Final report

Resource Flock Sensory Evaluation and MSA Model Development

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Abstract

The Australian sheep industry has identified the improvement of lamb eating quality as a key objective, which has been attained through the current Meat Standards Australia (MSA) pathways system. In order to provide a guaranteed eating quality outcome for individual cuts across multiple cooking methods on a commercial level, a cut-based grading system is paramount and is currently being developed (MSA Mark II). A grading system of this kind would require predictive, objective measurements of carcass traits including intramuscular fat and lean meat yield, however technology development to measure these traits at commercial processing speed remains a challenge for the industry. In order to develop such system alongside genomic predictions of eating quality to combat the negative association between lean meat yield and eating quality, a vast eating quality dataset is required on a genetically and phenotypically diverse flock. The objective of this project was to conduct MSA sensory panels on lambs from the MLA resource flock with known genetic linkage.

Executive summary

The current sheep Meat Standards Australia (MSA) model is a pathways system recognised to improve the overall eating quality of sheepmeat. Yet it is unable to predict individual consumer-based eating quality grades for specific cuts. As such, the development of a MSA Mark II cut based grading prediction model is underway, and an initial version of the model (unpublished) has been produced based on a starting Sheep CRC eating quality dataset of the loin and topside cut. Whilst factors impacting on the phenotypic eating quality variation have been defined (Pannier et al., 2018), of which sire type, intramuscular fat and lean meat yield are included in the new cut based MSA model, developing technological objective eating quality measurements (intramuscular fat and lean meat yield) that can operate in a commercial setting remains a challenge (Pannier et al., 2018; Pethick et al., 2015). In addition, the expansion of the current database with more cut types and cooking methods is needed for a future commercial role out of the system.

This report describes the collection and phenotypic variation of the eating quality data of lambs obtained from predominantly the MLA resource flock to establish the base dataset for the development of the new cut based MSA model based on 5 cut types for grilling and roasting each. In addition, the data will be used for the development of a new eating selection index which allows for both improvement in eating quality and lean meat yield and will further expand on the phenotypic and genetic relationships between sensory scores and other indicators of meat quality. The objective of this project was to conduct sensory panels with Australian untrained consumers as per the (MSA) protocols using a genetically and phenotypically diverse subset of the MLA Genetic Resource flock lambs.

In total 318 consumer sessions were completed involving 19,080 consumers where a total of 11,448 test cut types were consumed. All consumer tasting sessions were carried out using the standard MSA protocols with untrained consumer panels. Sixty consumers per session assessed each sample for tenderness, juiciness, flavour and overall liking. Tasting sessions were conducted at both University of New England and Murdoch University, with the remaining being conducted through subcontractor TastePoint.

A key outcome of this project is the delivery of an extensive dataset with the inclusion of new cut by cooking method combinations (grilling: knuckle, outside, rump; roasting: knuckle, leg, shoulder, rack cutlet, rack slice) in addition to the previously collected data for the grilled loin and topside under the Sheep CRC. This will allow for the further development of the sheepmeat MSA Mark II cut based grading prediction model in alliance with the development of genomic predictions of eating quality through establishing new Australian Sheep Breeding Values for the actual eating quality of lamb cuts. The development of such MSA Mark II cut based grading prediction model will allow for more efficient carcass sorting to underpin a value-based payment system throughout the supply chain. This will allow the supply chain to allocate cuts to different marketing strategies (branding) based on their eating quality performance and will improve the likelihood of consumers purchasing the right quality grades. In addition it will enable a value based carcass feedback system and subsequent pricing mechanisms for producers who select for eating quality.

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1. Background

Improving the eating quality experience of lamb for consumers is a goal of the Australian sheep industry (Pannier et al., 2018; Pethick et al., 2006). Achieving this goal requires an objective measure of eating quality and the knowledge of how critical factors along the supply chain impact eating quality variation (Pethick et al., 2015). Whilst many factors (genetic and non-genetic) contributing to the phenotypic variation in lamb eating quality have been defined (Pannier et al., 2018), an objective measurement for the determination of eating quality remains a challenge (Pannier et al., 2018; Pethick et al., 2015). Furthermore, as more accurate measurements of whole carcass lean meat yield to predict individual cut weights at a commercial level (Gardner et al., 2018) become available, an objective measurement for eating quality to balance the negative relationship between the two traits is crucial (Pannier et al. 2014; Pannier et al. 2018).

