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Benchmarking Callipyge Sheep Meat Eating Quality

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Abstract

A major constraint to the profitability of the sheep-meat industry is the relatively small size and yield of lean muscle mass from carcasses. Developing a better understanding of muscling and its control during growth and development is fundamentally important to improving the efficiency of sheep as a meat production species. Increasing muscling of lamb carcases has been generally associated with adverse effects on meat tenderness. In particular, the Callipyge mutation (in the US), a genetic mutation that is associated with extreme muscling has been associated with toughness. We had raised concerns regarding the reliability of US taste panel and consumer testing results as the majority of US consumers eat lamb once or less than once per year.

This aim of this research was to benchmark Australian consumer acceptability of *Callipyge* lamb and normal lamb sourced from the US (Utah State University) against Australian lamb with industry average muscling or industry leading muscling based on eye muscle depth. This was undertaken using Australian consumers under the established experimental environment utilised by the Australian Sheep Meat Eating Quality program.

The results reported here demonstrate that Australian consumers rate Callipyge loin samples eaten as grilled steaks as 40% lower quality across tenderness, juiciness, flavour and overall like attributes when compared to loin samples from Australian high muscled lambs and Australian and US normal muscled lambs. This equated to 60% of callipyge loin samples failing consumer expectations for eating quality, compared to a fail rate of approximately 10% in the other groups.

Australian consumers also reported smaller reductions in tenderness, juiciness, flavour and overall like attributes in leg (25%) and shoulder (10%) roasts of the Callipyge lamb carcases when compared to the other groups. This equated to approximately 40% of callipyge leg roasts failing consumer expectations for eating quality, compared to a fail rate of less than 20% in the other groups. The difference between Callipyge and the other sample groups in failure rates within the shoulder roasts were not as marked.

These results confirm the unsuitability of Callipyge as a production genotype for Australian and international markets for high quality grill and roast cuts.

Executive Summary

- A major constraint to the profitability of the sheep-meat industry is the relatively small size and yield of lean muscle mass from carcasses. However, increasing muscling of lamb carcases has been generally associated with adverse effects on meat tenderness. In particular, the Callipyge mutation (in the US), a genetic mutation that is associated with extreme muscling has been associated with toughness.

- Animals expressing the Callipyge phenotype show a marked difference in carcase composition of 25% more lean mass and 30% reduction in carcase fat.

- Available taste panel and consumer testing information on Callipyge lamb has used US consumers that typically eat lamb once or less than once per year.

- This aim of this research was to benchmark Australian consumer acceptability of *Callipyge* lamb and normal lamb against Australian lamb with industry average muscling or industry leading muscling based on eye muscle depth.

- This was undertaken using Australian consumers under the established experimental environment utilised by the Australian Sheep Meat Eating Quality program. All sample preparation was performed by Cosign Pty Ltd, with consumer eating quality trial run by Sensory Solutions Pty Ltd.

- This report demonstrates that Australian consumers rate Callipyge loin samples eaten as grilled steaks as 40% lower quality across tenderness, juiciness, flavour and overall like attributes when compared to loin samples from Australian high muscled lambs and Australian and US normal muscled lambs. This equated to 60% of callipyge loin samples failing consumer expectations for eating quality, compared to a fail rate of approximately 10% in the other groups.

- Australian consumers also reported smaller reductions in tenderness, juiciness, flavour and overall like attributes in leg (25%) and shoulder (10%) roasts of the Callipyge lamb carcases when compared to the other groups. This equated to approximately 40% of callipyge leg roasts failing consumer expectations for eating quality, compared to a fail rate of less than 20% in the other groups. The difference between Callipyge and the other sample groups in failure rates within the shoulder roasts were not as marked.

- Despite the marked benefits in carcase composition seen in Callipyge lambs, these results confirm the unsuitability of Callipyge as a production genotype for Australian and international markets for high quality grill and roast cuts.

Contents

1 Background

Australian consumers have identified that approximately 25% of lamb has unacceptable eating quality. Increasing muscling of lamb carcases has been generally associated with adverse effects on meat tenderness. In particular, the Callipyge mutation (in the US), a genetic mutation that is associated with extreme muscling has been associated with toughness. US researchers have reported that the Callipyge mutation increased objective toughness scores by between 123% (loin) to 13% (leg-quadriceps) across the 7 major muscle groups tested as grilled chops. However, they showed that a trained taste panel could not detect tenderness differences between Callipyge and normal lamb leg muscles when cooked as roasts (Shackleford et al., 1997). A later study using a trained tasted panel demonstrated that tenderness in grilled loin samples from Callipyge lambs were 30% tougher than their normal counterparts (Kerth et al., 2003). No difference was detected in the *Semitendinosus* muscle (leg) between Callipyge and normal. When these cuts were evaluated by consumers, consumers could not differentiate between Callipyge and normal leg chops. However, consumers rated Callipyge loin and shoulder chops 15% lower in overall palatability compared to normal chops. Concerns regarding the reliability of US taste panel and consumer testing must be raised considering that the majority of consumers eat lamb very infrequently. For example, in one of the studies listed above, over 50% of consumers tested ate lamb on average once or less per year. Hence, using US taste panels and consumers does not provide an accurate benchmark for lamb eating quality comparisons.

