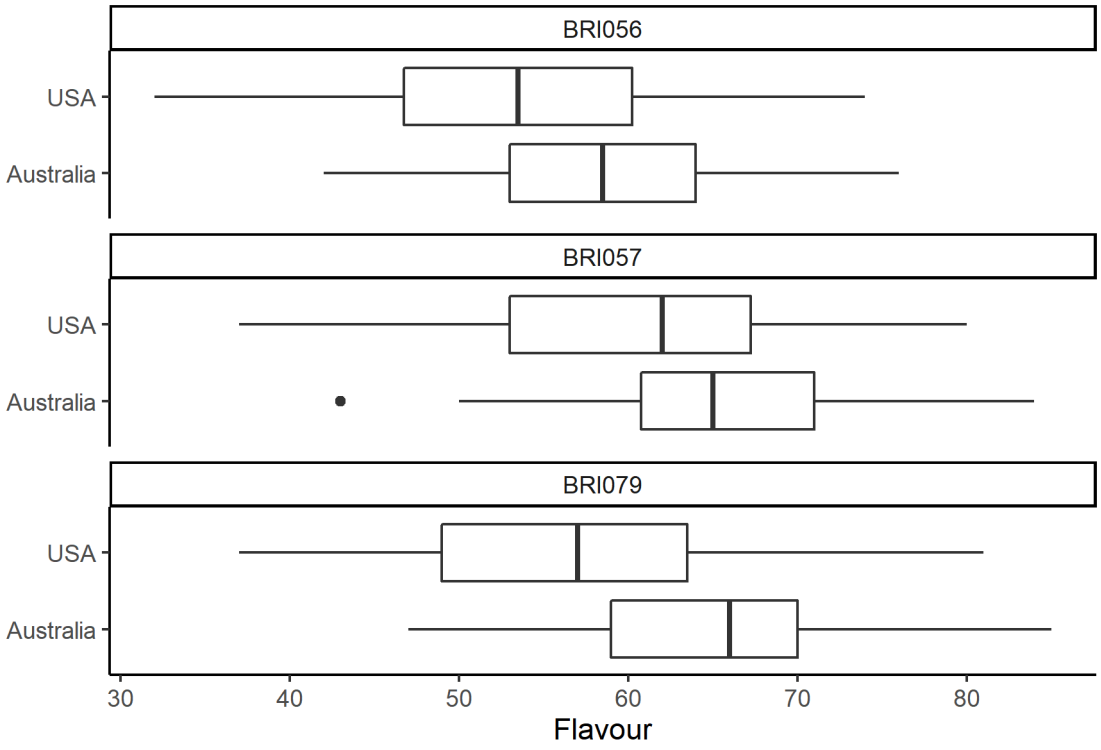

Figure 20: Flavour scores from Australian and USA consumers on paired briskets (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

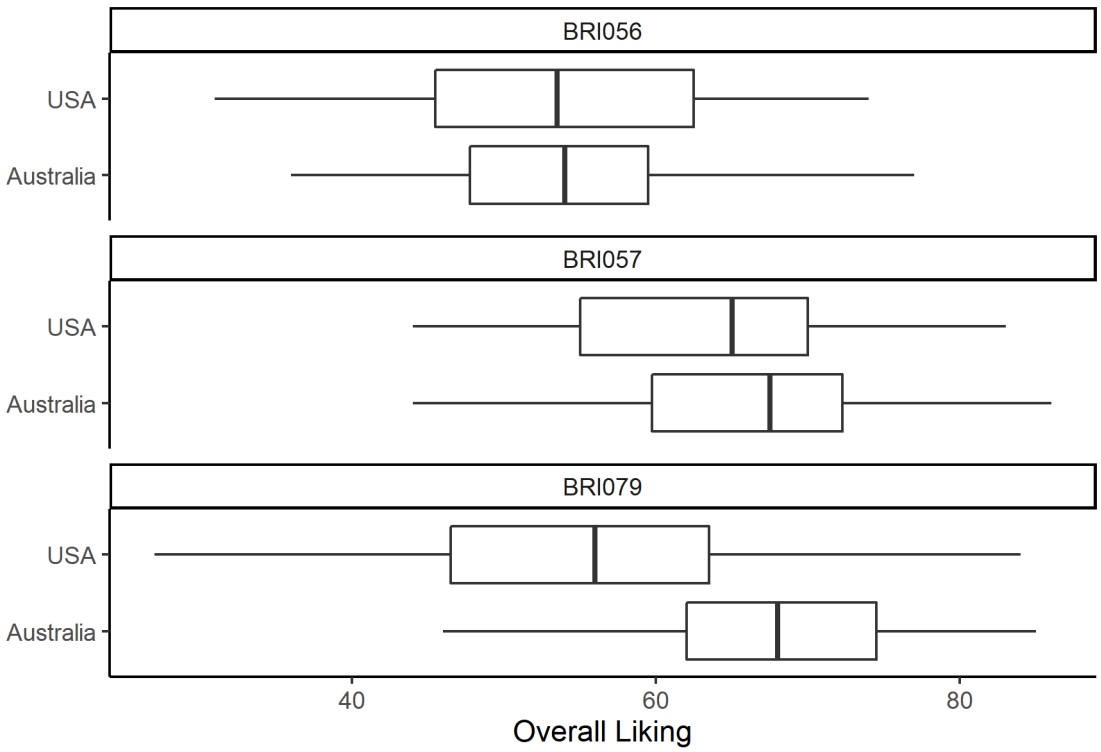

Figure 21: Overall liking scores from Australian and USA consumers on paired briskets (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

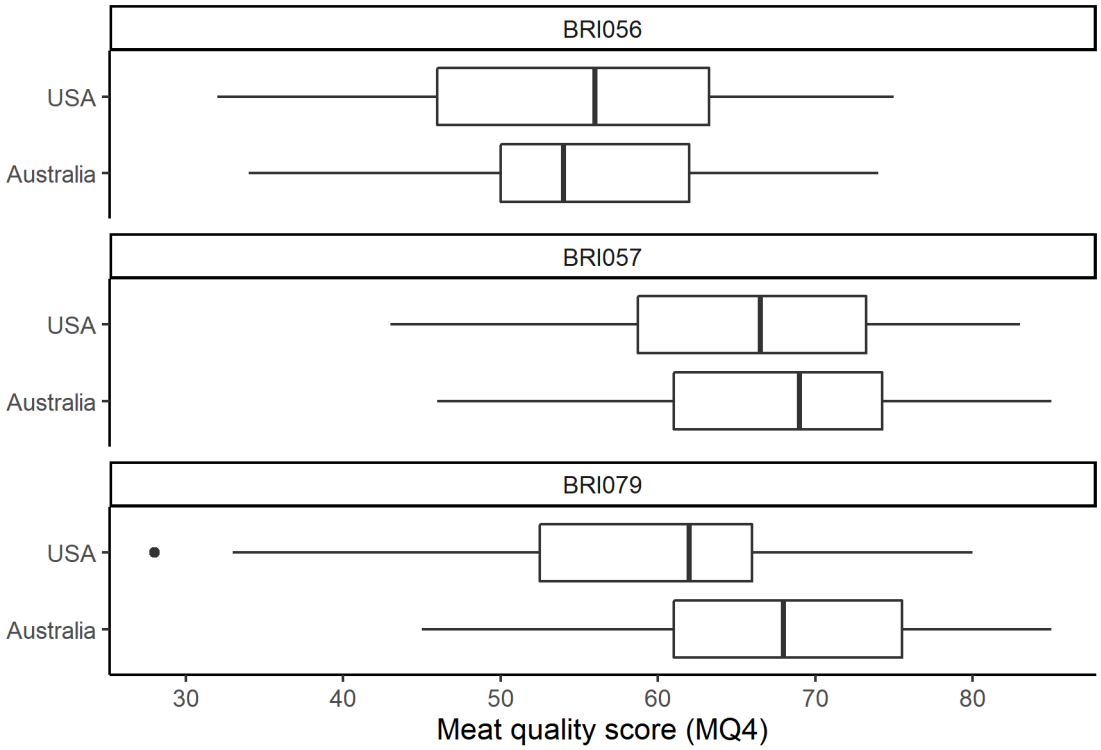

Figure 22: Meat quality (MQ4) scores from Australian and USA consumers on paired briskets (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

4.2.3 Position effect

Muscle, and position within muscle, were initially investigated as a fixed effect within the differenced model by testing whether there was a difference between their ability to predict consumer sensory measurements. The outcomes for all tests on consumer sensory measurements indicated that position had no effect on the outcome. As such it was removed from the outcomes of the previous section.

In order to elucidate why this was the case, a new model was developed for each consumer sensory measurement with position within muscle as a fixed effect and estimated marginal means were calculated. *Figure 23* below outlines the driver of the position effect as being the BRI079 Centre position for tenderness, juiciness and overall liking. This is explained by the fact that the briskets that were assigned a centre position were from carcases that were selected from the low quality group, where the BRI079 muscles were not large enough to gain two full samples from.

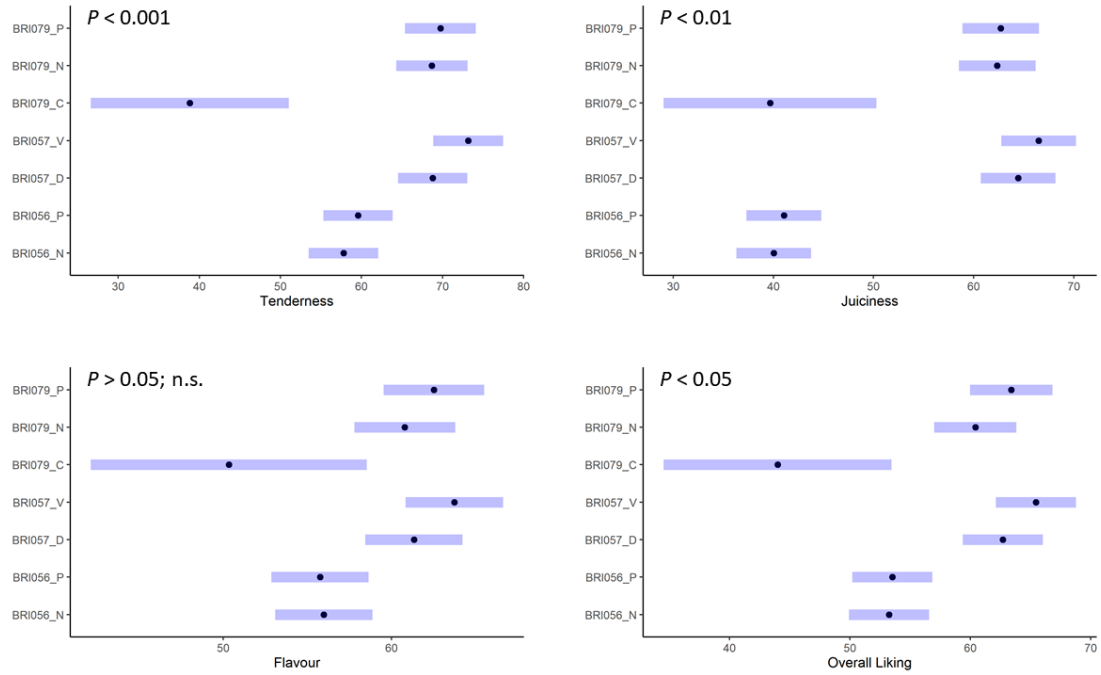

Figure 23: Estimated difference (± 95 % confidence interval) in consumer sensory measurements between positions (Navel, N; Point, P; Centre, C; Ventral, V; or Dorsal, D) within muscle (M. pectoralis profundus, BRI056; M. pectoralis superficialis, BRI057; and M. serratus ventralis, BRI079)

4.2.4 Serve method – chopped, pulled and sliced

Serve method had an effect on the consumer sensory measurements for briskets cooked using the low and slow method. Analysis of the data determined that the pulled method of serving brisket, regardless of muscle, reduced the meat quality score by an estimated four (4) eating quality points ($P < 0.01$). Table 24, below, outlines the difference in perceived eating quality for each cook method for each consumer sensory measurement. Interestingly, flavour changes were noted, with chopped receiving a higher eating quality when compared to pulled and sliced ($P < 0.05$). Some thought has been given to this and it is hypothesised that this may be a side effect of the consumers' perception

of the sample when provided as a pulled sample. Other samples are cut across the fibre of the meat, leaving the consumer with a short amount of meat through which to cut with their teeth. The pulled samples provide a long strand (70 mm) that requires more work to chew leaving the consumer with an unsatisfactory experience, thereby leading them to a lower sensory score.