Previous research undertaken in collaboration with the Sheep CRC has delivered a strong understanding of the meat science to underpin the eating quality and lean meat yield of Australian lamb. A key finding is the realisation of a negative association between eating quality and lean meat yield (Pannier et al., 2014). This antagonism has been found for both the indicators of eating quality (intramuscular fat, shear force) and actual consumer eating quality. In addition, the initial Sheep CRC eating quality data has been used to produce a beta version of the MSA Mark II cut based grading prediction model with sire type, intramuscular fat and an estimate of lean meat yield being used to predict the final star rating of the short loin and topside (unpublished). The same data has also been used by Sheep Genetics to develop a new eating selection index which can allow for both improvement in eating quality and lean meat yield.

This project provides a dataset of sufficient magnitude to determine genomic predictions of MSA based eating quality scores and hence the development of new Australian Sheep Breeding Values for eating quality. Furthermore, the data will establish the development of the updated MSA Mark II cuts-based model for lamb and further connect the new model to the genetic predictions of eating quality.

2. Objectives

The direct project objectives were:

- Conduct sensory panels with Australian untrained consumers as per the Meat Standards Australia (MSA) protocols using the MLA Genetic Resource flock lambs
- Gather additional information from the untrained consumer panel members such as simple demographic and willingness to pay information (as per the normal MSA protocols for sensory evaluation)
- Provide the raw data for each session back to the Sheep Resource Flock Data

At a high level this project will place the Australian lamb industry as a world leader to underpin consumer demand for lamb via transparent genetic progress. In particular it will deliver;

- the development of new breeding values for the MSA based eating quality of lamb
- an understanding of the phenotypic and genetic relationships between the new cut x cook combinations and lean meat yield
- an understanding of the phenotypic and genetic relationships between sensory scores and other indicators of meat quality including intramuscular fat, shear force and muscle structural properties and

- an expanded beta version of the MSA Mark II cuts-based model for lamb. The data will allow for the prediction of 6 new cut x cook combinations in addition to the short loin and topside.

3. Methodology

This project ran parallel with project L.GEN.1811. Under both projects, eating quality sessions were conducted and the methodology described below applies across both projects. The total amount of sessions (across both project projects) is described of which a portion of the sessions relates to this current project.

3.1 Slaughter and collection of cuts

Lambs (n = 3119) were sourced from the Meat and Livestock Australia's Research Flock across two sites (Katanning, WA; Kirby, NSW) and across two years (drop 2017 and 2018). A smaller subset of lambs (n = 71) were obtained from the Trigger Vale sheep stud. Lambs were wethers and females, and were progeny of Terminal (n = 158; Poll Dorset, Southdown, Suffolk, White Suffolk, Dorper, White Dorper, Commercial, Hampshire Down, New Zealand Southdown, Texel), Maternal (n = 76; Border Leicester, Commercial, Coopworth, Corriedale, Dohne Merino) and Merino (n = 66; Merino, Poll Merino) sires (Table 1), mated to Merino, Dorper and crossbred ewes. Animals were reared under extensive pasture grazing conditions, and were supplemented with grain, hay or feedlot pellets when pasture supply was low (Ponnampalam et al., 2014). All lambs were held in lairage overnight prior to being slaughtered and processed under commercial standard procedures with lambs being assigned to smaller kill groups (n = 16) for processing. Carcasses were trimmed according to AUS-MEAT specifications (Anonymous, 2005) and medium-voltage electrical stimulation (Pearce et al., 2010) was applied to all carcasses prior to chilling overnight (3-4°C) before sampling. The resource flock phenotypic and carcass measurements were also measured on all carcasses.

Table 1. Numbers of lambs at each research site with available sire type data.

Site	Maternal	Merino	Terminal	Total
Katanning	466	358	722	1546
Kirby	466	354	624	1444
Trigger Vale	-	71	-	71
Total				3061

Across both sites and each year, a subset of carcasses (n = 830) were transported to the University sites for subsequent computerised tomography (CT) scanning to capture full body lean meat yield measurements. The CT carcasses were scanned using a Picker PQ 5000 spiral CT scanner (Cleveland, Ohio, United States) at Murdoch University or using a Picker (Bavaria, Germany) at the University of New England, and the percentage of lean, fat and bone was determined.

