There are some differences between countries. Japanese consumers place a greater premium on high quality product. Irish and Polish consumers are the most price sensitive for premium product. However, there is a trend across countries: consumers are willing to pay a substantial premium for higher quality beef.

Dr David Pethick and his colleagues (L. Pannier and T. Pleasants, Murdoch University Australia) gave a presentation entitled "Towards a continuous grading model for MSA for lamb".

The current MSA for lamb is a best practice pathway approach to underpinning the eating quality of lamb cuts. The work underpinning the current MSA lamb was published as a series of scientific papers in 2005 (Special edition 1) and is still entirely valid. The major implications of the current system are best practice processing underpinned by manipulating the pH decline of the muscle in the carcase post slaughter (electrical stimulation) combined with aging requirements of the meat matched to the rate of pH decline. In addition, a key component is the need for registered producers ensuring that lamb producers understand the principals of supplying lamb to underpin the consumer.

Subsequent work undertaken as part of the Cooperative Research Centre for Sheep Industry Innovation including the initiation of the Information Nucleus genetic resource flock has lead to a raft of new information in relation to the science of lamb meat quality (Special editions 2,3 and 4; 2006, 2007, 2014). This work has lead to the realisation that an individual grading system is possible to underpin a more refined and accurate prediction of consumer satisfaction of cooked lamb. The new aspects include:

- positive effect that intramuscular fat plays in determining the eating quality of lamb
- the –ve effect that muscling (or lean meat yield) plays in determining the eating quality of lamb
- the strong influence of sire genetics on the eating quality outcome
- continued selection for lean meat yield in the Terminal sire seed stock sector will decrease the eating quality of lamb

The basis for underpinning carcase grading as an additional input into MSA cuts based lamb grading comes from MSA sensory consumer testing of the grilled short loin and topside steaks from 1,422 Terminal and Maternal sire cross and 221 Merino lambs. In total this equals 3,286 cuts of lamb tested by 5,476 consumers. A small number of Dorper x Merino cross lambs were also tested but the data was insufficient to make grading predictions at this stage. All lambs were slaughtered to current MSA specifications including electrical stimulation of the carcase and 5 days aging of the meat.

<u>Table 1:</u> Descriptive statistics of lambs sired by Terminal and Maternal sires used in consumer sensory studies

Variable	N	Mean	Std Dev	Minimum	Maximum
HCWT (kg)	1422	24.0	3.8	15	40.0
IMF%	1422	4.6	1.1	2.0	9.8
LMY%	1216	57.7	3.3	45.3	66.3
GR tissue depth (mm)	1422	15.5	6.0	2.0	30.0

HCW = hot carcase weight; IMF = intramuscular fat; LMY = predicted CT lean meat yield

The consumer testing was based on the standard MSA sensory protocols with untrained consumers consuming grilled lamb steaks cooked to medium. Each consumer rated the steaks on a scale from 0 - 100 for tenderness, juiciness, liking of flavour and over liking. They also ticked one box as their final grade answer, namely unsatisfactory (2*), good every day (3*), better than everyday (4*) or premium (5*). The distribution of grades is shown in Table 2 for the short loin and topside respectively.

<u>Table 2:</u> The average frequency of sensory grades for the grilled short loin and topsides steaks across the lamb progeny of all sire types

Cut	Star 2	Star 3	Star 4	Star 5
Loin	7	34	35	24
Topside	31	51	14	4

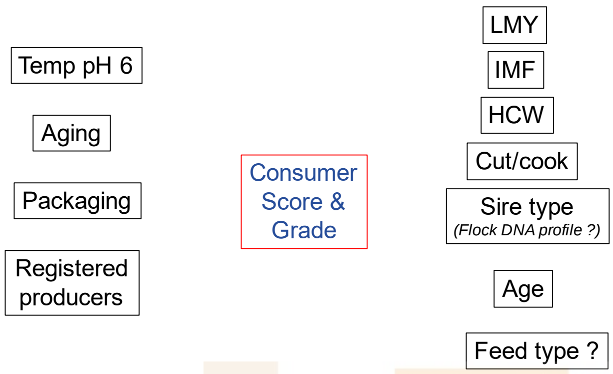
The best predictor of the final grade or star rating was:
Lamb MQ4 score = 0.3 (T) + 0.1 (J) + 0.3 (F) + 0.3 (OL)

The statistically significant predictors of the MQ4 score were (i) sire type (Merino, Maternal, Terminal) (ii) an accurate estimate of CT based lean meat yield [such as with the new DEXA based systems discussed by Gardner) and (iii) intramuscular fat.

A final new MSA lamb model for predicting the eating quality of lamb cuts can be designed.

The elements of a final MSA prediction currently being investigated are shown in Figure 8. An area of intense investigation in Australia is the development of on line technologies for grading of lean meat yield and intramuscular fat in lamb carcases.