Table 24: Estimated difference (± 95 % confidence interval) in Australian and USA consumer sensory scores of tenderness, juiciness, flavour, overall liking and meat quality score (MQ4) for each serve method (Chopped, Pulled and Sliced)

Serve	Tenderness	Juiciness	Flavour	Overall Liking	MQ4
Chopped	64.3 ± 2.38[a]	55.7 ± 1.87[c]	61.3 ± 1.24[c]	60.5 ± 1.58[c]	61.3 ± 1.65[e]
Pulled	59.6 ± 2.37[b]	51.7 ± 1.85[d]	57.7 ± 1.22[d]	56.0 ± 1.57 [d]	57.1 ± 1.63[f]
Sliced	66.9 ± 2.36[a]	55.9 ± 1.84[c]	59.3 ± 1.21[d]	59.1 ± 1.56 [c]	61.1 ± 1.63[e]

[a, b] Different superscripts within column denote a difference in the estimated difference between serve method ($P < 0.001$)
[c, d] Different superscripts within column denote a difference in the estimated difference between serve method ($P < 0.05$)
[e, f] Different superscripts within column denote a difference in the estimated difference between serve method ($P < 0.01$)

4.3 Low 'n slow barbeque ribs – Australian and American consumers

This portion of the report will be completed once paired ribs are eaten in the USA. Work is underway and it is expected this will be complete in October 2019.

4.4 Low 'n slow barbeque briskets – Hot vs Reheated

A summary of carcase traits can be found in *Table 8*. Subsequent histograms (Fig. 25) illustrate the distribution of scores for each trait among the carcases used for consumer testing.

Table 8: Mean (± SD), minimum and maximum carcase characteristics for the 81 carcases that striploins were collected for the hot vs reheat experiment

Variable	Mean	Minimum	Maximum
Hot standard carcase weight (kg)	344.1 ± 86.5	184	526
Hump height (mm)	80.6 ± 26.2	50	170
Rib Fat (mm)	9.0 ± 5.4	1	31
Ossification	266.8 ± 165.1	110	590
Marbling	428.6 ± 199.6	130	970
pH	5.60 ± 0.1	5.40	6.21
Sex (F, M, Unknown)	26, 53, 2	-	-
HGP treatment status (Y, N)	38, 43	-	-

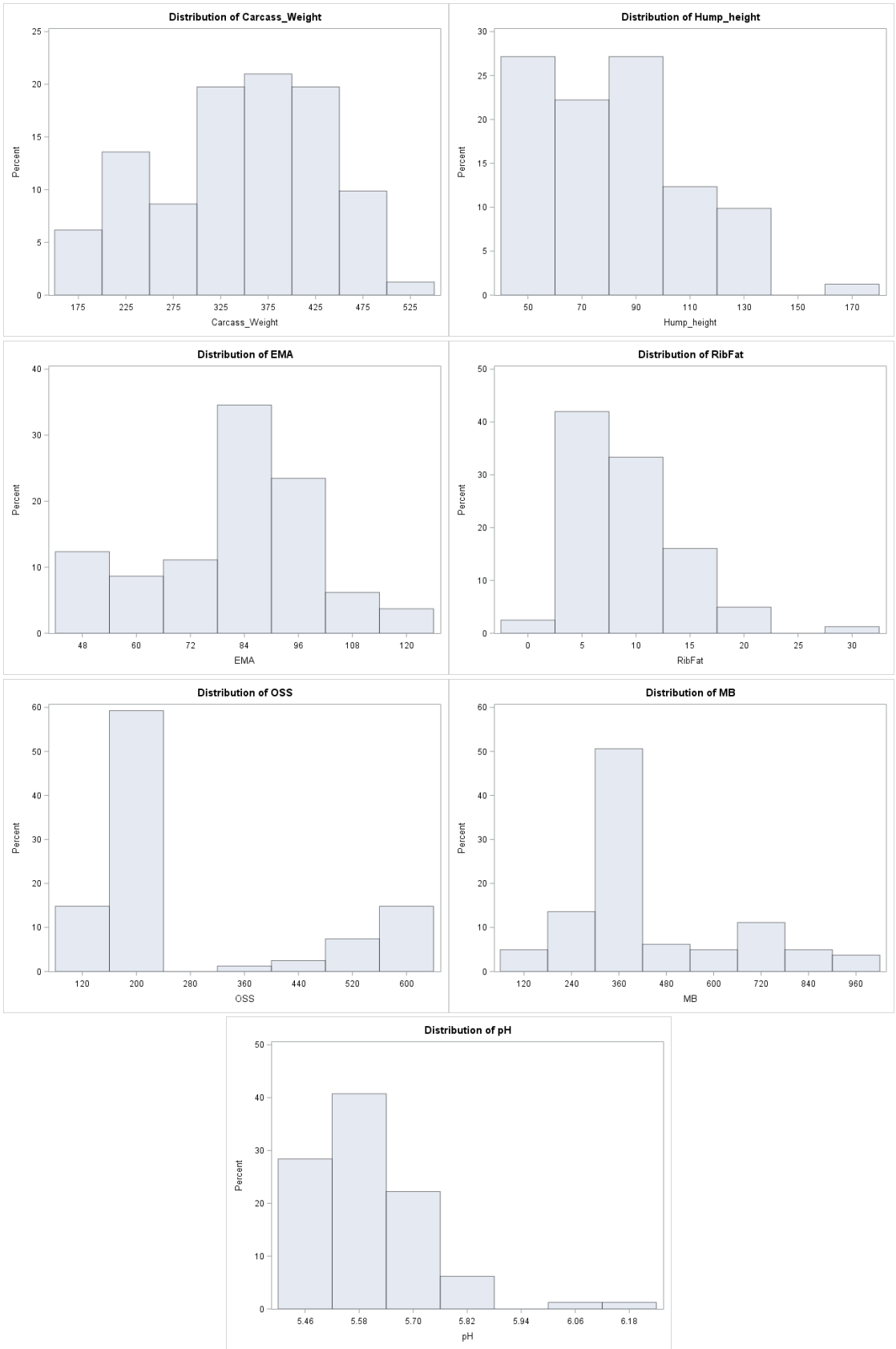

Figure 25: Histograms outlining the distribution of carcase attributes for briskets utilised in the hot vs reheat experiment

4.4.1 Muscle

Consumers could clearly distinguish BRI057 vs. BRI056 muscles ($P < 0.01$), regardless of serve time or serve form (Table 9). BRI057 portions were scored more favourably than BRI056 portions across all traits. Despite an overwhelming difference in juiciness (over 20 units) and a moderate difference in tenderness (8.5 units), less disparity was observed in flavour liking (4.5 units). Ultimately, consumers liked BRI057 portions more than BRI056 portions (7.4 units), which resulted in a greater composite MQ4 score and greater average satisfaction.

Table 9: Least Squares means for muscle (M. pectoralis profundus, BRI056; and M. pectoralis superficialis, BRI057)

CUT	Tenderness	Juiciness	Flavour Liking	Overall Liking	MQ4	Satisfaction
BRI056	69.8[b]	52.3[b]	61.1[b]	62.1[a]	63.1[b]	3.3[b]
BRI057	78.3[a]	72.9[a]	65.6[a]	69.5[b]	71.3[a]	3.6[a]
SEM (largest)	1.5	1.3	1.2	1.2	1.2	0.04
P-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

[ab] Within a column, means sharing a common superscript, do not differ ($P < 0.01$).

4.4.2 Serve Time & Serve Form

There was a desire to investigate if eating quality would be affected by reheating vs serving directly post cooking and also if eating quality was influenced by the form in which the brisket samples were served. *Table 10* illustrates the influences of serving time (hot vs. reheat) and serving form (chopped, pulled, sliced) on consumer eating quality of smoked brisket. The brisket samples that were served fresh "hot" on the day they were cooked, had greater ($P < 0.01$) consumer scores for all traits, which resulted in greater ($P < 0.01$) MQ4 and Overall Liking. Despite greater average Overall Liking, briskets served Hot and Reheated would both be considered "good everyday quality."

The effects of serving form on brisket eating quality can also be found in *Table 10*. Brisket samples that were served sliced and chopped were similar and had greater ($P < 0.05$) consumer scores for tenderness, juiciness, flavour liking, and overall liking compared to pulled brisket samples, which resulted in reduced ($P < 0.05$) MQ4 and Overall Liking. Despite any differences in palatability traits, all serving forms would be considered "good everyday quality" according to average satisfaction (3 = good everyday quality; 4 = better than everyday quality).

Table 10: Least square means for serve time and serve form (chop, pull, slice)

Treatment	Tenderness	Juiciness	Flavour	Overall Liking	MQ4	Satisfaction
Serve Time						
Hot	76.1[a]	65.4[a]	65.3[a]	67.7[a]	69.3[a]	3.5[a]
Reheat	72.1[b]	59.8[b]	61.4[b]	63.9[b]	65.2[b]	3.4[b]
SEM (largest)	1.5	1.3	1.2	1.3	1.2	0.04
P-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Serve Form						
Chop	75.2[a]	63.8[a]	64.9[a]	67.1[a]	68.5[a]	3.5[a]
Pull	69.6[b]	59.5[b]	61.0[b]	63.1[b]	64.1[b]	3.3[b]
Slice	77.4[a]	64.3[a]	64.1[a]	67.2[a]	69.1[a]	3.5[a]
SEM (largest)	0.8	1.5	1.3	1.4	1.3	0.05
P-value	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01

[ab] Within a column and treatment, means sharing a common superscript, do not differ ($P < 0.05$).

4.4.3 Relationship of Brisket Eating Quality to Carcase Traits

As seen in *Table 11*, Pearson correlation coefficients suggested there were linear relationships between carcase traits and brisket eating quality (data was pooled, so there was no differentiation between muscle, serving time, or serving form). Carcase weight, eye muscle area (EMA), rib fat, and marbling were all positively related to eating quality ($P < 0.01$), while hump height, ossification, and pH were negatively associated with eating quality ($P < 0.01$). Increased carcase weight and EMA, which could be a function of grain feeding, was linked to greater eating quality scores. Unsurprisingly, marbling was also positively related to eating quality. Conversely, hump height, which is tied to tropical breed content, had a negative influence on eating quality. Likewise, increased ossification scores, which result from advanced maturity, also had a negative relationship with eating quality. This negative correlation was most apparent in tenderness (r = -0.70). Finally, increased pH was negatively associated with eating quality. It should be noted that most carcases (87.7%) were pH compliant for MSA grading (pH $\leq$ 5.70). Also, only 2.4% of carcases utilised had a pH > 6.0, and the maximum pH recorded for any carcase used for consumer testing was 6.21 (refer to histograms shown previously).

Table 11: Pearson correlation coefficients between carcase traits and consumer sensory measurements*

Trait	Tenderness	Juiciness	Flavour	Overall Liking	MQ4	Satisfaction
Carcase Weight	0.53	0.40	0.31	0.43	0.46	0.40
Hump Height	-0.48	-0.38	-0.40	-0.48	-0.48	-0.44
Eye Muscle Area	0.46	0.31	0.30	0.39	0.41	0.35
Rib Fat	0.37	0.33	0.32	0.37	0.37	0.36
Ossification	-0.70	-0.50	-0.45	-0.59	-0.62	-0.54
Marbling	0.38	0.36	0.26	0.33	0.35	0.31
pH	-0.34	-0.22	-0.21	-0.28	-0.30	-0.25

*All coefficients differed from 0 ($P < 0.01$)

Regression analysis revealed that carcase characteristics accounted for 52%, 29%, 24%, and 38% of the variation in tenderness, juiciness, flavour liking, and overall liking, respectively ($P < 0.01$; Table 12). Despite significant relationships when isolating each carcase trait and its relationship to eating quality, carcase weight and EMA had little influence on eating quality, except for tenderness. Otherwise, hump height, ossification, and pH were negatively related to eating quality (specifically MQ4), while rib fat and marbling were associated with positive eating quality.

Table 12: Regression equations developed to predict consumer sensory measurements and satisfaction based on carcase characteristics*

Trait	Tenderness	Juiciness	Flavour	Overall Liking	MQ4	Satisfaction
Intercept	83.04220	60.02931	68.75743	73.44337	116.07410	3.47303
Carcase Weight	0.03687					
Hump Height	-0.05758		-0.07596	-0.08153	-0.06395	
Eye Muscle Area	-0.12768					
Rib Fat			0.36808	0.44916	0.31103	0.01858
Ossification	-0.08625	-0.06358	-0.03464	-0.05554	-0.05471	-0.00190
Marbling	0.00879	0.02048			0.00676	
pH					-7.99548	
R^2	0.5194	0.2879	0.2440	0.3884	0.4230	0.3388
C(p)	5.3601	4.1325	2.6520	4.2056	6.0133	3.7829

*Significance level for entry into the model ($P < 0.15$). All variables left in the model are significant ($P < 0.15$)

4.4.4 Discussion of results – hot vs reheat experiment

Muscle

BRI057 portions likely contained more intramuscular fat, which has not been quantified at this time, than BRI056 portions, which resulted in the consistently greater scores of BRI057 for all traits. Although subcutaneous fat was trimmed before serving, point portions would have more exposure to subcutaneous fat during the cooking process. Juiciness is also greatly affected by fat level; heating meat creates a melting/rendering effect. This effect produces a liquid that is a vital factor in perceived juiciness. Low heat, moist cookery (Griswold, 1955, Weir, 1960) is beneficial for cuts like the brisket, which historically have the highest shear force values in Warner-Bratzler shear force (WBSF) tests (Ramsbottom et al., 1945). Previous research (McKeith et al., 1985) evaluating 13 individual muscles found pectoral muscles to produce the highest WBSF values and the lowest overall tenderness values. The same brisket samples had the lowest level of connective tissue, which suggests that the form (soluble vs. insoluble) of the connective tissue plays a more relevant role than the amount of total connective tissue.