From all carcasses (CT and non-CT scanned), sensory cuts were boned out for grilling and roasting. These cuts included; the M. *longissimus lumborum* (loin), M. *semimembranosus* (topside), M. *biceps femoris* (outside) and M. *gluteus medius* (rump) for grilling, the M. *rectus femoris* and M. *vastus lateralis* (knuckle) for both grilling and roasting, and the 8-rib rack, easy carve leg and an oyster boneless shoulder for roasting. From all CT carcasses the loin, topside, both knuckles, outside, rump, 8-rib rack, easy carve leg and shoulder were removed, whereas from the non-CT carcasses the loin, topside, and knuckle were removed. Of the cuts collected, in total 11,232 cuts were used as test samples for sensory analysis. The number of cuts consumed from both CT and non-CT carcasses for each cooking method is shown in Table 2.

Additionally, 110 commercial mutton sheep (Merino; New South Wales) and 115 lambs (satellite flock Temora) were sourced. From each lamb and mutton, 2x eight rib racks were collected as sensory cuts, as well as the mutton knuckles. Phenotypic and carcass measurements were measured, and all carcasses were DEXA scanned. From all racks collected, 216 rack pairs were used to run 6 consumer roast sessions with the knuckles used as starter samples.

3.2 Sensory sample preparation

Each cut collected for the grill sensory analyses was sliced into five 15 mm thick steaks. For the roast cuts, the leg and shoulder cuts were rolled and netted whole, the racks had the cap fat removed, and the knuckles remained as whole cuts. All cuts were vacuum packed and aged for five to ten days prior to being frozen at -20˚C. On the day of each eating quality session, the corresponding cuts were thawed in a 4˚C fridge until cooking. The samples were tasted by untrained consumers based on the Meat Standards Australia sensory protocols (Thompson et al., 2005).

The design of the cuts into each eating quality session was carried out in conjunction with Rod Polkinghorne (Birkenwood International Pty Ltd), and allocation of cuts to consumers was carried out according to a 6x6 Latin square design allocation as described in Thompson et al. (2005). Each eating quality session consisted of 36 different cuts (excluding starter samples), tasted by 60 consumers. The grill sessions were mainly designed as such that each session contained the cuts of three CT scanned lambs rotated between the different kill groups at each site (1 CT lamb from each kill group, 3x 5cuts), with the remaining cuts (21 cuts) obtained from the non-CT lambs (loins and topsides only). This allowed for a balanced design across cuts collected from CT and non-CT animals. The roast sessions were constructed for only CT animals containing cuts (rack, legs, shoulder) from mostly 6 different animals. Additionally, 6 roast sessions were designed containing only lamb (18 cuts) and mutton (18 cuts) racks.

3.3 Eating quality sessions

All consumer tasting sessions were carried out using the standard MSA protocols with untrained consumer panels (Thompson et al., 2005). Sixty consumers per session assessed each sample for tenderness, juiciness, flavour and overall liking using a 100-score scale and graded each sample as unsatisfactory (2 star), good everyday (3 star), better than everyday (4 star) or premium (5 star) quality. Additionally, simple demographic data on each consumer was also collected. During each tasting session, each consumer received seven samples, commencing with a starter sample followed by six test samples, allocated by a 6x6 Latin square design (Thompson et al., 2005). Knuckles of the non-CT scanned carcasses were used as starter samples in the sensory grill sessions, whereas one knuckle of the CT scanned carcasses was used as a starter sample in the sensory roast sessions. For the lamb and mutton rack roast sessions, the mutton knuckles were used as starter samples.