Figure 8: The elements of a new Meat Standards Australia lamb model currently being evaluated



Andrea Garmyn (Texas Tech. University, USA) presented the New Zealand experience regarding beef and lamb grading for satisfying the consumer.

Beef in New Zealand is classified into carcass categories based on carcass type (sex) and further sorted based on fat thickness, carcass weight, and muscling (NZMCA, 2004a). This classification system is used for marketing purposes, but provides no indication of eating quality. In 2013, Silver Fern Farms, a leading red meat producer, launched a consumer-based grading system that relies on the chiller assessment of marbling, ossification, pH, ribfat thickness, and carcass weight to predict eating quality on an individual cut by cooking method basis and incorporates chiller assessment of meat and fat color for aesthetic purposes.

In order to develop the model used for this grading system, carcasses were selected with a wide range of marbling and ossification scores to generate the model algorithm. This was achieved via three sample collections (August, November, April) at three chilled beef abattoirs (Pacific, Belfast, Finegand) to account for seasonal and regional variation that may exist in the beef population. Each sample collection focused on a strategic concentration to build a robust model. Initially, carcasses were selected to evaluate the interaction between cut (32 different muscles) and cook method (grill, roast, slow cook, stir fry) in short aged beef, as well as to examine grills *vs.* roasts within one cut, and to assess consumer responses in New Zealand *vs.* United States. The second and third collections focused on the effects of *postmortem* aging and alternative carcass suspension methods. Ultimately, 276 sides were utilized to generate 96,600 consumer samples, which were tested by 13,800 consumers in New Zealand and the United States. This grading system now allows for the selection of premium carcasses with guaranteed eating quality. In 2013, Silver Fern Farms Premier Selection Reserve Beef value-add restaurant product range was released to market following consumer and customer testing. Their value-add retail beef range was released in 2014 with an EQ Master Grade guarantee. By 2016, over 1 million retail packs had been sold. Silver Fern Farms retail packs are also available in select international markets.

Much like beef, lamb in New Zealand is classified into carcass categories according to maturity of the carcass, sex, fat content, weight, and muscling (NZMCA, 2004b). Again, this classification system is used for marketing purposes, but offers no insight into eating quality. Based on the success of Silver Fern Farms Reserve premium beef program, the company sought out to determine which traits could be used on farm or in the abattoir to predict lamb eating quality. Gender, weight, GR score, and pH were used as carcass selection parameters. Four muscles (loin, rump, topside, and knuckle) were retained from those carcasses and aged 1, 7, 14, or 28 days *postmortem*. Weight gain, breed, and diet were also available during selection. Carcasses were selected at two time periods (February, April) at two different abattoirs (Takapau, Finegand) each time to account for seasonal and regional variation that may exist in the lamb population. Ultimately, 385 carcasses were utilized, which were tested by 3,240 consumers in New Zealand and the United States. To ensure a premium lamb product, carcass weight, sex, and GR should be considered. Incorporating season, feed type and breed type can improve the sorting accuracy. Ultimately, this system can predict eating quality of the 4 tested cuts, when grilled, following postmortem aging anywhere from 1-28 days; however, logistical limitations have hindered implementation at this time.

Finally, Prof. John Thompson (UNE) and his collaborators (RJ Polkinghorne, J Philpott, J Pervovic, J Lau, L. Davies, W. Mudannayake, D. Summerville, J. Nixon, R. Watson, G. Tarr) gave a presentation entitled "Packaging effects on eating quality".

The Meat Standards Australia (MSA) beef grading model uses commercial inputs to predict eating quality of individual cuts prepared using different cooking methods. The MSA grading model is dynamic and capable of including new inputs if shown to impact on eating quality. An example of the dynamic nature of the MSA grading model was the addition of hormonal growth promotants (HGP) as an input, after research showed that HGPs had a large negative effect on eating quality of some muscles in the carcass. The scientific literature makes reference to a negative effect on beef eating quality when retail cuts are packaged in high oxygen gas packs, although generally the magnitude of the effect is not well quantified. If the effect of high oxygen packaging can be quantified it could be included as an input into the MSA beef grading model.

Previously the MSA grading system excluded both high MCS (MCS) at grading (ie MCS > 3), and also high ultimate pH carcasses (pHu > 5.7) as threshold traits. There are questions as to the usefulness of MCS at grading as a predictor of eating quality. Recent studies have also shown an increasing incidence of grass fed carcasses with high MCS and low ultimate pH at grading (JM Thompson and R Polkinghorne, unpublished data). If the high MCS and low ultimate pHu carcasses at grading are regraded at a later time the proportion of carcasses that have high MCS is reduced. This questions the usefulness of MCS at grading as a tool to exclude carcasses from the MSA beef grading system.

This experiment examined the effect of three different packaging methods (ie MAP – cuts packed in 80% oxygen;20% CO_2, OWP - cuts wrapped in oxygen permeable film, or VSP - vacuum packed cuts in bags or preformed pouches) across a matrix of MCS at grading (1C, 2, 3, 4 and 5 MCS), with high or low ultimate pH (pH> or < 5.7) and a range of dentition categories (0, 2, 4 and 6 tooth carcasses).