Although definitive research on the effects of other genetic selection for muscling on eating quality across the carcase have not been published, it has been reported that Carwell lambs can have inferior eating quality due to increased toughness as measured by objective tenderness in the loin. Given the level of disparity seen between objective and consumer derived eating quality data, a more rigorous investigation of the influences of genetic mutations on muscle growth on lamb meat eating quality is warranted. The body of evidence outlined here precis the general trends observed in driving lamb growth through selection for increased muscling and muscle mass. Consistencies are found in the shift towards glycolytic myofibre metabolism, muscle growth and reduced meat tenderness.

This aim of this proposal is to benchmark Australian consumer acceptability of Callipyge lamb and normal lamb sourced from the US (Utah State University) against Australian lamb breed for industry average muscling or industry leading muscling EBV's. This will be undertaken using educated Australian consumers under the established experimental environment utilised by the Australian Sheep Meat Eating Quality program.

2 Project Objectives

1. AQIS approval will be gained for importation of lamb from the US.
2. Loin, shoulder and leg primals from Callipyge, normal US lamb, high muscling Australian lamb and normal Australian lamb will be available for consumer evaluation of sheep meat eating quality.
3. Loin, shoulder and leg primals from Callipyge, normal US lamb, high muscling Australian lamb and normal Australian lamb will have been evaluated against current SMEQ framework.
4. A report on the consequences of selection for extreme muscling genotypes on sheep meat eating quality as evaluated by consumer taste panels will be delivered to MLA.

3 Methodology

3.1 Obtaining an AQIS importation permit for US lamb

An AQIS permit to import uncanned meat products (lamb – less than 12 months of age) was granted to the Victorian Department of Primary Industries has. This permit was valid from the 22nd of August 2007.

3.2 Sampling of US lambs

Lambs from sires and dams of known *callipyge* genotype (NN and CC) were bred at Utah State University (USU), Logan Utah for this experiment. Prior to lambing (February 2006), a subset was chosen with predicted genotypes of CN and NN to provide n=10 animals for each genotype. Prior to sampling, blood samples were taken to confirm *callipyge* genotype using SNP makers at the *callipyge* locus (performed by the USU, Cockett laboratory).

Genotyped lambs were slaughtered at 6 months of age and approximately 45-50kg liveweight. The pH and temperature profile of the lamb carcases was followed after slaughter during chilling until ultimate pH and temperature are reached. In accordance with SMEQ best practices, lamb carcases will be aged for 10 days prior to breakdown into shoulder, loin and hind-leg sections, vacuum packaging and freezing.

Extended storage, transport and shipping of frozen lamb to Australia was been completed. The lamb from USU arrived and cleared AQIS inspection for final release from quarantine on the 16th of August 2006. Lamb is being stored frozen at Polar Cold Storage Co. (Laverton North, Vic) until required for consumer sheep meat eating quality evaluation.

3.3 Sampling of Australian lambs

Australian lambs were sourced from Richard Gunner of Pure Suffolk lamb, South Australia. Lambs were chosen based on live animal eye muscle depth scanning 1 week prior to slaughter to establish 2 groups of 10 lambs per group that differed in mean eye muscle depth from 30mm in the low EMD group to 38mm in the high EMD group. Lambs were slaughtered at 6 months of age and approximately 45-50kg liveweight. The pH and temperature profile of the lamb carcases was followed after slaughter during chilling until ultimate pH and temperature are reached. In accordance with SMEQ best practices, lamb carcases were aged for 10 days prior to breakdown into shoulder, loin and hind-leg sections, vacuum packaging and freezing.

3.4 Sample preparation for consumer eating quality

All sample preparation and consumer eating quality evaluation was conducted by Cosign Pty Ltd under standard SMEQ methods. Lamb samples were thawed slowly to 0°C, boned and prepared for cooking as required for the trial model (see table 1 below). Groups were defined as follows; 1. Callipyge group, animals sourced from the US genotyped as CN, 2. USA normal, animals sourced from the USA genotyped as NN, 3. Aus muscle, animals sourced from the Australian population with high EMD, and 4. Aus normal, animals sourced from the Australian population with average EMD.