Serving Time (Hot Vs. Reheat)

Some consumers are driven by convenience, while others may not have access to their own backyard barbeque. As a result, ready-to-eat and ready-to-heat meat products have grown in popularity. Ready-to-heat products have received negative anecdotal reviews for years, however the reason has not been investigated in-depth in all food products. The hot served product was held in higher regard (3.8 units) in terms of overall liking. The greatest spread between Hot and Reheat occurred for juiciness, suggesting the second heat exposure may have dried the product out to some extent. Samples remained in their original vacuum packaging when placing in the circulating water bath for reheating so that no juice would escape. However, if ready-to-heat brisket is an avenue that will be pursued, consideration for enhancement (including an antioxidant) is warranted to improve water holding capacity and juiciness in product that is intended to be heated two or more times. Another reason for increased overall liking of Hot vs Reheat may be due to the flavour differences between the samples. On average, Hot samples were scored 3.9 units higher for flavour liking than Reheat samples. This could be due to the reduced total oxidation of lipids combined with the reduced cooking loss due to a single heat treatment compared to the reheat where a second heat treatment was required (Ladikos and Lougovois, 1990). The samples also remained in dark refrigerated storage for one week prior to being served. The combination of cooking and a longer period at refrigerated temperatures vastly increases the potential for oxidation. The samples were stored under vacuum packaging, however they were exposed to the atmosphere for approximately 24 hours from seasoning to packaging of the final product. All these factors could contribute to increased oxidation.

Serving Form

Differences were observed in consumer eating quality due to serving form. Consumers generally did not discriminate between chopped and sliced brisket and scored those forms greater for tenderness, juiciness, and flavour than pulled brisket, resulting in greater overall liking. There could have been a visual bias where the consumer can clearly see the sample fibres in pulled brisket and they were also biting across the muscle fibres, as opposed to biting between the muscle fibres in the sliced and chopped samples. The sample size could also influence the tenderness scores. Chopped brisket measured approximately 20-mm on any given side, whereas brisket was sliced 6-mm in thickness. If brisket was pulled to a smaller dimension that could influence those results.

Carcase Traits

Despite significant relationships when isolating each carcase trait and its relationship to eating quality, carcase weight and EMA had little influence on eating quality, except for tenderness. Otherwise, hump height, ossification, and pH were negatively related to eating quality (specifically MQ4), while rib fat and marbling were associated with positive eating quality. As previously mentioned, ossification is associated with advanced maturity. Palatability from older animals is generally diminished compared to young animals (Herring et al., 1967), provided those cull animals were not part of a feeding program before slaughter. In the current study, the breakdown of collagen did not appear to occur during the cooking process of briskets from older animals. This could be due to the increased level of crosslinking (Bendall, 1964, Piez, 1968), as it is known that total collagen levels go down as animals' age. Collagen solubilizes around 70 °C leading to an increase in tenderness from cooking.

It is well documented that fat is a vital component of any meat product. Fat provides a source of volatile compounds that are essential in flavour production. The fatty acid profile is unique to the individual animal, however there is typically a positive correlation between fat level (quality grade) and flavour liking (Miller et al., 2000). Juiciness is also greatly affected by fat level; heating meat creates a melting/rendering effect. This effect produces a liquid that is a vital factor in perceived juiciness. Juiciness and flavour liking were both positively related to both rib fat and marbling; however, regression analysis revealed slightly different results than simple correlation analysis. Marbling was a positive predictive trait for tenderness and juiciness, but not flavour liking. Conversely, rib fat was a positive predictive trait for flavour liking, but not tenderness or juiciness. These results suggest that the subcutaneous fat, rather than intramuscular fat (IMF), plays a bigger role on flavour for cuts like the brisket, which are cooked with fat on the muscle. As that external fat is heated during the cooking process and melts, this potentially plays a bigger role in flavour development than the intramuscular fat present within the muscle. This also demonstrates the need to determine the intramuscular fat content of these muscles to determine the relationship between IMF of brisket and the marbling (predictor of IMF) of the ribeye (*M. longissimus thoracis*), where marbling is assessed during MSA grading.

4.5 Low 'n slow barbeque briskets – Animal factors

Eighty-two (82) carcases were utilised within this section of the analysis, with a total of 284 samples taken across two muscles (BRI056 and BRI057). *Table 13* outlines the average carcase traits for the carcases collected at the Northern and Southern abattoirs.

Table 13: Count and mean (± SD) carcase data of carcases cooked and served hot to consumers

Trait	Northern	Southern
Hot standard carcase weight (kg)	246.62 ± 48.9	367.7 ± 59.3
Hump Height (mm)	110.95 ± 21.2	80.66 ± 14.7
MSA Marble Score	309.05 ± 100.2	400.98 ± 148.1
Ossification score	521.9 ± 72.6	182.13 ± 46.7
Ultimate pH	5.7 ± 0.2	5.51 ± 0.1
Rib Fat (mm)	5.86 ± 3.9	8.59 ± 3.8
Sex (F,M)	21, 0	8, 53
HGP (Y,N)	20, 1	32, 29

Differences were noted between the northern and southern cattle, due to the collection of lower eating quality carcases from the northern abattoir. This quality is outlined specifically in the hump height and ossification score of the carcases (Fig. 26 and 27; below). While ossification is known to play a large role in eating quality, results from this section must be interpreted with the knowledge that the carcases collected may not be a representative sample of the population. The low quality carcases were, for the majority, collected from high *Bos indicus* content, high ossification females. While this group of animals are one article, which may benefit greatly from a cook method that increases eating quality, drawing conclusions about briskets as a whole from this group would be unwise.

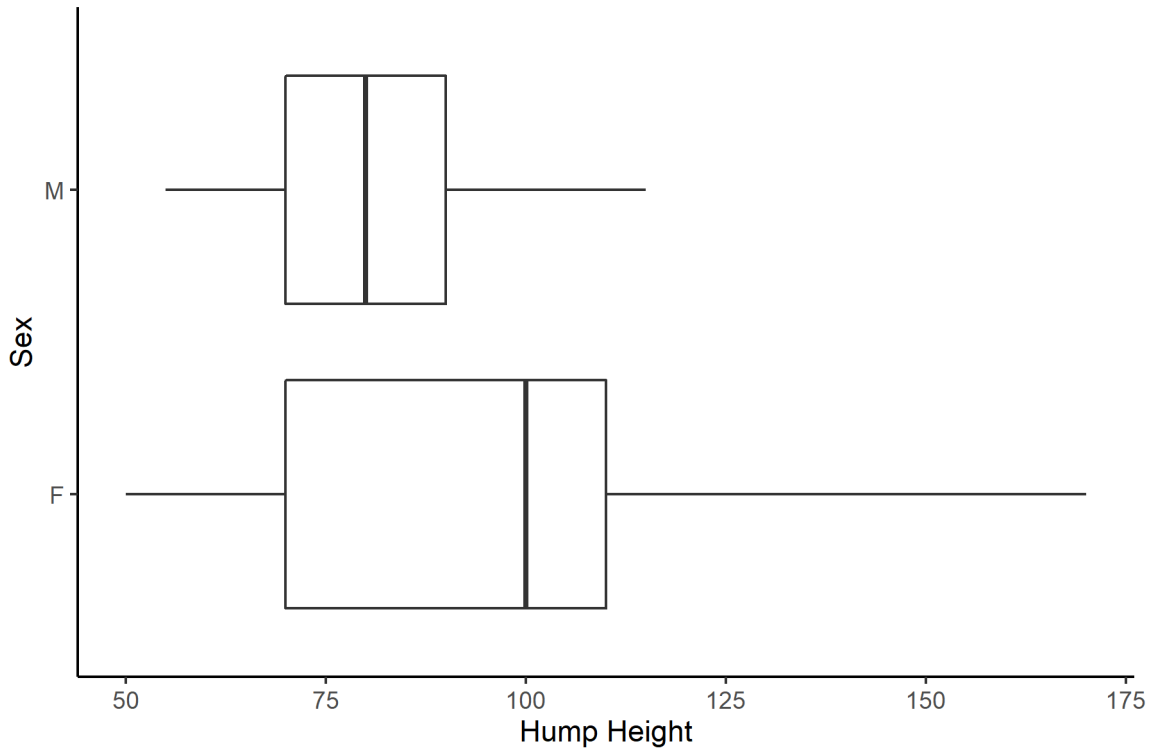

Figure 26: Hump height differences between female (F) and male (M) carcases

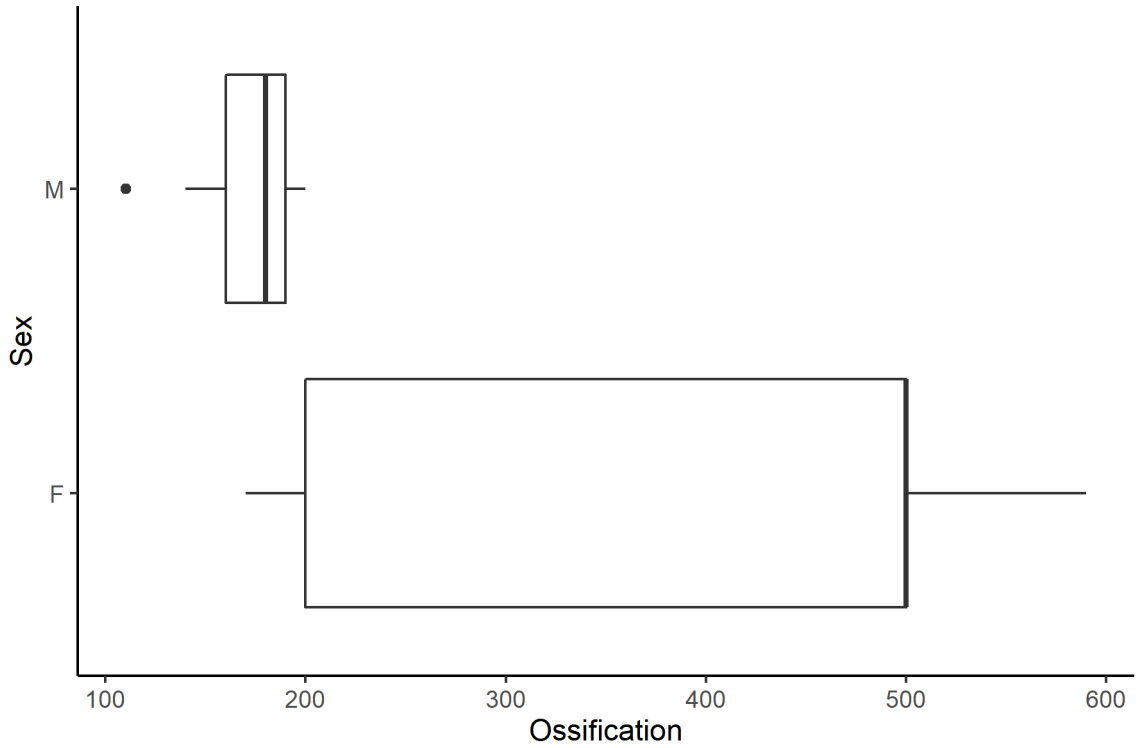

Figure 27: Ossification differences between female (F) and male (M) carcases

Base models were calculated for tenderness, juiciness, flavour, overall liking and MQ4. *Table 14* shows the estimated means for muscle, as well as serve type. There were differences between BRI056 and BRI057 for all consumer sensory measurements, with MQ4 scores of 54.1 and 63.5 respectively. This places both muscles within a Good Everyday consumer satisfaction group, however BRI057 almost meets the Better than Everyday. The main difference was in juiciness, with BRI056 scoring 22 points lower than BRI056. This was likely driven by the higher degree of intramuscular fat that is visually evident in BRI057 as compared to BRI056; which appears quite dry in comparison. This difference in eating quality presents an opportunity for further fabrication of briskets in to separate muscles prior to packing in the boning room. The higher eating quality of BRI057 allows for different marketing opportunities than marketing a whole point end brisket.