For the grills, the five samples from each muscle were grilled using a Silex griller to a medium degree of doneness (internal temperature of 65°C), rested for approximately two minutes and halved to form ten test samples per cut. Roast cuts were cooked in an Electrolux 10 tray dry oven and set to a temperature of 160°C. To achieve an internal temperature of 65°C, roasts were removed from the oven at an internal temperature of 60°C and rested for 10 minutes. The leg, shoulder and knuckle cuts were trimmed into a 15cm x 15cm block. Roasts were then sliced across the grain into 4mm samples using an electric slicer. Ten suitable samples that were representative of the entire cut were selected for consumer testing. Any external fat and gristle seams were removed, and slices were trimmed to approximately 50mm wide x 50mm long x 4mm thick. The rack cuts were either sliced on the bone as cutlets (rack cutlet) or the rack loin was removed from the bone and sliced like the other roast cuts (rack slice). The 10 consumer samples were placed in steel pans which were maintained at a temperature of 50°C until serving. For the lamb and mutton rack roast sessions, the rack cuts were sliced on the bone as cutlets (rack cutlet) and served to consumers as cutlets.

In total, 312 eating quality sessions were conducted (238 grills, 74 roasts) containing 18,720 consumers, with an additional 6 roast sessions (360 consumers) for the lamb and mutton racks. Recruitment of the consumers and conduction of the sensory sessions were undertaken at Murdoch University, University of New England, and through a third-party company, to which all participants consented on attending and participating in the tasting sessions.

3.4 Statistical analysis

Given that this dataset will form the basis of multiple statistical analyses, including the construction of the MSA Mark II cut based grading prediction model, descriptive statistics are provided for this final report. A list of statistical analysis based around publication outcomes is provided below.

4. Results

4.1 Phenotypic variation

The data consisted of 112,320 measurements (excluding starter samples) of consumer evaluations of the eating quality sessions. The number of cuts consumed from both CT and non-CT carcasses for each cooking method is listed in Table 2. This represents the test samples across both flocks and drops. Whilst some number of cuts are available in small numbers (Rack cutlet, knuckle roasts and knuckle grills), the majority of the cuts are well represented. For the lamb and mutton rack roast sessions, 2160 measurements (excluding starter samples) were obtained. These were represented by 108 lamb and 108 mutton racks.

The descriptive phenotypic carcass data for the lambs of the resource flock are listed in Table 3, and Table 4 for the lamb and mutton roast sessions. The range of carcass weights and fatness parameters represent the typical mean and ranges seen in many export focused lamb processing plants emphasising the applicability of carcass data to be used in developing an MSA model.

Table 2. Number of test cuts consumed from both CT and non-CT carcasses for each cooking method.

		2017 drop		2018 drop		
		Kirby	**Katanning**	**Kirby**	**Katanning**	**Trigger Vale**
Cut	**n**	**Non-CT**		**Non-CT**		
Knuckle (GRL)	26	0	4	21	1	0
Loin (GRL)	2261	538	580	478	594	71
Topside (GRL)	2271	595	584	501	591	0
		CT		CT		
Knuckle (GRL)	786	194	205	202	185	0
Loin (GRL)	803	189	206	192	216	0
Outside (GRL)	787	185	205	202	195	0
Rump (GRL)	808	201	206	203	198	0
Topside (GRL)	826	201	206	203	216	0
Knuckle (RST)	139	73	0	66	0	0
Leg (RST)	863	199	192	268	204	0
Rack Cutlet (RST)	96	0	96	0	0	0
Rack Slice (RST)	704	200	96	204	204	0
Shoulder (RST)	862	200	192	266	204	0

GRL: grilled cuts; RST: roasted cuts

Table 3. The number of animals, mean, standard deviation and range (min-max) of the carcass variables of the lambs tested.