Table 1. Structure of the consumer eating quality evaluation.

Cut	*Source*	*Side*	*Qty*	*Cook*	*Purpose*	*Consumer Taste Tests*
Backstrap	Callipyge	L	9	Grill	Taste Test	90
Backstrap	USA normal	L	9	Grill	Taste Test	90
Backstrap	Aus normal	L	9	Grill	Taste Test	90
Backstrap	Aus muscle	L	9	Grill	Taste Test	90
			36			360
			1 pick			
Boneless Leg	Aus normal	L	9	Roast	Taste Test	90
Boneless Leg	Aus muscle	L	9	Roast	Taste Test	90
Boneless Leg	Callipyge	L	9	Roast	Taste Test	90
Boneless Leg	USA normal	L	9	Roast	Taste Test	90
Rolled Shoulder	Aus normal	L	9	Roast	Taste Test	90
Rolled Shoulder	Aus muscle	L	9	Roast	Taste Test	90
Rolled Shoulder	Callipyge	L	9	Roast	Taste Test	90
Shoulder	USA normal	L	9	Roast	Taste Test	90
			72			720
			2 picks			

3.4.1 Shoulder Roasts

One side of this section was to be converted to a Rolled Shoulder Roast, (de-boned and netted). Compared to a normal rolled shoulder roast, our end result is a severely trimmed roll of fairly small proportions, consisting principally of the eye of the quarter rolled inside a flange of internal material only.

3.4.2 Leg Roasts

Legs prepared as boneless leg roasts (de-boned and netted). The initial prep only involved the sawing back of the butt and shank areas. All deboning was performed after cooking.

3.4.3 Loin Grills

The usual process was employed in that all the saddles were boned out once thawed, the backstraps were denuded and glued together, rolled in glad wrap, snap vacuum packed and held at 1 degree for 24 hours to ensure full adhesion of the glue then sliced and re-frozen for distribution across 60 consumers. The mini steak slices were 15mm thick.

3.4.4 Consumer tasting

Prepared taste test samples were shipped for immediate taste testing in Sydney and surrounds. All consumer testing was carried out by Sensory Solutions Pty Ltd. Sensory Solutions have long performed this service and provided chefs, waiters, administrators, venues and the actual consumers.

The sampling and pick protocol in Table 1 gave 108 taste test samples in all and with 180 consumers, each tasting six taste test samples, (following an initial link sample that was not part of the trial).

The two nights of Roasts were conducted on Monday 2nd March and Tuesday 3rd March 2009. The night of grills was 4th March 2009.

We have 1080 answers for each of five eating quality variables – four semi-objective and one hedonic. Semi objective scores are smell, tenderness, juiciness, flavour and overall liking.

Hedonic scoring is given for satisfaction, where we have 1080 statements of satisfaction, (Stars 1, 2, 3, 4, or 5). These translate basically as follows:-

1 = Awful
2 = Unsatisfactory
3 = Acceptable, good everyday quality
4 = Better than average, acceptable
5 = Premium quality

Consumers ate in pairs in that odd with odd, and even with even are tested on the same material. Typically consumer 1 eats with 3 and 2 eats with 4, 5 with 7 etc.

A Sheep-meat Eating Quality score (SEQ) was calculated as follows according to Meat and Livestock Australia (1999).

SEQ = 0.4 x overall liking + 0.3 x flavour liking + 0.2 x tenderness = 0.1 x juiciness

3.5 Data collation and analysis for consumer eating quality

Two datasets were produced for this analysis, one that was the mean of all ten respondents to each sample and the other is where the top two and bottom two scorers are “Clipped”, (i.e. removed), and the mean of the remaining six are displayed. A means table was produced which summarises all nine of the animals in each cell showing a mean of the results for all nine. The data was analysed by Cuts, (shoulder, leg and loin) each Cut having a single Cook method of its own. Within cut, four categories are displayed in a rising order of “Failure”. This “Failed” calculation is based on the sum of consumer satisfaction scores (Stars), where less than 3 Star in terms of eating quality satisfaction is worse than everyday eating quality. This procedure is the typical process for SMEQ data reporting and the data are reported in this format.

4 Results and Discussion

The consumer eating quality data is summarised in table 2. It demonstrates that Australian consumers clearly distinguished between Callipyge lamb samples and the other three sample groups in this study (normal US and normal and high muscle (high EMD) Australian lamb samples). This distinction was seen across all the three cuts, with one prepared as a grill and two prepared as roasts.