Table 14: Estimated mean (± 95 % confidence interval) consumer sensory scores of tenderness, juiciness, flavour, overall liking and meat quality score (MQ4) for muscle (*M. pectoralis profundus*, BRI056; and *M. pectoralis superficialis*, BRI057) and serve method (Chopped, Pulled and Sliced)

Fixed Effect	Tenderness	Juiciness	Flavour	Overall Liking	MQ4
BRI056	57.9 ± 1.93^{a}	42.4 ± 1.47^{f}	55.4 ± 1.04^{j}	53.0 ± 1.34^{l}	54.1 ± 1.38^{o}
BRI057	67.6 ± 1.93^{b}	64.4 ± 1.47^{g}	61.2 ± 1.04^{k}	61.8 ± 1.34^{m}	63.5 ± 1.38^{p}
Chopped	62.9 ± 2.00^{c}	54.0 ± 1.57^{h}	59.4 ± 1.15	58.4 ± 1.43^{n}	59.5 ± 1.45^{q}
Pulled	59.6 ± 2.01^{d}	50.6 ± 1.59^{i}	56.8 ± 1.17	55.2 ± 1.45^{o}	56.4 ± 1.46^{r}
Sliced	65.8 ± 2.00^{e}	55.6 ± 1.57^{h}	58.9 ± 1.15	58.6 ± 1.43^{n}	60.4 ± 1.45^{q}

$^{a-q}$ Different superscripts within column denote a difference in the estimated value ($P < 0.05$)

Tenderness of briskets was driven by a negative effect of ossification ($P < 0.001$) and a positive effect of marble score ($P < 0.01$) as well as an interaction between muscle and ossification ($P < 0.01$) and marble score ($P < 0.05$). The outcomes here are not surprising. Ossification is known to be a driver of tenderness (Smith et al., 1988).

Similarly to tenderness, juiciness was also driven by lesser negative effect ossification ($P < 0.001$) and a similarly positive effect of marble score ($P < 0.001$), with an interaction between muscle and ossification ($P < 0.05$).

Flavour outcomes appeared to be negatively associated with sex (6.9 points higher for males; $P < 0.001$), ultimate pH ($P < 0.05$), HGP status ($P < 0.05$), and hump height ($P < 0.05$). These outcomes, particularly sex and hump height, may have been in part due to the type of animals that were sourced for this research. In order to gain a number of low quality cuts there was a need to source cattle from an abattoir in northern Australia where there is a higher *Bos indicus* content in the animals. Figure 26 (above) depicts the breakdown of hump height by sex and shows that there was a large number of females with high humps.

Ossification had the main impact on overall liking of the carcase traits ($P < 0.001$), along with a tendency for a muscle by ossification interaction ($P = 0.084$). This is not surprising, given the impact of ossification on both tenderness and juiciness. Interestingly, rib fat appeared significant in this model ($P < 0.05$) however it is unclear what may have caused this to become important, where it was not relevant within the tenderness, juiciness or flavour models developed. It may be theorised that this result is due, once again, to the lower quality carcases. Those pulled from northern Australia had a

lower mean rib fat than the southern cohort. Briskets from the carcases received lower consumer sensory scores, including overall liking. This may have led to this result.

There was a tendency for hump height to have an effect on overall liking as well (P = 0.067); which may be explained by the carcases collected. As outlined above, the high ossification carcases from the northern Australian abattoir were collected as the low eating quality carcases, thus skewing the results. A shortcoming of the carcases collected was that there were no, or at least minimal, carcases with a higher eating quality collected which also had a higher *Bos indicus* content.

5 Conclusions/recommendations

There were two main aspects of this project; i) the effect of ageing striploins out to 84 d; and ii) the effect of low 'n slow barbeque on consumer perceptions of eating quality.

The striploins that were collected and aged showed a distinct decline in eating quality from 21 d to 84 d aged. This was not expected and the underlying causes do not appear apparent. The immediate decrease in tenderness, as measured by untrained consumer panels, was nonsensical, however it matched a similar decline in flavour over the ageing periods. It may be concluded that the reduction in liking of flavour influenced the consumer sensory experience and caused a harsher response on other consumer sensory measurements. A suggestion for all future work into long ageing is that;

a. Microbial population measurements are taken at portioning and then prior to service, and
b. Collect and portion primals into pre-portioned blocks of meat at the abattoir to ensure minimal chance of microbial contamination may occur. Portioning into consumer sensory samples may then be done immediately prior to freezing down.

The low 'n slow barbeque cook method was tested among Australian and USA consumers; a naive population compared to an experienced population. With no differences found between the two when eating paired point end briskets, it appears that this cook method is acceptable across countries.

While consumers liked the flavour, briskets sourced from lower quality carcases were scored lower than those of higher quality carcases when served hot. This was likely due to the age and feed type (pasture fed) of the cattle. It must be noted here that briskets were minimally seasoned for this study. Investigation of alternative rubs, spice blends, and sauces could completely mitigate any flavour differences that were observed, which could be something to consider for future funding and research. This would provide the ability to further value add lower quality carcases.

The differences noted between Australian and USA consumers for navel end brisket may be attributed to the preparation of the muscle for service; i.e. with or without silver skin on the *M. serratus ventralis*. The commercial relevance of the navel end brisket for this cook method should also be questioned. The level of fat that must be removed prior to service, and the presence of a large amount of connective tissue means there is a considerable loss of weight before the meat is in an acceptable form for service. This cut has more potential for value adding into new products, perhaps similar to those made from pork belly.

Obviously, hot samples were preferred, but reheating briskets did not result in scores that would drop those samples out of the “good everyday” eating quality designation. Future work could look to the addition of antioxidants or enhancement to combat potential oxidation and reduced juiciness from multiple heat exposure incidents, which should produce a product that is more consistent between hot and reheated product.

Consistent with previous research, carcase traits had significant relationships with eating quality. Notably, hump height, ossification, and pH had negative relationships, while rib fat and marbling were positively related to eating quality. These are not surprising given hump height is linked with tropical breed content, ossification with maturity, and pH with pre-slaughter stress; all known factors to negatively influence eating quality, especially tenderness. Both rib fat and marbling were positively linked with eating quality, but there is a need to determine the chemical composition, specifically intramuscular fat and collagen content (soluble/insoluble) of these muscles to determine the relationship between the brisket and the ribeye (*M. longissimus thoracis*), where carcase traits are assessed for MSA grading.

Work is currently ongoing with ribs, with all Australian product eaten. Results appear promising and point toward the chuck end of the rib set eating at a higher level than the short rib end of the rib set.

While this research has outlined that the eating quality of brisket is acceptable to Australian consumers, there is still a need to test the low ‘n slow barbeque cook method with current MSA cook methods to ensure that there is a relevant comparison to benchmark differences seen in eating quality. Ideally, this work would occur within the same consumer sensory session, as well as between consumer sensory sessions.

6 Key messages

- Australian and USA consumers did not differ in their rating of point end briskets, however there was a difference in navel end briskets.
- The individual muscles within the point end brisket eat 9.4 points different. This difference presents an opportunity for further fabrication into separate muscles for direction into different markets.
- Serve method is important when discussing eating quality. The pulled method scores lower than chopped or sliced; a factor that is important for determining the eating quality of the cooked product.
- The influence of carcase traits on eating quality was not unexpected and aligns with previous research in other muscles. As a result, we don't recommend any dramatic changes to practices of producers to try to rear cattle that would produce a different type of carcase to meet a demand for a brisket market.
- The low/slow smoked cooking method does present an additional marketing avenue for briskets, which are historically lower palatability muscles if cooked using a method that doesn't suit their composition. When implementing a cooking method capable of solubilizing the collagen, this presents opportunities for both a freshly cooked (Hot) presentation in a restaurant setting or a ready-to-heat/ready-to eat product that could be marketed through supermarkets.

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8 Appendix

8.1 Brisket protocol

PROTOCOL FOR TEXAS BBQ COOKING

Version 1.2 – 17th July, 2019

Nicholas Hardcastle, Aaron Van Den Heuvel, Rod Polkinghorne, Jarrod Lees

SUMMARY

This protocol relates to the cooking of beef brisket in a Green Mountain Jim Bowie Model Wood Pellet smoker. Raw point end briskets are trimmed and lightly seasoned (salt & pepper) from 14 hours prior to placing fat side down in the smoker after reaching the temperature set point of 120 ˚C. Each brisket is weighed and identified with an ovenproof tag prior to cooking. Internal brisket temperature is monitored regularly by placing the smoker probe in the smallest brisket within the smoker. Alternatively, temperature probes may be placed into each individual brisket. When the internal temperature reaches 65.6 ˚C the brisket is removed and wrapped in heavy duty aluminium foil and returned to the smoker in the same orientation with time recorded. When the internal temperature reaches 93.3 ˚C the brisket is removed, retained in the foil wrapping and placed in an insulated holding box with time and temperature recorded. Briskets are rested for minimum of 30 minutes before portioning. Ninety (90) minutes prior to the planned consumer taste panel start time, the brisket is removed from storage, unwrapped, weighed, and processed.

After weighing the entire point or navel end brisket, processing commences with separation and weighing of the primary muscle/s. Muscle identification and orientation is maintained and linked to specified preparation. The source brisket ID is extended to individual consumer EQSRef ID with multiple EQSRef ID's specified per brisket. Preparation styles of sliced (1/4 inch / 6mm), pulled or chopped are pre-assigned to the individual muscle and position. Once prepared, additional product is placed in the bottom of a pre-heated 1/9th bain-marie 100mm deep pan with sufficient prepared product to adequately serve 10 consumers placed on top together with a laminated EQSRef ID. Additionally, a matched EQSRef is placed on the pan lid to ensure identification is maintained. The pan is then transferred to a specified serving bain marie pre-heated to 50˚C.

EQUIPMENT LIST

Brisket preparation:

- Plastic tubs/totes to store seasoned brisket Cutting board
- Knives and steel for trimming briskets
- Cut proof glove/s
- Calibrated scales for weighing cold briskets
- Oven-proof tags and skewers (70 mm long minimum)
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens

Cooking:

- Green Mountain Jim Bowie wood pellet smokers (one needed per 2 large briskets)**
    - ** For assembly and pre-cooking instructions please visit: https://greenmountaingrills.com/wpcontent/uploads/2016/04/GMG_OperatingApp_Manual_Web.pdf
- Calibrated probe thermometer
- Fire extinguisher
- Insulated storage (cooler/esky/ice box)
- Heat proof gloves
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens

Processing and service

- Plastic tubs/totes to weigh cooked brisket/individual muscles
- 4 bowls to transfer portioned product to bain-marie's
- Calibrated scales for weighing cooked briskets
- Cutting guide
- 6mm (1/4 in) cutting guide measure
- Knife for trimming cooked product
- Brisket knife (or similar) for slicing
- Knife for chopping
- Cut proof glove/s
- 3 large cutting boards
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens
- 5 bain maries
- 42 x 1/9 x 100mm bain marie steamer pans and lids plus 1 x 1/3 / 2 x 1/6 or additional 3 x 1/9 pans and lids

Reheated product:

- Vacuum packer (for reheated product)
- Additional bain marie(s) if reheated product is to be tested – number TBA when picking
- Sammic SmartVide 4 or equivalent water bath for water circulation during reheating
- Oven racks and pegs to secure vacuum bagged product

CONSUMABLES

- Rag on a roll or large paper towelling
- Cotton gloves
- Food grade nitrile gloves
- Coarse salt

- Course black pepper
- Green Mountain Premium Gold Blend hardwood cooking pellets (blend of red oak, hickory, and maple wood)
- Heavy duty aluminium foil
- Laminated EQSRef labels
- Preparation labels (PULLED, SLICED, CHOPPED)
- Vacuum bags (where required)
- Serving time charts
- 420 paper or plastic 150 mm or greater plates
- 60 sets of plastic knives and forks plus spares
- 2 sets of consumer labels
- 60 consumer questionnaire sets

HEALTH & SAFETY

The protocol requires the application of high temperature which creates a potential burn hazard. Cooked product is also hot when removed from the cooker and during preparation. In addition all personnel need to recognise the risk of cut or stick injuries through incorrect or unsafe knife handling practices.

Hygiene standards must also be of the highest standard and at a minimum meet all relevant local, state and federal regulations.

To avoid burns and knife injuries personnel must be fully instructed in safety requirements and trained in appropriate practices. Appropriate clothing must be worn including ovenproof gloves when handling hot product. For hygiene cotton gloves must be covered by food grade nitrile gloves.

RECORDING

Standard recording sheets are to be utilised throughout the preparation, cooking and preparation process to ensure weight, time and temperature data are consistent. Where additional data are to be recorded care should be taken to ensure all ID directly uses or is accurately linked to the standard ID of the source brisket and subsequently derived component ID's.

Unlike a majority of MSA protocols the transformation of a base primal cut to component muscles and from muscles to positions and preparations occurs after the cooking process requiring amended ID transfer protocols. The related ID are presented through the **Cook Record** sheet which is developed from the relevant Pick Sheet for each group of 60 consumers. For Texas BBQ the CUD (CutUpDeveloper) processes are also inverted to accommodate the cooking process with EQSRef pre-assigned to muscles and positions to create EQSRef identified samples prior to their physical production. Similarly a consumer pick is designed and produced to the Picking Sheet stage prior to cooking to enable the Cook Record to be produced and provide adequate preparation instruction with related ID.