	2017 drop						**2018 drop**								
	Kirby			**Katanning**			**Kirby**			**Katanning**			**Trigger Vale**		
	n	Mean (± SD)	Range	n	Mean (± SD)	Range	n	Mean (± SD)	Range	n	Mean (± SD)	Range	n	Mean (± SD)	Range
HCWT (kg)	800	24.8 ± 3.0	13.6 - 38.6	742	24.5 ± 3.7	13.8 - 40.4	708	26.3 ± 3.3	15.6 - 38.8	805	24.7 ± 3.7	13.4 - 35.2	71	19.0 ± 2.5	14.1 - 25.0
HGRFAT (mm)	802	16.9 ± 4.1	4.0 - 30.0	792	17.7 ± 6.2	4.0 - 39.0	708	19.4 ± 4.8	4.0 - 30.0	809	18.1 ± 6.5	4.0 - 42.0	71	10.7 ± 3.5	3.0 - 19.0
LMY (%)	768	56.6 ± 2.3	48.3 - 65.8	733	56.8 ± 2.7	45.7 - 64.2	681	55.5 ± 2.3	47.3 - 63.0	757	56.7 ± 6.2	48.2 - 203.8	0	-	-
EMA (cm^2)	796	14.7 ± 2.6	8.1 - 22.1	792	16.8 ± 3.1	9.3 - 25.2	707	15.7 ± 2.6	8.0 - 25.3	811	18.8 ± 44.5	6.7 - 1216.8	71	11.7 ± 2.2	5.6 - 19.0
LLWT (g)	791	377.8 ± 62.9	168.0 - 612.0	792	356.2 ± 66.8	189.0 - 617.0	706	401.3 ± 74.1	192.0 - 699.0	809	337.0± 67.6	165.0 - 738.0	0	-	-
LLFAT (g)	790	324.4 ± 90.1	98.0 - 751.0	793	285.5 ± 102.9	73.0 - 672.0	706	328.2 ± 97.8	53.0 - 775.0	811	264.2 ± 87.0	59.0 - 559.0	0	-	-
Shear force (5 days) (N)	800	32.9 ± 8.6	16.4 - 68.6	793	34.8 ± 11.4	17.9 - 93.2	707	30.6 ± 9.7	12.9 - 74.6	811	29.7 ± 6.9	16.0 - 66.7	71	32.2 ± 8.0	19.4 - 55.9
Loin IMF (%)	800	4.9 ± 1.0	2.7 - 9.8	792	4.7 ± 1.1	2.1 - 8.9	707	5.9 ± 1.4	3.2 - 12.7	811	4.7 ± 1.2	2.3 – 11.0	71	4.90 ± 0.8	3.5 - 6.8
pH6TEMP	722	21.3 ± 6.9	0.7 - 38.3	338	18.3 ± 8.3	2.0 - 38.5	490	23.5 ± 7.3	0.7 – 40.0	621	21.4 ± 7.1	2.2 - 38.3	48	15.7 ± 6.4	3.6 - 27.4
pH24LL	800	5.6 ± 0.2	5.4 - 6.5	720	5.6 ± 0.2	5.2 - 6.2	707	5.6 ± 0.1	5.2 - 6.4	809	5.7 ± 0.1	5.3 - 6.9	66	5.6 ± 0.2	5.2 - 6.1
pH24ST	793	5.8 ± 0.2	5.5 - 6.5	721	5.6 ± 0.2	5.11 - 6.3	708	6.0 ± 0.2	5.4 - 6.8	809	5.7 ± 0.2	5.1 - 6.8	71	6.0 ± 0.2	5.7 - 6.7

HCWT: hot carcass weight; HGRFAT: hot carcass GR fat; LMY: lean meat yield; EMA: eye muscle area; LLWT: M. *Longissimus lumborum* muscle weight; LLFAT: M. *Longissimus lumborum* fat weight; IMF: intramuscular fat; pH6TEMP: temperature at pH 6; pH24LL: pH of M. *Longissimus lumborum* at 24 hours; pH24ST: pH of M. *Semitendinosus* at 24 hours.

Table 4. The number of animals, mean, standard deviation and range (min-max) of the carcass variables of the lamb and mutton tested.

	Lamb				Mutton		
	n	Mean (± SD)	Range		n	Mean (± SD)	Range
HCWT (kg)	108	29.6 ± 4.4	19.6 - 39.9		108	19.2 ± 2.8	13.5 - 26.9
HGRFAT (mm)	108	20.2 ± 6.6	6.5 - 39.0		108	6.7 ± 5.0	1.0 - 25.0
Shear force (5 days) (N)	108	28.7 ± 6.1	17.4 - 54.6		108	35.5 ± 6.9	21.9 - 60.6
Loin IMF (%)	94	3.7 ± 0.9	2.2 - 7.3		108	6.0 ± 2.4	1.7 - 13.2