Within the leg roast responses, consumers consistently scored Callipyge samples at least 12 points lower (25% lower) for tenderness, juiciness and flavour. This effect was consistent across clipped sample means. Although overall likeness was also scored lower by an equivalent magnitude in the non-clipped data, satisfaction scores were graded as acceptable (3) for all four groups. Satisfaction scores within clipped data were reduced for the Callipyge group (2) compared to the other groups (3). Leg roasts from the Callipyge group showed a marked difference in scoring distribution across the 1 to 5 star scoring scale, with the majority of consumers grading Callipyge leg roast at 1 or 2 stars. The majority of consumers leg roasts from the other treatment groups as 3 or 4 star. As a result, more than 50% of consumer scores for Callipyge leg roasts were classed as failed by SMEQ ratings in clipped and non-clipped data. Fail rates in the other treatment groups were approximately 20% for non-clipped data and approximately 10% for clipped data. These results clearly demonstrate that Australian consumers regard leg roasts from Callipyge lambs as having much lower eating quality characteristics compared to high muscling Australian lambs and normal muscling Australian and US lambs.

This finding is in contrast to previously reported results from a trained taste panel in the US, which could not detect tenderness differences between *Callipyge* and normal lamb leg muscles when cooked as roasts (Kerth *et al*., 2003). A second study using a trained tasted panel also found that tenderness in grilled *Semitendinosus* muscle (leg) between *Callipyge* and normal lambs did not differ (Shackleford *et al*., 1997). When these cuts were evaluated by consumers, US consumers could not differentiate between *Callipyge* and normal leg chops. As such, our findings demonstrate that Australian consumers have very different capacity to define eating quality differences callipyge vs normal muscling and high muscling animals. Australian consumers clearly report Callipyge leg roast as having inferior eating quality compared to the other tested groups. No effects were observed in the high muscling Australian group, with eating quality sensory scores, SEQ and pass ratings all reported at the top of the experimental range.

The results of responses for tenderness, juiciness, flavour and overall like for the shoulder roast show a similar trend to that of the leg roast, although the magnitude of the reduction in scores was much less than that seen in the leg. Scores for these traits were approximately 10% lower in the Callipyge group compared to the other test groups in non-clipped and clipped data sets, with juiciness being reduced by 20% in both sets. Predicted SEQ scores also trended lower for the Callipyge shoulder roasts, although the effect on distribution of star rating responses for the shoulder was not markedly different between Callipyge and the other treatment groups. Overall satisfaction was not influenced by treatment group. When assessed as % passed and failed based on MSA star rating, both Callipyge and US normal lamb groups behave similarly, having higher % failed in non-clipped and clipped data sets.

The trend to towards reduced consumer eating quality in the Callipyge shoulder roasts is a novel finding, with other reports (Shackleford *et al*., 1997, Kerth *et al*., 2003) suggesting that Callipyge has no adverse effects on eating quality in shoulder cuts. This is also important as it suggests that although muscle hypertrophy is not evident in the forequarter of Callipyge animals, eating quality as assessed by Australian consumers, is negatively influenced.

Table 2. Summary of consumer responses for smell, tenderness, juiciness, flavour and overall like for lamb from animals of the Callipyge genotype sourced from the US, normal muscled lambs sourced from the US, normal muscled lambs sourced from Australia, and high muscled (high eye muscle depth) lambs sourced from Australia. SEQ is the calculated sheep meat eating quality score and satisfaction is the score given regarding overall satisfaction with the sample. Means for all 9 samples are presented along with "clipped means" where the top and bottom response for each cell is removed to leave the mean of remaining 7 samples. Distinct differences are denoted with red text.