The 48 beef carcasses used in this experiment were selected largely from grass fed carcasses slaughtered at one abattoir over a single day. The striploin, rump and tenderloin primals were collected from both sides at boning, vacuum packed and allocated to either 5, 12 or 40 days ageing treatments. After ageing primals for the appropriate time they were broken out of the vacuum packs and the mm. *longissimis dorsi, gluteus medius* and *psoas major* prepared as steaks in the three packaging treatments.

The consumer acceptability of meat colour in the retail packs was scored using untrained consumers. OWP packs were scored one day after packaging, whilst the MAP and VSP packs were scored at three, five and seven days after packaging. Consumer appreciation of meat colour of the retail packs was scored using a line scale anchored by the words extremely unappealing/extremely appealing. In addition consumers were also asked to tick one of three boxes, the first indicated they would definitely buy the retail pack, secondly they would definitely buy the retail pack if discounted, or thirdly they would definitely not buy the retail pack. After nine days steaks from the retail packs were frozen and allocated for sensory testing. Steaks were thawed and grilled steaks tested using untrained consumers for tenderness, juiciness, like flavour overall acceptability and a composite meat quality score (MQ4) using the MSA consumer protocol.

Results and discussion: Results showed that MCS at grading, ultimate pH class and dentition category did not impact on consumer sensory scores (P>0.05). Packaging had a large effect on consumer sensory scores with steaks stored in high oxygen MAP packs scoring 10 to 12 lower scores (on a 100 point scale) compared with steaks packed in either OWP or VSP systems (P<0.001). The MAP penalty was similar regardless of muscle, or the time primals were aged in the vacuum pack. This suggested that the MAP effect was not caused by inhibition of post-mortem proteolysis, but rather oxidative cross linking of proteins.

A discriminant analysis of the consumer appreciation of MCS at retail showed boundaries between definitely would purchase/definitely not purchase unless discounted/definitely not purchase was 62 and 38. This confirmed that consumer appreciation of MCS at retail was related to purchase intent.

Using the data from day one in the OWP packs and day three for the MAP and VSP packs showed that the MAP had the highest consumer appreciation of meat colour followed by the OWP packs, with the VSP packs having the lowest consumer appreciation of meat colour (P<0.001).

Within the OWP packs, MCS at grading was not related to consumer appreciation of meat colour at retail after one day in the retail pack. Given that the oxygen film of the OWP packs was permeable to oxygen the expectation was that the surface of the OWP steaks from low MCS carcasses would have bloomed and converted the dark purple deoxymyoglobin to a layer of bright red oxymyoglobin on the cut surface, which would have resulted in higher consumer appreciation of meat colour at retail. However, this did not occur as the current experiment showed no relationship between MCS at grading and consumer appreciation of meat colour in retail packs.

Within both the MAP and VSP packs, MCS at grading were not related to consumer appreciation in meat colour in retail packs when evaluated at three, five and seven days after being placed in the retail pack. Previous studies have shown that high oxygen MAP tended to increase the effective penetration of oxygen in the surface of the meat so that even dark cutting beef appeared to be bright red when packaged in high oxygen MAP. Hence the lack of any relationship between MCS at grading and consumer appreciation of meat colour in MAP was not surprising. Similarly in VSP the deoxymyglobin would remain in the reduced form and remain dark purple in colour, hence the lack of relationship between MCS at grading and consumer appreciation of meat colour in VSP was also not surprising.

In conclusion, the recommendation from this experiment was that MSA include a penalty for high oxygen MAP as part of the MSA model. Obviously, how long after MAP before the effect was apparent, along with the effect of other gas mixtures on the magnitude of the MAP effect still needs to be investigated.

It was also recommended that MCS at grading be removed as an input trait in the MSA beef grading scheme which has now occurred.

CONCLUSION

The MSA system is based on estimating the eating quality response of untrained consumers, i.e. the population who purchase meat. Australia has already a large data set of consumer responses to beef and lamb. This has allowed the development and commercial application of the MSA prediction tool for beef within Australia.

Data sets using common MSA protocols have now been obtained in several countries (France, South Korea, Poland, Republic of Ireland, New Zealand, Northern Ireland, South Africa, United States of America). It is now proposed to generate an international database joining these national datasets since the MSA model is an adequate tool for predicting the eating quality of beef in all these countries. Indeed, the value of a combined global database is now recognized as well as cooperative development of eating quality standards. In addition, there is a trend across countries that consumers are willing to pay more for higher quality beef.

More recent research has been developed using the MSA protocols and standards to assess eating quality of dry aged beef or following different packaging methods. The MSA grading model is indeed dynamic and can include new inputs important for eating quality such as different packaging methods or longer ageing periods in interaction with existing factors already present in the MSA grading scheme.

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