An example Cook Record is attached as an appendix.

Muscle Identification

Brisket Point End – Deckle Off (HAM 2353)

The *M. pectoralis profundus* (HAM 056) and *M. pectoralis superficialis* (HAM 057) are the two major muscles of the brisket point end deckle off (HAM 2353). Understanding these major muscles are important for post-cook processing. Visual representation of these muscles can be found in *Figures 1* and *2*. Though Figure 2 represents these raw muscles portioned out, it is important to leave these muscles intact for cooking. Muscle HAM 056 constitutes the major weight of the cut. It possesses muscle fibres that run at a 45° angle to the length of the muscle. Muscle HAM 057 constitutes the smallest portion of the point end brisket. This muscle possesses fibres that run horizontal to the length of the muscle. Additionally, HAM 057 possesses an end that is very thick and an end that is very thin. It is important to become familiar with the orientation and physical components of these muscles. Familiarity with the muscles will ensure samples are fed properly to consumers.

Though all point end briskets may not visually look the same, it is easy to differentiate between each muscle. Muscle HAM 056 is triangular in shape and will sit on the "internal" surface of the brisket point end, next to the ribs. Due to the position and orientation of HAM 056, cooked samples will be segregated into Point (P; the most anterior portion of the brisket) and Navel (N; the most posterior portion of the brisket, or the portion that sits closest to the beef navel cut) Ends for consumer analysis. Muscle HAM 057 will be very rounded at one end and will be at the cranial end (toward the front of the animal) of the brisket point end toward the outside of the carcase. Due to the position and orientation of HAM 057, cooked samples will be segregated as Dorsal (D; the portion of the muscle that sits closest to the dorsal side, or backline, of the live animal) and Ventral (V; the portion of the muscle that sits closest to the ventral side, or belly, of the live animal) ends for consumer analysis. The ventral end of HAM 057 is identified by checking for the presence of where the fat parallel to the sternum bone was removed (see Figure 2).

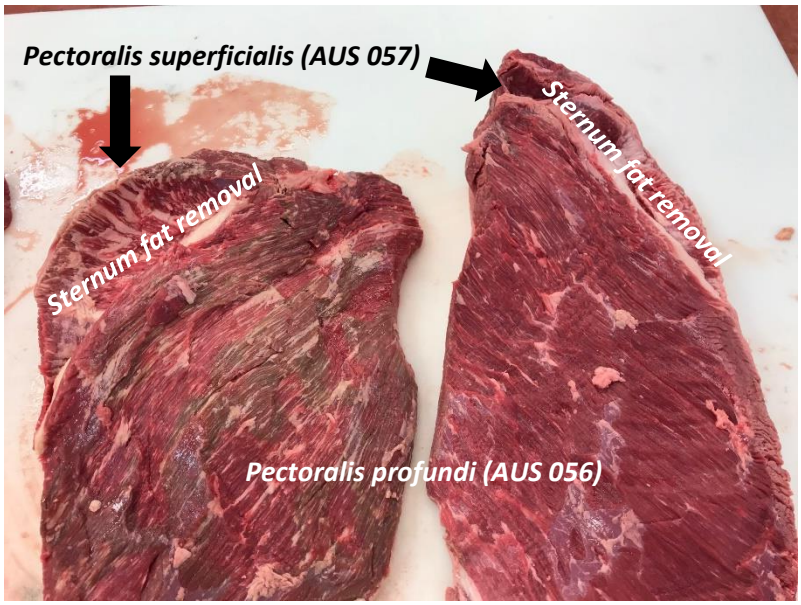
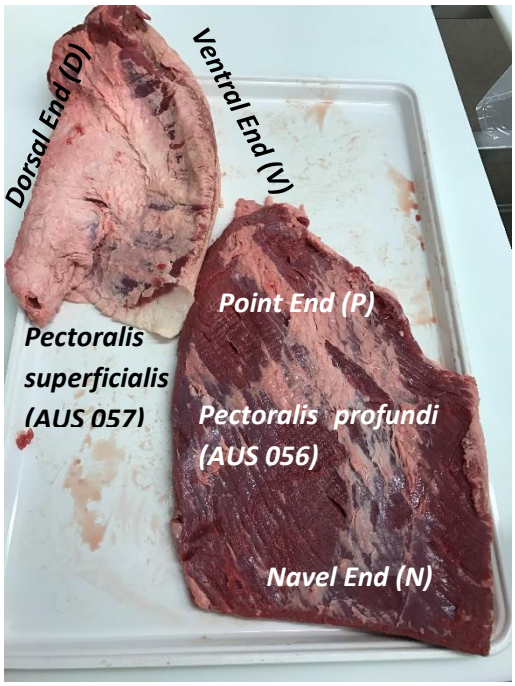


Figure 1: Visual representation of two point end briskets with muscle identification.

Figure 2: Visual representation of HAM 056 and 057 separated with muscle fibre orientation. DO NOT separate muscles prior to cooking. Muscles will be separated post cooking for consumer analysis.



Brisket Navel End (HAM 2342)

The *M. serratus ventralis thoracis* (HAM 079) is the target muscle in the brisket navel end. It is positioned on the dorsal edge of the brisket navel end, lateral to the intercostals (HAM 037) and the caudal end of the *M. pectoralis profundus (HAM 056)*. The *M. pectoralis profundus* may be present to differing degrees depending on the rib at which the brisket (HAM 2323) was portioned into the brisket point end (HAM 2332) and the brisket navel end (HAM 2342); usually caudal of the 4th rib. It is important to become familiar with the orientation and physical components of these muscles. Familiarity with the muscles will ensure samples are fed properly to consumers.

PRODUCT PREPARATION

FROZEN PRODUCT

Where product to be used is frozen and vacuum packed it is to be transferred to chilled storage between 34˚F / 1˚C and 38˚ / 3˚C 3 days (72 hours) prior to cooking.

Once thawed the product is treated identically to fresh product.

FRESH PRODUCT

The briskets are to be prepared for cooking within 15 hours and not less than 1 hour prior to cooking.

Briskets are individually removed from vacuum packaging and placed singularly on a tray or in a tub with their Primal ID to ensure accurate identification.

The surface fat is to be trimmed to an even 6 mm depth.

The primal is then placed fat side down and the surface membrane removed from the exposed *M. pectoralis profundus* (HAM 056; MSA BRI056) with the muscle squared off at the caudal end to leave a minimum 25 mm thickness on the piece to be cooked (*figure 3*).

Figure 3: Membrane and silver skin removed from M. pectoralis profundus.

The trimmed fully prepared brisket is then weighed with the weight recorded on the Cook Record sheet.

A standard rub 50% coarse iodised salt and 50% coarse black pepper is applied to all surfaces of the prepared brisket (*Figure 4)*, ensuring to regularly remix the rub to prevent separation of components.

Figure 4: Lightly seasoned brisket with salt and pepper standard rub.

RUB:

50% coarse iodised salt and 50% coarse black pepper

COOKING PROCESS

The smoker must be located in a clean open area away from combustible material to avoid fire hazard. For safety ensure that a fire extinguisher is accessible. The power cord must be connected and power confirmed by observing that the digital display activates when turned on. The pellet hopper must be filled and topped up as required through the cooking cycle.

The smokers are to be turned on and brought to a temperature of 250˚F / 121˚C eleven hours prior to the planned consumer session commencement time.

After turning on the grill the digital display will display “OFF”. Push the up arrow to start the heating process. The grill will cycle through 4 stages (0-1-2-3) which will take about 4 minutes after which the internal grill temperature will be displayed. At this point use the up or down arrows to set the temperature to 250˚F. The fixed thermometer on the grill lid should also be monitored and, in the event of major discrepancy, calibration of both checked.

Prior to placing the briskets in the smoker, a numbered metal or other ovenproof and readable ID tag must be securely pinned to each brisket and this ID (in the case of a stamped metal or other re-useable tag type) recorded on the Cook Record against the Primal ID (*Figure 5)*.

Figure 5: Application of a numbered metal oven tags to be matched with primal identification.

When the smokers have reached 250˚F / 121˚C the briskets are placed on the cooker rack fat side down ensuring that the ovenproof ID is attached and visible. The related primal ID should be placed on the external shelf and oriented in identical order to the briskets being cooked.

The smoker temperature probe must be inserted into a thicker portion of the upper muscle taking care to ensure it is not within a fat seam. The probe should be placed in the smallest brisket being cooked at the time. Alternatively, each brisket should have an independent temperature probe (e.g. Weber iGrill2).

The cooking performance within each smoker should be monitored over time to establish the extent that position influences cooking rate. Where one position is found to be cooler lighter briskets should be placed there to assist in reducing the range in cooking times to reach critical temperatures (see also assembly notes regarding positioning of the heat shield).

The temperature probe reading should be observed at regular intervals, not exceeding 30 minutes early in the cycle and more frequently as target temperatures are approached.

FOIL WRAPPING

When the probe reads 150˚F / 65.6˚C the temperature should be checked with a calibrated probe thermometer and, when confirmed, the brisket removed, time recorded on the Cooking Record, and wrapped in heavy duty aluminium foil. The brisket must be securely wrapped covering all surfaces which will typically require two sheets of foil. Once wrapped the brisket is returned to the cooker in the same position and fat side down (*Figure 6, 7, 8)*.

Figure 6: 150°F Brisket getting wrapped in Aluminium foil

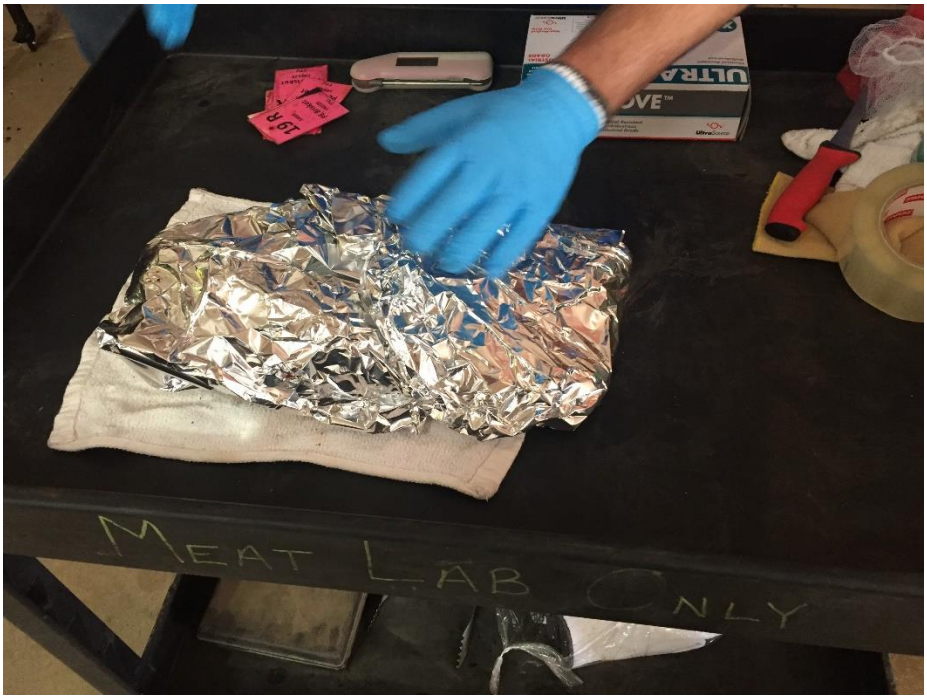


Figure 7: Completely wrapped brisket

Figure 8: Wrapped brisket placed back, and temperature probe placed in the next brisket

When the first brisket in the smoker is removed for wrapping the probe is placed in the next lightest until all have been wrapped at which point the probe should be placed back in the initial brisket.

FINAL COOK ENDPOINT

When a probe temperature of 200˚F / 93˚C is reached it must be confirmed with a calibrated probe thermometer after which the brisket is removed, left in the foil wrapping and placed in an insulated holding box with time recorded.

The probe must be transferred to the next lightest brisket until all are cooked.

A minimum holding time of 30 minutes is mandated but in practice will generally be controlled by the planned consumer taste panel sitting time.

Once all briskets have been removed from the smoker it may be turned off and cooled prior to cleaning. To turn off the smoker toggle the down temp arrow until it reads 150°F and then press the down arrow again till the display reads 'FAN'. Once that is displayed the smoker will run a fan cycle before automatically turning off.

POST COOK PREPARATION

HOT PRODUCT HOLDING

Once a brisket reaches the final cook temperature of 200°/93°C remove the brisket from the smoker and place it in an insulated holding container. When all briskets in the cooking session are complete a time is recorded for the final cooked brisket to ensure that during processing the final briskets still receives the required 30-minute post cooking rest. Processing of the briskets can commence starting with the first brisket to reach 200°F.

