Lecture 10: Sheep meat eating quality

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Learning objectives

- Understand the importance of the SMEQ research program in developing tools to provide consistent sheep meat products
- Understand the factors influencing sheep meat eating quality and how manipulating these factors can improve sheep meat eating quality

Key terms and concepts

Sheep meat eating quality; shear force; tenderness; type of cut; animal age; genotype; pre slaughter stress

10.1 Sheep meat eating quality

In 1998 a well known lamb exporter made the following statement "**I can tell when I see a lamb come on to the plant whether it will be tough or not**" (The Weekly Times, 18/11/1998). This was a bold statement that wasn't true, because toughness is a trait that can only be determined by testing the cooked meat or predicting the toughness using established relationships.

Background

Testing of lamb purchased at the retail counter has shown that a significant percentage is below acceptable standards for tenderness. An audit (Safari *et al.* 2002) of lamb loin tenderness was conducted across four Australian capital cities over a year (Oct 1997 to Oct 1998). Approximately 20% of all loins (about 900) purchased had a shear force value greater than five kilograms (Figure 10.1). Consumers regard meat with a shear force below five kilograms to be tender and above 10-kg tough, so that product between 5 and 10 is considered neither tough nor tender. Melbourne (4%) and Perth (32%) contributed largely to the percentage of loins with shear force values above 5 kg while samples from Canberra and Sydney had lower values.

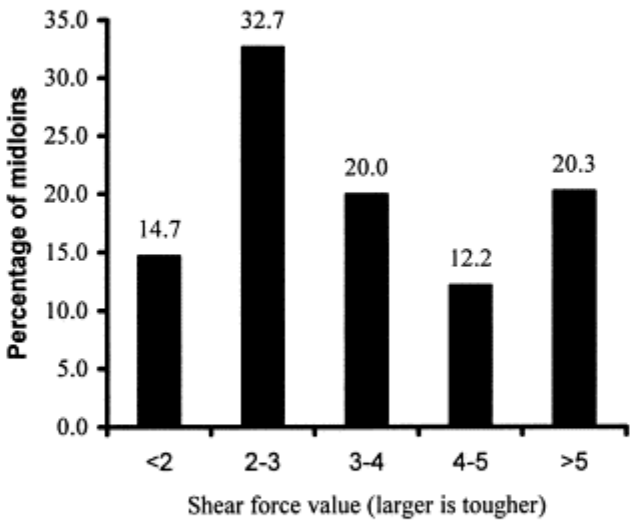

Figure 10.1: Frequency distribution of shear force (kg) for loins (Safari *et al.* 2002).

For a reduced number of samples (n = 220) it was found that there was no relationship between price per kilogram and shear force for loins purchased in Sydney (Figure 10.2). However, price per kilogram differed between months and suburbs, but not between retail butcher shops and supermarkets for loins purchased in Sydney.

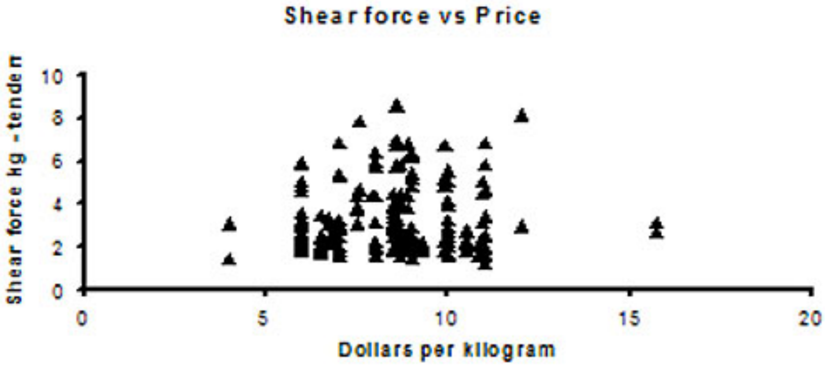

Figure 10.2: Relationship between shear force (kg) and dollars per kilogram for 220 lamb loins (Safari *et al.* 2002).

An analysis of the Australian sheep meat industry showed that:

- Consumers were demanding improved quality, consistency, versatility and value for money in food
- Major competitors to lamb and sheep meat in domestic and export markets were investing in research and development to improve product quality and consistency
- There was a desire among hogget and mutton producers to add value to their meat production.

Overall these outcomes highlighted the need for the industry to come up with ways to ensure the supply of consistently high, eating-quality sheep meat to consumers. To achieve this aim the sheep meat eating quality (SMEQ) program was undertaken with funding by Meat and Livestock Australia starting in 2000.

10.2 SMEQ – program

The SMEQ research program followed, in principal, the approach adopted by Meat Standards Australia (MSA) for rating the eating quality of beef, where the impact of different critical control points was established (Figure 10.3).