4.2 Eating quality variation

The descriptive data for the sensory traits for grilling and roasting has been summarised in Table 5 and 6, respectively, and Table 7 for the lamb mutton roasts. For the grill cuts, the average eating quality scores of majority of the cuts were consistent between sites, though the grill outside and topside cut from Katanning scored lower for all eating quality traits in drop 2018 compared to the Kirby site by as much as 6.4 eating quality scores for tenderness and flavour respectively. Noticeably was also the difference in eating quality for the leg and shoulder roasts from Katanning compared to the Kirby site for both years (up to 10.9 eating quality scores for juiciness), though the differences were less profound in drop 2018. On the other hand, the rack slice ate better at the Katanning site across both years. For the lamb and mutton roasts, as expected the lamb cuts were more favourable then mutton cuts for all sensory traits.

Table 5. Mean (± SD) for tenderness, overall liking, juiciness, and flavour sensory for the grill cuts.

Cut	Tenderness	Juiciness	Flavour	Overall liking
2017 drop				
Kirby				
Knuckle	68.8 ± 22.3	67.7 ± 21.2	67.8 ± 20.8	68.5 ± 20.9
Loin	68.3 ± 22.6	62.5 ± 23.1	67.5 ± 20.7	67.7 ± 21.0
Outside	56.4 ± 24.9	61.4 ± 22.7	61.4 ± 21.8	60.5 ± 22.4
Rump	70.5 ± 22.1	67.9 ± 21.7	69.4 ± 20.8	70.1 ± 20.9
Topside	48.4 ± 25.9	53.6 ± 23.7	56.5 ± 22.1	53.9 ± 23.0
Katanning				
Knuckle	70.2 ± 21.6	67.3 ± 20.9	67.3 ± 20.4	68.7 ± 20.1
Loin	67.5 ± 22.6	62.3 ± 22.8	65.7 ± 20.8	66.0 ± 21.0
Outside	57.5 ± 24.8	61.4 ± 22.3	61.7 ± 21.6	61.1 ± 22.0
Rump	71.1 ± 21.5	68.8 ± 20.5	69.2 ± 19.7	70.3 ± 19.7
Topside	45.8 ± 25.6	51.5 ± 23.9	54.0 ± 22.2	51.5 ± 23.0
2018 drop				
Kirby				
Knuckle	64.3 ± 24.3	66.9 ± 21.9	64.3 ± 21.9	65.1 ± 22.1
Loin	69.6 ± 22.4	66.3 ± 22.1	68.3 ± 21.1	69.1 ± 21.1
Outside	60.2 ± 24.7	63.7 ± 22.0	63.0 ± 21.7	62.8 ± 22.0
Rump	68.2 ± 22.5	66.7 ± 21.5	67.0 ± 21.1	67.9 ± 21.0
Topside	48.5 ± 26.0	56.3 ± 23.4	55.9 ± 22.8	53.8 ± 23.3
Katanning				
Knuckle	68.9 ± 22.4	67.4 ± 21.2	67.6 ± 20.0	68.8 ± 20.2
Loin	68.7 ± 22.0	63.9 ± 22.4	67.0 ± 20.2	67.7 ± 20.2
Outside	53.8 ± 25.1	59.2 ± 22.8	60.2 ± 21.1	58.8 ± 22.0
Rump	67.8 ± 22.9	67.4 ± 21.4	67.9 ± 20.2	68.8 ± 20.4
Topside	42.5 ± 25.6	49.8 ± 23.7	52.9 ± 22.2	49.4 ± 22.8
Trigger Vale				
Loin	65.2 ± 22.5	60.0 ± 23.0	64.4 ± 21.3	64.5 ± 21.0

Table 6. Mean (± SD) for tenderness, overall liking, juiciness, and flavour sensory for the roast cuts.