PREPARATION FOR CONSUMER SERVING

Remove the brisket from the insulated container, unwrap and weigh the complete brisket and record. Separate the *M.pectoralis profundus* (HAM 056, MSA BRI056) and *M.pectoralis superficialis* (MSA BRI057) and record the individual weights. Once weights are recorded trim any extra external fat. Using the cook record sheet identify the 4 treatments and positions, allocate a laminated EQS tag and treatment tag to each portion before separating the muscles (*Figure 9)*. Samples allocated to a re-heat treatment should be cooked and prepared 1 week prior to the taste panel. These samples should be placed in a bag vacuum sealed with the designated EQS reference number and stored at between 34˚F / 1˚C and 38˚ / 3˚C. Samples allocated to the 'HOT' treatment, once prepared should be placed into the corresponding EQS labelled bain marie container.

Figure 9: Treatment and EQS number to be present with sample through out processing.

Sliced:

Prepare a cutting guide to cut 1/4inch/ 6mm slices (*Figure*). Identify the position of the brisket to be prepared as a sliced sample. Make an initial cut at 90° to the fibre direction to square off the leading edge prior to slicing. Cut the slices one at a time and observe for fibre direction changes and re-surface the leading edge accordingly. A minimum of 10 samples are required, with extra's being desirable. Ideal sample dimension should be about 6mm thick x 70mm long x 40 mm wide.

Figure 10: Sliced samples ready for service

Chopped:

Trim excess fat from the portion if any is still present at this stage and cut the portion into cubes roughly measuring 10mm square (*Figure 11)*. A minimum amount of half of a 100mm deep 1/9th bain marie container is required for this sample.

Figure 11: Chopped brisket sample.

Pulled:

Trim excess fat from the portion and starting from the edge start to separate the sample by pulling in the direction of the fibres, segments should measure about 10mm thick by 70mm long. If the portions pulled are too long cut to length (*Figure 12, 13)*. Minimum of 10 samples are required with more being desirable.

Figure 12: Pulling the brisket portion into lengths of 20mm thick sample.

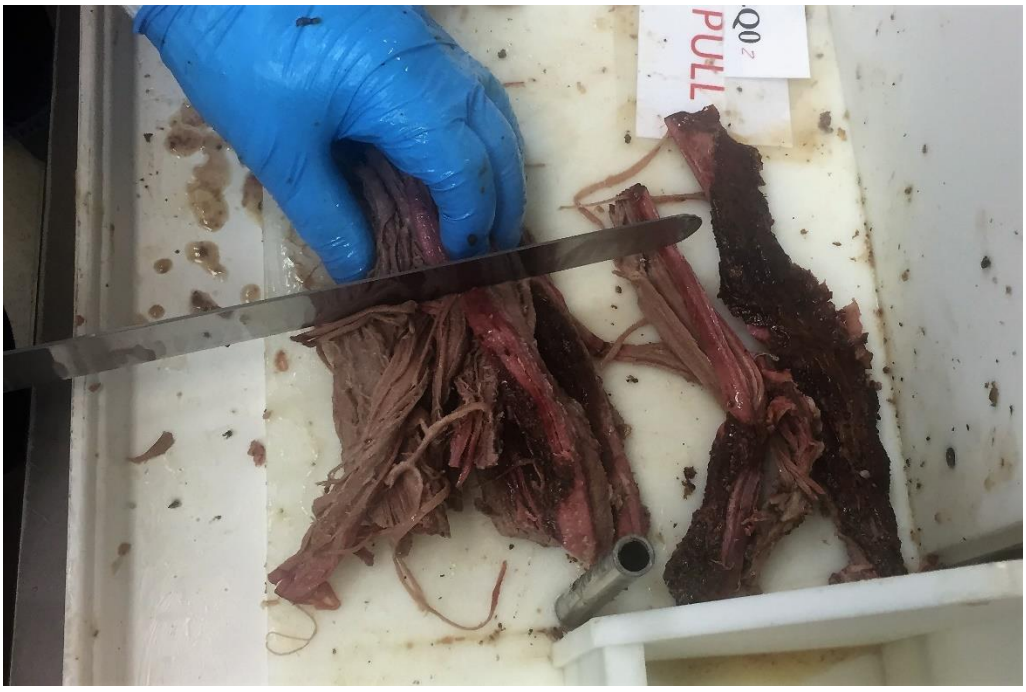


Figure 13: Cutting pulled samples to length.

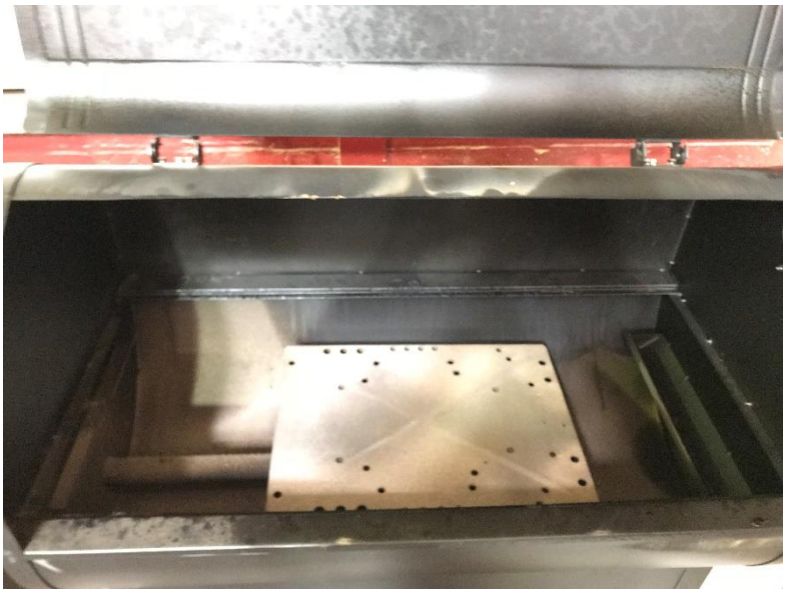
REHEAT PROCEDURE

Samples that have been allocated to a re-heat treatment and cooked the week before should be pulled out of refrigeration no less than 5 hours prior to serving. Samples should be let to rest at room temperature for at least an hour before being placed in a Sous vide water bath set at 50°C (*Figure 14)* for a minimum of 3 hours prior to being moved into allocated bain marie containers.

Figure 14: Souve machine with re-heat samples being heated to 50°C

Pre-cook Assembly

1. Place heat regulator directly in the middle of the smoker (18 cm from each side), over the fire box.



2. Line the drip tray with aluminium foil and place in slotted groves over the sides of the smoker.

4. Place cooking grates on the allocated slots.

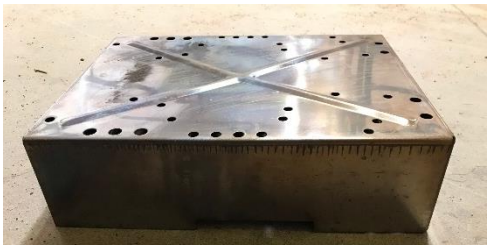
5. Line the inside of the drip bucket with aluminium foil. Begin by fitting the foil to the outside of the bucket and then place on the inside.

CLEANING

1. Remove cooking grates, drip trays (discard aluminium foil covering drip tray), and heat regulator.

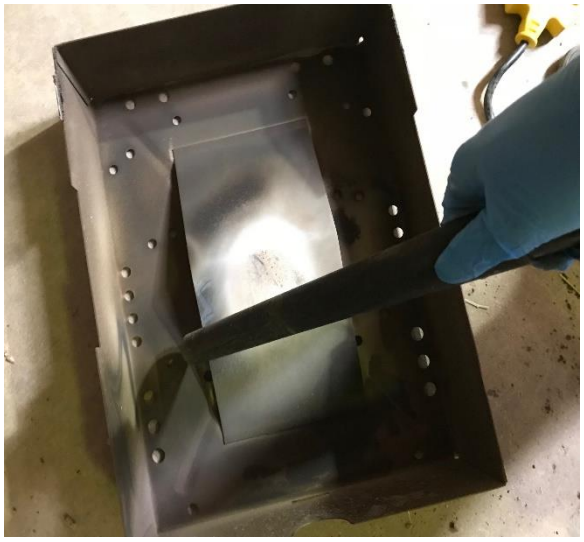
Smoker with cooking grates, drip tray, and heat regulator inside.

Drip Tray



Heat Regulator

2. Use a vacuum to remove ash residue from inside of the grill and bottom of the heat regulator.



3. Use soap and hot water to scrub cooking grates and drip trays.

4. Remove aluminium foil from drip bucket and discard.

SERVING

The Meat Standards Australia Roast protocol is utilised for the brisket service.

EXAMPLE COOK SHEET

Cook 1537		COOK RECORD									Date HOT			
Carcase	Primal No	Cold Wt	Time In	Time Wrap	Time Out	Cut Hot Wt	Muscle	Muscle Wt	Position	SERVE	EQSref	Check	COOK	
149	54387						BRI056		N	BQC	L4J1		HOT	
149	54387		Temp	Temp	Temp		BRI056		P	BQS	Y5V8		HOT	
149	54387						BRI057		D	BQC	D8T7		HOT	
149	54387						BRI057		V	BQP	V7F2		HOT	
166	54399						BRI056		N	BQC	N1K4		HOT	
166	54399		Temp	Temp	Temp		BRI056		P	BQP	R8R9		HOT	
166	54399						BRI057		D	BQS	S3A0		HOT	
166	54399						BRI057		V	BQP	G9P7		HOT	
526	54393						BRI056		N	BQC	C8L9		HOT	
526	54393		Temp	Temp	Temp		BRI056		P	BQS	R1C4		HOT	
526	54393						BRI057		D	BQC	T1V1		HOT	
526	54393						BRI057		V	BQP	B0B1		HOT	
554	54405						BRI056		N	BQC	U7D1		HOT	
554	54405		Temp	Temp	Temp		BRI056		P	BQP	Z4M8		HOT	
554	54405						BRI057		D	BQS	G1T1		HOT	
554	54405						BRI057		V	BQP	W3Z7		HOT	
573	54421						BRI056		N	BQS	R0K9		HOT	
573	54421		Temp	Temp	Temp		BRI056		P	BQP	K7H0		HOT	
573	54421						BRI057		D	BQS	U4D9		HOT	
573	54421						BRI057		V	BQC	W2P9		HOT	
818	54379						BRI056		N	BQP	B9P4		HOT	
818	54379		Temp	Temp	Temp		BRI056		P	BQS	M6M5		HOT	
818	54379						BRI057		D	BQC	D5N0		HOT	
818	54379						BRI057		V	BQS	W0N7		HOT	
149	54386	Temp							N	BQP	B3X3		HOT	
149	54386						BRI079		P	BQS	T3V4		HOT	
166	54398	Temp							N	BQP	K6P8		HOT	
166	54398						BRI079		P	BQC	X2G6		HOT	
526	54392	Temp							N	BQC	L7V5		HOT	
526	54392						BRI079		P	BQS	B9C1		HOT	
554	54404	Temp							N	BQP	C2Q2		HOT	
554	54404						BRI079		P	BQS	R4M0		HOT	
		Temp												
704	54434						BRI079		C	BQS	X8G4		HOT	
		Temp												
720	54426						BRI079		C	BQC	J8J2		HOT	
818	54378	Temp							N	BQP	F0F3		HOT	
818	54378						BRI079		P	BQC	N7S1		HOT	
5	59826						BRI056		P	BQS	T0Q7		RHT-L	LINK
5	59826		Temp	Temp	Temp		BRI056		N	BQS	W0V7		RHT-L	LINK
5	59826						BRI057		C	BQS	G6L0		RHT-L	LINK
6	59827						BRI056		P	BQS	Z0B3		RHT-L	LINK
6	59827		Temp	Temp	Temp		BRI056		N	BQS	Z4A8		RHT-L	LINK
6	59827						BRI057		C	BQS	N6V1		RHT-L	LINK

8.2 Low 'n slow beef rib protocol

PROTOCOL FOR TEXAS BBQ COOKING BEEF RIBS V1.0

June 21, 2019

Authors: J. Lees, N. Hardcastle, A. van den Heuval, R. Polkinghorne

SUMMARY

This protocol relates to the cooking of beef chuck ribs and beef short ribs in a Green Mountain Jim Bowie Model Wood Pellet smoker. Raw short ribs are trimmed, where required, and lightly seasoned (salt & pepper) approximately 14 hours prior to placing rib side down in the smoker after reaching the temperature set point of 120 ˚C. Each primal is weighed and identified with an ovenproof tag prior to cooking. Internal rib temperature is monitored regularly by placing the smoker probe in the smallest primal within the smoker, or inserting an independent temperature probe into each rib set. At an internal temperature of 66.6 °C the ribs are removed, wrapped in foil and placed back on the smoker, with the time and temperature recorded. At an internal temperature of 93.3 ˚C the ribs are removed and placed into an insulated holding box with time and temperature recorded. Ribs are rested for minimum of 30 minutes. From 90 minutes prior to the planned consumer taste panel start time, the ribs are removed from storage, unwrapped, weighed, and processed.