GROUP	CUT	COOK	Like Smell	Tender	Juicy	Flavour	O/all Like	SEQ	Satisfaction	Cl. LikeSmell	Cl. Tender	Cl. Juicy	Cl. Flav	Cl. O/all Like	Cl. SEQ	Cl. Satisf.	1 Star %	2 Star %	3 Star %	4 Star %	5 Star %	Failed %	Passed %	Clp 1 Star %	Clp 2 Star %	Clp 3 Star %	Clp 4 Star %	Clp 5 Star %	Clp Failed %	Clp Passed %
AusMus	LEG	RST	59	60	51	60	60	59	3	59	60	52	61	61	59	3	1	16	46	32	6	17	83		6	61	33		6	94
AusNorm	LEG	RST	57	59	52	57	57	57	3	57	60	51	59	58	58	3	1	19	50	30		20	80		7	74	19		7	93
USANorm	LEG	RST	56	56	44	54	55	54	3	55	56	44	55	55	54	3	3	20	48	26	3	23	77		17	67	17		17	83
Callipyge	LEG	RST	53	42	32	42	41	40	3	53	40	31	42	41	41	2	8	44	38	9	1	52	48	2	52	44	2		54	46
AusMus	SDDLE	GRL	67	73	71	71	73	72	4	68	74	74	73	75	74	4		9	29	37	26	9	91		2	28	56	15	2	98
AusNorm	SDDLE	GRL	65	71	72	67	71	70	4	66	74	74	69	74	72	4		10	30	30	30	10	90			37	44	19		100
USANorm	SDDLE	GRL	65	75	67	68	70	70	4	66	78	69	69	73	72	4		13	27	38	22	13	87		2	31	56	11	2	98
Callipyge	SDDLE	GRL	58	33	40	45	41	41	3	60	31	39	44	40	39	2	10	47	28	13	2	57	43	4	57	35	4		61	39
AusMus	SHLDR	RST	54	63	62	55	57	58	3	54	64	63	57	58	59	3	6	17	45	27	6	23	77	2	11	63	24		13	87
AusNorm	SHLDR	RST	54	60	61	57	60	59	3	54	61	62	57	61	60	3	3	22	31	34	9	26	74		19	43	39		19	81
USANorm	SHLDR	RST	54	61	65	52	54	55	3	53	62	65	52	54	55	3	4	29	34	26	7	33	67		26	52	22		26	74
Callipyge	SHLDR	RST	51	55	52	50	51	52	3	51	55	53	50	50	51	3	3	34	41	18	3	38	62		31	57	11		31	69

By far the largest changes in eating quality were seen in the grilled loin samples. Here, tenderness, juiciness, flavour and overall like quality attributes were reduced by approximately 40% in the Callipyge loin samples compared to all other groups. This effect was maintained across un-clipped and clipped datasets and calculated SEQ scores reflected this magnitude of difference. Satisfaction rating was reduced by 1 level in un-clipped data and by 2 levels in clipped data. Almost 90% and 100% of loin samples were classed as passed in un-clipped and clipped data respectively for the non-Callipyge treatment groups. Only 40% of Callipyge samples were classed as passed in un-clipped and clipped data sets. Hence, 60% of Callipyge loin samples failed to meet consumer eating quality expectations. The majority of Callipyge loin samples were classed as 2-star, whilst the majority of loin samples from the other treatment groups were classed as 4-star. This finding is consistent with reported effects within the loin muscle (*M. longissimus dorsi*; Shackleford *et al*., 1997, Kerth *et al*., 2003)

5 Success in Achieving Objectives

This report demonstrates successful completion of all objectives.

6 Impact on Meat and Livestock Industry – now & in five years time - Section

This report provides definitive evidence that eating quality problems previously associated with the Callipyge genotype from objective and US-based taste and consumer panel evaluations can be detected by Australian consumers. Australian consumers rated tenderness, juiciness, flavour and overall like of loin samples from Callipyge lambs cooked as grilled steaks 40% lower than loin samples from Australian high muscled lambs and Australian and US normal muscled lambs. Smaller reductions in these traits were found in leg (25%) and shoulder (10%) roasts of the Callipyge lamb carcases when compared to the other groups.

Improvements in carcase composition of 25% more lean mass and 30% reduction in carcase fat have been shown previously in Callipyge lambs. However, our results confirm the unsuitability of Callipyge as a production phenotype for Australian and international markets for high quality grill and roast cuts.

7 Conclusions and Recommendations

This report demonstrates that Australian consumers rate loin samples eaten as grilled steaks at 40% lower across tenderness, juiciness, flavour and overall like attributes when compared to loin samples from Australian high muscled lambs and Australian and US normal muscled lambs. This equated to 60% of callipyge loin samples failing consumer expectations for eating quality, compared to a fail rate of approximately 10% in the other groups.

Australian consumers also reported smaller reductions in tenderness, juiciness, flavour and overall like attributes were found in leg (25%) and shoulder (10%) roasts of the Callipyge lamb carcases when compared to the other groups. This equated to approximately 40% of callipyge leg roasts failing consumer expectations for eating quality, compared to a fail rate of less than 20% in the other groups. The difference between Callipyge and the other sample groups in failure rates within the shoulder roasts were not as marked.

These results confirm the unsuitability of Callipyge as a production phenotype for Australian and international markets for high quality grill and roast cuts.

No influence of carcase muscling level (based on eye muscle depth) was seen on eating quality outcomes across the Australian lambs eaten here. However, the power of this analysis is very limited and this finding should be evaluated through more extensive evaluation across a range of progeny from industry sires as being performed within the meat program of the CRC for Sheep Industry Innovation.

8 Bibliography

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