Cut	Tenderness	Juiciness	Flavour	Overall liking
2017 drop				
Kirby				
Knuckle	62.2 ± 23.1	56.6 ± 24.5	60.9 ± 22.9	61.4 ± 22.7
Leg	51.0 ± 25.0	44.8 ± 25.1	53.8 ± 23.6	52.5 ± 24.0
Rack Slice	70.8 ± 22.0	62.9 ± 24.7	67.0 ± 22.4	68.2 ± 22.2
Shoulder	66.5 ± 23.0	60.3 ± 24.2	63.7 ± 23.7	64.6 ± 23.4
Katanning				
Leg	41.2 ± 24.4	33.9 ± 22.7	44.2 ± 22.4	42.0 ± 22.3
Rack Cutlet	76.9 ± 18.8	73.1 ± 20.4	74.3 ± 20.0	75.7 ± 19.5
Rack Slice	75.9 ± 21.3	71.6 ± 22.5	73.4 ± 20.1	74.7 ± 20.6
Shoulder	56.0 ± 23.5	50.1 ± 23.7	54.3 ± 22.6	54.7 ± 22.7
2018 drop				
Kirby				
Knuckle	58.1 ± 23.3	51.6 ± 24.2	55.8 ± 23.8	55.9 ± 23.4
Leg	49.3 ± 24.8	43.1 ± 24.3	52.9 ± 23.1	50.7 ± 23.2
Rack Slice	71.2 ± 21.9	63.1 ± 24.7	67.5 ± 22.6	68.6 ± 21.0
Shoulder	64.2 ± 22.8	59.8 ± 23.7	61.4 ± 23.4	62.1 ± 23.2
Katanning				
Leg	46.2 ± 25.3	38.5 ± 24.4	49.9 ± 23.4	47.7 ± 23.9
Rack Slice	75.1 ± 20.2	69.8 ± 22.1	71.7 ± 20.2	73.1 ± 20.2
Shoulder	56.1 ± 24.6	50.6 ± 25.3	54.8 ± 24.1	55.2 ± 23.9

Table 7. Mean (± SD) for tenderness, overall liking, juiciness, and flavour sensory for the rack roast cuts for lamb and mutton.

Cut	Tenderness	Juiciness	Flavour	Overall liking
Rack Cutlet Lamb	75.7 ± 19.6	65.7 ± 23.8	70.3 ± 20.2	71.5 ± 20.5
Rack Cutlet Mutton	57.4 ± 24.4	57.7 ± 23.8	60.8 ± 21.8	58.9 ± 22.5

4.3 Progress on MSA development

An MSA Mark II cuts-based model for the loin and the topside cut has been developed. A first draft of the paper has been compiled and was discussed at the MSA pathways meeting in July 2020. Data analysis to determine the eating quality score (discriminant score) based on overall liking, tenderness, liking of flavour and juiciness was carried out with two approaches; method 1 was developed by Tony Pleasants in which overall liking was regressed on the other sensory variables (tenderness, juiciness, liking of flavour) and the residuals from this regression were used to test for significant relationships with the other sensory variables; method 2 utilises the methodology of Watson et al. (2008) which is used in the Beef MSA system. Within each methodology, the cuts-off scores are relatively similar for each cut and both discriminant functions provide essentially the same accuracies in the prediction of the eating quality star ratings. Though, method 2 has the advantage of being compatible with the Beef Meat Standards Australia system. Following this, the relationship between carcass variables (hot carcass weight, intramuscular fat %, lean meat yield %) and the eating quality discriminant scores for each sample (and ultimately each cut) were tested and were finally related to the quality grading given by consumers (star rating). The results show that the predicted discriminant functions from the carcass variables give a good guide to the consumer eating quality of the loin and topside cuts.

The MSA Mark II cuts-based model for the loin and the topside cut is based on eating quality data from drop 2009, 2010 and 2012. Future work to expand this prediction model to include more cuts and different cooking methods by using the data of drop 2017 of this project has commenced. These additional cuts include the rump, outside, knuckle for grilling and the racks, easy carve leg and boneless oyster blade for roasting. A first draft of this multi cut by cook model paper has been compiled and was discussed at the MSA pathways meeting in March 2021. This multi cut by cook model describes one discriminant score for all cuts based on the Beef MSA system methodology (Watson et al., 2008), and therefore provides one set of cut boundaries. This discriminant score equates to 0.3×tenderness + 0.1×juiciness + 0.3×liking of flavour + 0.3×overall liking. Further work is needed to understand the possible adjustments made to the cut boundaries to know how this will impact the accuracy of cut allocations to a predicted star rating. Currently the cut boundaries are agreed to be 45 between 2/3 star; 64 between 3/4 star; and 77 between 4/5 star. This first version of the multi cut by cooking method model has been delivered to MSA who are undertaking benchmarking of intramuscular fat and lean meat yield in processing plants to examine the range of eating quality scores in lamb processing plants. Furthermore, the drop 2018 data will be included within this prediction model to strengthen the prediction model.