Processing and preparation for consumer sensory testing commences with separation and weighing of the two (2) primary muscles; *M. serratus ventralis* and *M. intercostales externus et internus*. The source primal ID is extended to individual consumer EQSRef ID with multiple EQSRef ID's specified per primal. Preparation styles of sliced (15 mm) for *M. serratus ventralis*, and chopped for *M. intercostales externus et internus* are pre-assigned to the individual muscle and position. Positions are only required for *M. serratus ventralis* as chuck rib (cranial or rib 2 end) and short rib (caudal or rib 7 end). No position is required for *M. intercostales externus et internus*. Once prepared, extra product is placed in the bottom of a pre-heated 1/9th bain-marie 100mm deep pan with sufficient prepared product to adequately serve 10 consumers placed on top together with a laminated EQSRef ID with a further matched EQSRef on the pan lid. The pan is then transferred to a specified serving Bain Marie pre-heated to 50˚C.

Rib samples are served utilising the Meat Standards Australia Roast service protocol (Watson et al., 2008a, Watson et al., 2008b).

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- # HEALTH & SAFETY

The protocol requires the application of high temperature which creates a potential burn hazard. Cooked product is also hot when removed from the cooker and during preparation. In addition all personnel need to recognise the risk of cut or stick injuries through incorrect or unsafe knife handling practices.

Hygiene standards must also be of the highest standard and at a minimum meet all relevant local, state and federal regulations.

To avoid burns and knife injuries personnel must be fully instructed in safety requirements and trained in appropriate practices. Appropriate clothing must be worn including ovenproof gloves when handling hot product. For hygiene cotton or cut proof gloves must be covered by food grade nitrile gloves.

• RECORDING

Standard recording sheets are to be utilised throughout the preparation, cooking and preparation process to ensure weight, time and temperature data are consistent.

Unlike conventional MSA protocols the transformation of a base primal cut to component muscles and from muscles to positions and preparations occurs after the cooking process requiring amended ID transfer protocols. The related ID are presented through the Cook Record sheet which is developed from the relevant Pick Sheet for each group of 60 consumers. For Texas BBQ the CUD (CutUpDeveloper) processes are also inverted to accommodate the cooking process with EQSRef pre-assigned to muscles and positions to create EQSRef identified samples prior to their physical production. Similarly a consumer pick is designed and produced to the Picking Sheet stage prior to cooking to enable the Cook Record to be produced and provide adequate preparation instruction with related ID.

An example Cook Record is attached in Appendix 1.

MUSCLE IDENTIFICATION

Short ribs (HAM 1694)

As per the Handbook of Australia Meat, Short Ribs are prepared from a Forequarter after the removal of the Brisket (item 1643/Ribs Prepared/Chuck Square Cut). The cutting line is approximately 75mm from the *M. longissimus thoracis* and parallel to the vertebral column. The *M. cutaneous trunci* is removed.

Short Ribs comprise of the *M. latissimus dorsi* (HAM 041) and the *M. serratus ventralis thoracis (HAM 079)*, and are prepared from the 5th to the 13th rib. The HAM 041 may be removed. They may be cut to one (1) rib through to nine (9) ribs (HAM 1686 to 1694 depending on number of ribs).

Chuck short ribs (HAM1631)

As per the Handbook of Australia Meat, Chuck Short Ribs are derived from a Chuck and comprises of the ribs, intercostal muscles (*M. intercostales externus et internus*) and the major portion of the *M. serratus ventralis thoracis (HAM 079)*. These ribs may be cut from the 2nd to the 6th rib. The number of ribs shall be determined prior to boning.

NOTE: Specific to L.EQT.1814 ribs

The 6 ribs obtained for L.EQT.1812 were collected from the 2nd to the 7th rib, with the Chuck rib being made up of the 2nd 3rd and 4th ribs, with the short rib being made up with the 5th 6th and 7th ribs.

Once portioned, the cranial end of *M. serratus ventralis thoracis* is referred to as Chuck rib, and the caudal end of *M. serratus ventralis thoracis* will be referred to as Short rib. Where only one sample is available from *M. serratus ventralis thoracis*, there will be a Centre (C) position. Intercostal meat will not have a position.

• PRODUCT PREPARATION

• Thawing

Where product to be used is frozen and vacuum packed it is to be transferred to chilled storage between 1 - 3 ˚C, two (2) days (36 hours) prior to cooking.

Once thawed the product is treated identically to fresh product.

The ribs are to be prepared for cooking within 15 hours and not less than 1 hour prior to cooking.

• Trimming and identification

Ribs are individually removed from vacuum packaging and placed singularly on a tray or in a tub with their Primal ID to ensure accurate identification. To ensure identification is maintained, only one primal will be prepared at any one time.

The surface fat is to be trimmed to an even 6mm depth, **where required**. If *M. latissimus dorsi* is intact, trimming may be required. Where it has been removed trimming may not be required (Figure 1).

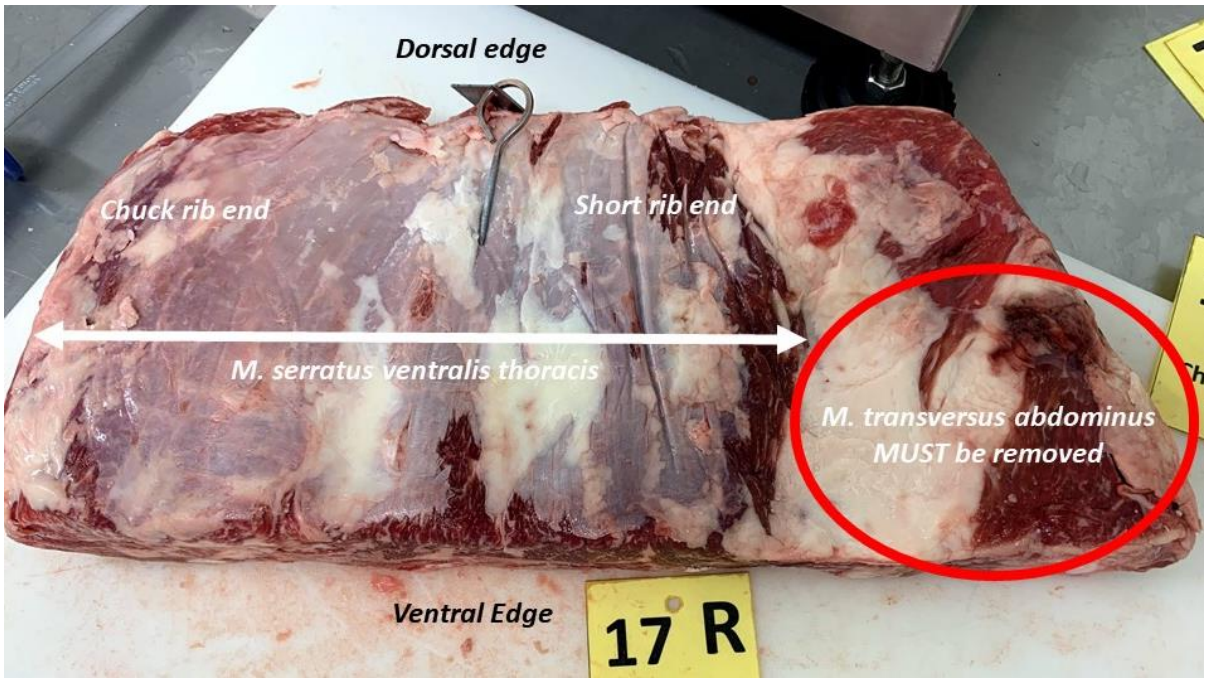

Figure 1: Untrimmed rib set, ready for seasoning

Once prepared, a metal or other ovenproof and readable ID tag must be securely pinned to each rib set and this ID recorded on the Cook Record against the Primal ID (Figure 1).

• Salt and pepper rub

50% coarse iodised salt and 50% coarse black pepper, by volume.

COOKING PROCESS

Cook preparation

Ensure the pellet hopper on Green Mountain Grill is filled and topped up as required through the cooking cycle.

The smokers are to be turned on and brought to a temperature of 120 ˚C (approximately 15 minutes) eight (8) hours prior to the planned consumer session commencement time. See the instruction manual for the smoker for starting sequence.

Once the smoker has completed its start sequence, use the up or down arrows to set the temperature to 120 °C. The fixed thermometer on the grill lid should also be monitored and, in the event of major discrepancy, calibration of both checked.

Cooking – Stage 1: Starting the cook

When the smokers have reached 120 ˚C the ribs are placed on the cooker rack rib side down ensuring that the ovenproof ID is attached and visible.

The smoker temperature probe must be inserted into a thicker portion of the *M. serratus ventralis*. The probe should be placed in the smallest ribs being cooked at the time. Adjust smoker display to the probe temperature by pressing the “FOOD” button. Where possible, an independent thermometer should be inserted into each rib set e.g. Weber iGrill.

The cooking performance within each smoker should be monitored over time to establish the extent that position influences cooking rate.

The temperature probe reading should be observed at regular intervals, not exceeding 30 minutes early in the cycle and more frequently as target temperatures are approached.

Cooking – Stage 2: Foil wrapping

When the temperature probe reads 66˚C the temperature should be checked with a calibrated probe thermometer. When a temperature of 66.6 °C has been confirmed the ribs are removed, time recorded on the Cooking Record, and wrapped in heavy duty aluminium foil. The ribs must be securely wrapped, covering all surfaces (typically two or three sheets of foil) paying particular attention to the ends of the ribs which may break through foil. Once wrapped the ribs are returned to the smoker in the same position, rib side down.

Cooking – Stage 3: Removing product

When a probe temperature of 93 ˚C is reached it must be confirmed with a calibrated probe thermometer after which the ribs are removed, left in the foil wrapping and placed in an insulated holding box with time recorded and temperature recorded.

The probe must be transferred to the lightest rib set remaining on the smoker until all are cooked.

A minimum holding time of 30 minutes is mandated but in practice will generally be controlled by the planned consumer taste panel sitting time.

Once all ribs have been removed from the smoker it may be turned off and cooled prior to cleaning.

• POST COOK PREPARATION

• Hot product holding

Ribs are held in an insulated box once an internal temperature of 93.3 °C is reached (see *Cooking – Stage 3: Removing product* above). Processing of the ribs can commence starting with the first rib set to reach 93 °C.

• Preparation for consumer serving

Remove the ribset from the insulated container, unwrap and weigh the complete ribset and record.

Separate the *M. serratus ventralis* from the ribs by and intercostal meat working along the intermuscular seam (Figure 2a and b). Once removed, isolate the *M. serratus ventralis* from the extra muscle situated on the ventral and caudal edge of the rib set (presumed to be *M. transversus abdominus;* ribs 6 and 7). Record the weight.

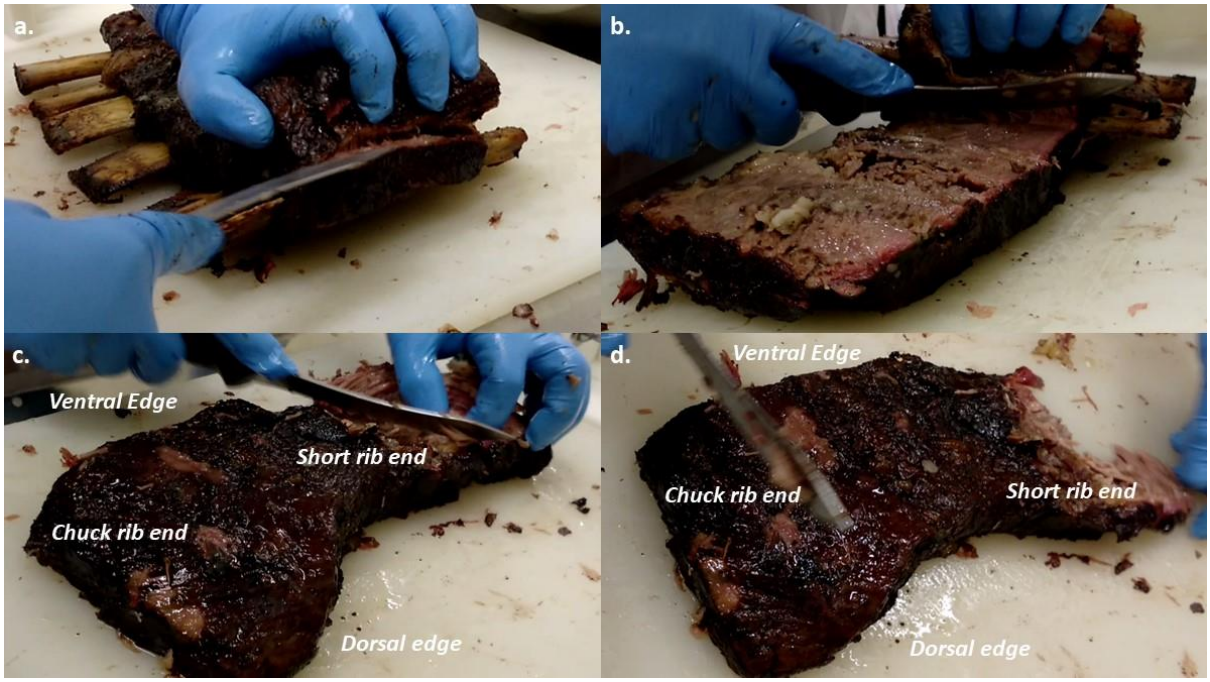

***Figure 2: Removing the* M. serratus ventralis *from the rib bones and* M. intercostales externus et internus**

Remove *M. intercostales externus et internus* from the rib bones and trim thick connective tissue from around muscle and weigh remaining meat. Note that trimming of intercostal meat will take some time.