5. Conclusion

A key outcome of this project was the delivery of an extensive eating quality dataset using genetically and phenotypically diverse lambs with known genetic backgrounds. A total of 318 consumer sessions were completed resulting in 114,480 data points to be analysed. All consumer tasting sessions were carried out using the standard MSA protocols with untrained consumer panels. The next phase is the application of this data to further develop the sheepmeat MSA Mark II cut based grading prediction model and the Australian Sheep Breeding Values for lamb eating quality.

5.1 Key findings

Key finding from this project include:

- Establishment of an extensive eating quality dataset as the basis for the development of the new cut based MSA model and the development of new eating quality breeding values.
- Key findings will further be generated from the planned individual analyses as outlined below in the potential publication list.

5.2 Benefits to industry

At a high level this project will place the Australian lamb industry as a world leader to underpin consumer demand for lamb via transparent genetic progress. In particular it will deliver

1. the development of new breeding values for the MSA based eating quality of lamb,
2. an understanding of the phenotypic and genetic relationships between the new cut x cook combinations,
3. an understanding of the phenotypic and genetic relationships between the new cut x cook combinations and lean meat yield,
4. an understanding of the phenotypic and genetic relationships between sensory scores and other indicators of meat quality including intramuscular fat, shear force and muscle structural properties, and

5. an expanded version of the MSA Mark II cuts-based model for lamb.

6. Future research and outcomes

Given that this dataset will form the basis of multiple statistical analyses, including the construction of the MSA Mark II cut based grading prediction model, the following publication outcomes are expected in the very near future (each point represents a potential publication):

Genetic analyses

- Use of genomics (+- phenotypes) to predict eating quality
- OVIS genetic parameters for eating quality and carcass traits (Merino's)
- OVIS genetic parameters for eating quality and carcass traits (Terminals/Maternals)
- Breeding objectives/indexes for eating quality for diverse production systems

MSA model development

- The construction of a sheep meat eating quality MSA prediction model for Australian Lamb
- Inclusion of different lean meat yield measures as measured through different technologies within the MSA prediction model
- Variation in the responses of Australian consumers in the assessment of sheep meat eating quality (Consumer repeatability, effect of consumer variance on the weighting or effect)
- Construction of the lamb MSA Index and modification of a sheep meat eating quality index for retailing

Phenotypic analyses

- The influence of demographics of Australian consumers on eating quality; are all Aussie consumers the same (across different suburbs eaten)?
- The genetic and environmental effects on shear force in relation to eating quality
- Loin intramuscular fat as predictor versus individual cut intramuscular fat, ability to predict eating quality
- The ability to use CT versus lean meat yield as calculated from cuts weights to predict eating quality
- Relationship between the starter samples (links) and subsequent test samples in an eating quality session. Can the link data be useful?
- The power of consumer pairwise serving within an eating quality session
- The effect of boneless or bone-in racks on eating quality and slice thickness
- What production factors (site, sex, breed, kill group etc) impact the development of IMF in different muscles
- The ability to use CT lean meat yield to predict IMF of loin and other muscles
- Bone CT to predict eating quality
- Phenotypic production analysis and covariates on eating quality of different cuts (site, sex, breed, kill group, ageing, ASBV etc)
- Relationship between growth, intramuscular fat across different muscles and eating quality (Is growth impacting eating quality, or is growth impacting eating quality via intramuscular fat)
- Hyperspectral camera prediction of intramuscular fat effect on eating quality, comparison in loin
- The use of DEXA to predict eating quality in relation to the effect of age on eating quality (lamb/mutton eating quality data)

Future research

- Examine more optimal roasting methods for the lamb legs and shoulders (extension of cooking time, semi wet cooking and other cooking methods). These cuts have shown to eat not as well as expected.
- Examine more roasted racks bone-in presented as a commercial cut to consumers
- Examine more grilled cutlets bone-in or served as 25mm thick grill boneless cutlets

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