Once weights are recorded trim any excess fat. Using the cook record sheet identify the treatments and positions and allocate a laminated EQS tag to each portion before separating the muscles. Once prepared, samples should be placed into the corresponding EQS labelled Bain Marie container.

• Sliced – M. serratus ventralis:

Prepare a cutting guide to cut 15 mm. Identify the position of the *M. serratus ventralis* (Chuck rib, Short rib or centre) to be prepared (Figure 3a). Where the *M. serratus ventralis* is to be served as a Chuck rib and Short rib, cut the muscle in half, parallel to the direction of the rib bones (Figure 3b).

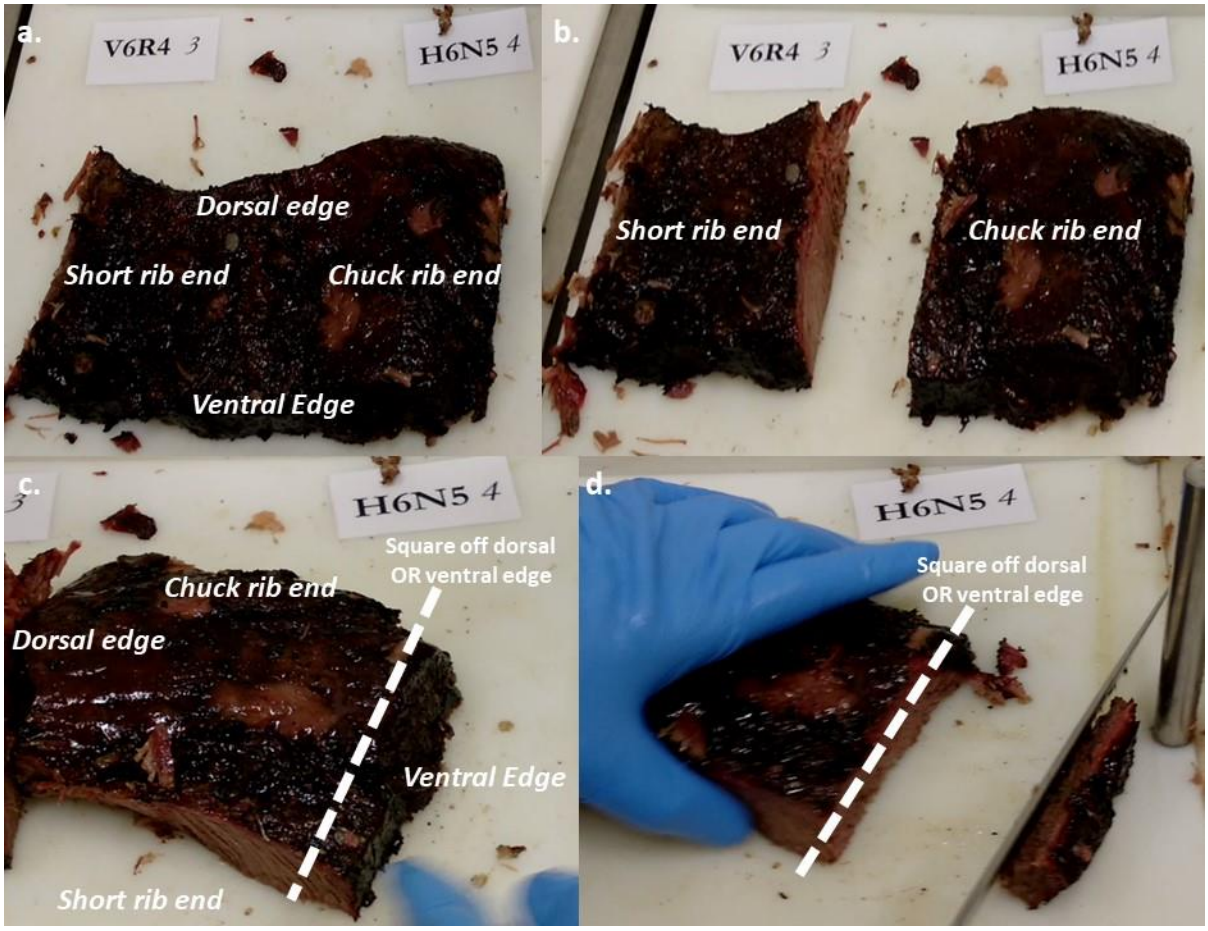

Figure 3: Preparing* M. serratus ventralis *for portioning into consumer sensory samples

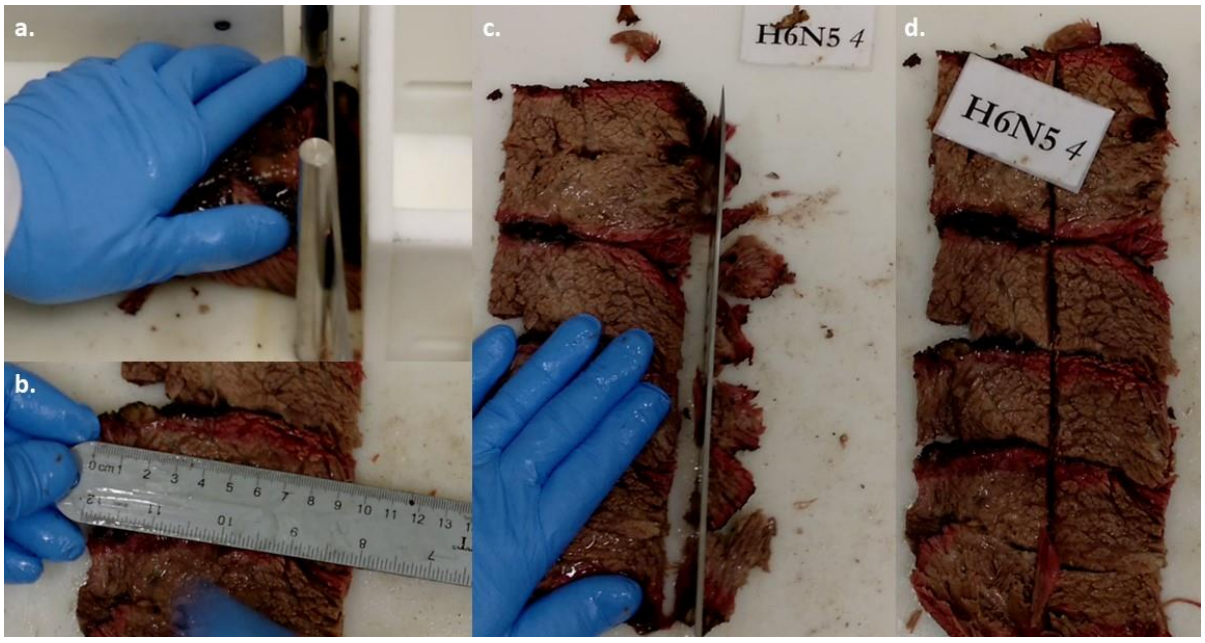

Figure 4: Portioning* M. serratus ventralis *into 15 mm x 40 mm x 30 mm consumer sensory samples

On each portion, square off the dorsal or ventral edge of the sample prior to slicing to provide a flat surface for the cutting guide (Figure 3c and d).

Utilising the cutting guide to slice 1mm thick samples (Figure 4a). Trim cooked edge of each slice (Figure 4c) and halve each slice to provide two (2) samples per slice (Figure 4d). Ideal sample dimension should be 15 mm thick x 40 mm long x 30 mm wide (Figure 4b), however this will be dictated by the size of the portion. A ***minimum*** of 10 samples are required, with extra's being desirable.

- Chopped – M. intercostales externus et internus:

Once intercostal meat is removed from the bones, trimmed of excess connective tissue and sample weight recorded, each "finger" is separated into two (2) pieces. Each sample may only be 30 mm long. A ***minimum*** of 10 samples are required, with extra's being desirable, however it is highly likely that only 10 samples will be available for consumer sensory testing.

- Service

The service protocols are the same as those of a Roast pick.

- # Appendix 1: Example Cook Sheet

Night	1588		RIBS COOK RECORD						Date			
Carcase	Primal No	Cold Wt	Time In	Time Wrap	Time Out	Cut Hot Wt	Muscle	Muscle Wt	SERVE	EQSref	Check	COOK
9999	61002	Temp					CHK178			W1V6		Link
9999	61002						RIB141			X4F0		Link
9999	61003	Temp					CHK178			E6B5		Link
9999	61003						RIB141			X1B1		Link
9999	61004	Temp					CHK178			D7Y2		Link
9999	61004						RIB141			S2W3		Link
13	54770						CHK178			F1S2		
13	54771		Temp	Temp	Temp		INT137			R2F3		
13	54771						RIB141			G3P4		
95	54768						CHK178			F1G6		
95	54769		Temp	Temp	Temp		INT137			X0K9		
95	54769						RIB141			E2W7		
147	54744						CHK178			J9Q5		
147	54745		Temp	Temp	Temp		INT137			H4Y5		
147	54745						RIB141			E9H1		
149	54746						CHK178			F3P0		
149	54747		Temp	Temp	Temp		INT137			N4X4		
149	54747						RIB141			N5D0		
167	54756						CHK178			U9E4		
167	54757		Temp	Temp	Temp		INT137			J8X8		
167	54757						RIB141			F0U5		
219	54754						CHK178			W5E1		
219	54755		Temp	Temp	Temp		INT137			N2H0		
219	54755						RIB141			G7J5		
441	54760						CHK178			A3B1		
441	54761		Temp	Temp	Temp		INT137			T9M2		
441	54761						RIB141			Z3G5		
506	54762						CHK178			G1T0		
506	54763		Temp	Temp	Temp		INT137			H1F7		
506	54763						RIB141			G8A3		
531	54750						CHK178			P5Y8		
531	54751		Temp	Temp	Temp		INT137			B9J1		
531	54751						RIB141			Q4L8		
552	54748						CHK178			N5U7		
552	54749		Temp	Temp	Temp		INT137			W4K4		
552	54749						RIB141			S2G7		
817	54736						CHK178			U8S5		
817	54737		Temp	Temp	Temp		INT137			S9L2		
817	54737						RIB141			C0C2		
818	54738						CHK178			H6N5		
818	54739		Temp	Temp	Temp		INT137			T4Y7		
818	54739						RIB141			V6R4		

Appendix 2: Equipment

Rib preparation:

- Plastic tubs/totes to store seasoned ribs
- Cutting board
- Knives and steel for trimming ribs (where required)
- Cut proof glove/s
- Calibrated scales for weighing cold ribs
- Oven-proof tags and skewers
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens
- Consumables
    - Food grade nitrile gloves
    - Coarse salt
    - Course black pepper

Cooking:

- Green Mountain Jim Bowie wood pellet smokers
- Calibrated probe thermometer
- Insulated storage (cooler/esky/ice box)
- Heat proof gloves
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens
- Consumables
    - Food grade nitrile gloves
    - Green Mountain Premium Gold Blend hardwood cooking pellets (blend of red oak, hickory, and maple wood)
    - Heavy duty aluminium foil

Processing and service

- Calibrated scales for weighing cooked ribs
- Plastic tub to weigh cooked product
- 3 large cutting boards
- Cutting guide
- 15 mm cutting guide measure
- Knife for portioning and trimming cooked product
- Long slicing knife (or similar) for slicing
- Boning knife (or similar) for trimming intercostals
- 4 bowls (or similar) to transfer portioned product to bain-marie's
- Cut proof glove/s
- Standard recording sheets for recording weights, tag numbers, cook times and temperatures
- Clipboard
- Pens

- 5 Bain Marie's
- 42 x 1/9 x 100mm Bain Marie steamer pans and lids plus 1 x 1/3 / 2 x 1/6 or additional 3 x 1/9 pans and lids
- Consumables
    - Food grade nitrile gloves
    - Rag on a roll or large paper towelling
    - Laminated EQSRef labels for Bain Marie pots
    - EQSRef labels for Bain Marie lids
    - Serving time charts
    - 420 paper or plastic 150 mm or greater plates
    - 60 sets of plastic knives and forks plus spares
    - 2 sets of consumer labels
    - 60 consumer questionnaire sets