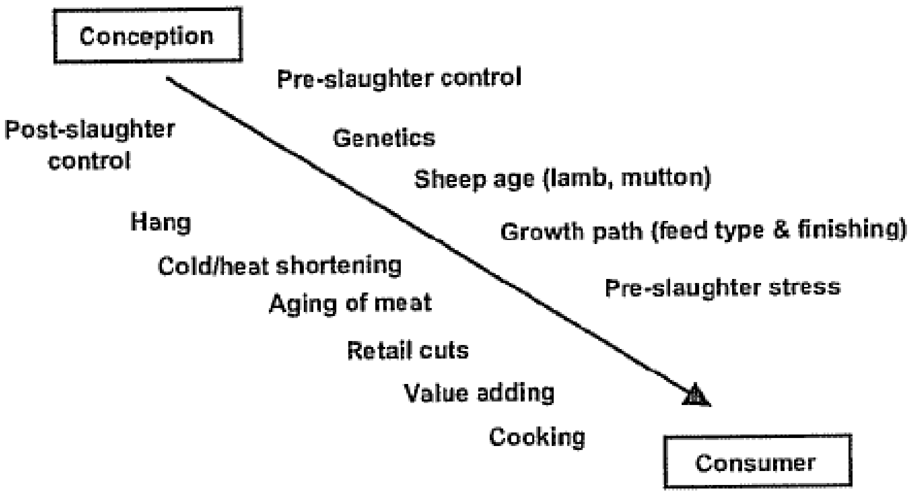

Figure 10.3: Critical control points for Sheep Meat Eating Quality (Russell *et al.* 2005).

A range of experiments were designed and the results were implemented to produce a model which can be used by supply chains to optimise and continuously improve product quality. A team of scientists from the Universities of New England and Murdoch and from NSW Agriculture, DPI in Victoria and Agriculture Western Australia worked on the program and the results presented here are a summary of the key findings.

In many ways the science behind this research has not covered new ground, but the distinctive feature is the fact that real consumers have tested every piece of meat in the program. Consumer taste panels are the closest we have to “the real thing” in terms of assessing the quality of sheep meat. For this testing a consumer is defined as anyone who is between 20-50 years old and eats sheep meat at least once every 2 weeks. For any muscle/cut 10 consumers test the cooked product using the following attributes:

Attribute	Scale
Tenderness	0-100
Liking of flavour	0-100
Juiciness	0-100
Overall liking	0-100

After this the consumer is then asked to give an 'overall rating' for the product eg.

Awful
Unsatisfactory
Good everyday (say ***)
Better than everyday (say ****)
Premium (say *****)

The research has focused on establishing how much impact each of the following variables have on eating quality:

- Cooking method
- Type of cut
- Animal age
- Genotype of animal
- Sire of animal
- Pre-slaughter handling
- Chilling regimes
- Electrical stimulation
- Tenderstretching
- Ageing.

10.3 Cooking method/type of cut

The first project conducted in the program was designed to establish the impact of the interaction between cooking method (roasting, grilling), muscle type and age class (lamb, mutton). Lamb and mutton carcasses were either stimulated or not stimulated using a high voltage system after slaughter prior to boning. Grill samples were prepared from the left and roast samples from the right side of the carcass for the following cuts; loin, outside, rump, topside and rib. Due to size constraints, muscle from the left and right sides was used to form a grill for the knuckle and a roast from the blade. It should be stressed that within the R&D program only denuded, boneless cuts have been tested. Interestingly there was no impact of cooking method on scores for the topside, which had the lowest eating quality (Table 10.1).

The differences between cuts and between lamb and mutton are reduced by roasting compared with grilling. This is because the slower cooking method helps connective tissue (the background toughness in meat) to degrade, so narrowing the differences between younger and older animals.

For testing production and processing effects on palatability, grilling was more sensitive for detecting treatment effects, than roasting and so it was decided to only use grilling as the method of cooking for subsequent experiments.

The first project also showed that significant differences existed between the sensory scores of different muscles, such that the difference between cuts within a carcass can be as high as 25 points (Table 10.1).

Table 10.1: Average overall liking score for representative grilled and roasted cuts from lamb and mutton (Thompson *et al.* 2005a).

	Grill		Roast	
Cut	**Lamb**	**Mutton**	**Lamb**	**Mutton**
Loin	75	63	65	54
Rib	71	58	61	53
Knuckle	66	54	58	60
Rump	65	58	54	54
Outside	58	44	52	44
Topside	44	50	46	49

10.4 Animal age

An interaction between cut type and age was also detected (as outlined in Table 10.1). This has been followed up in further experiments and some related results from a project in WA are shown (Figure 10.4).

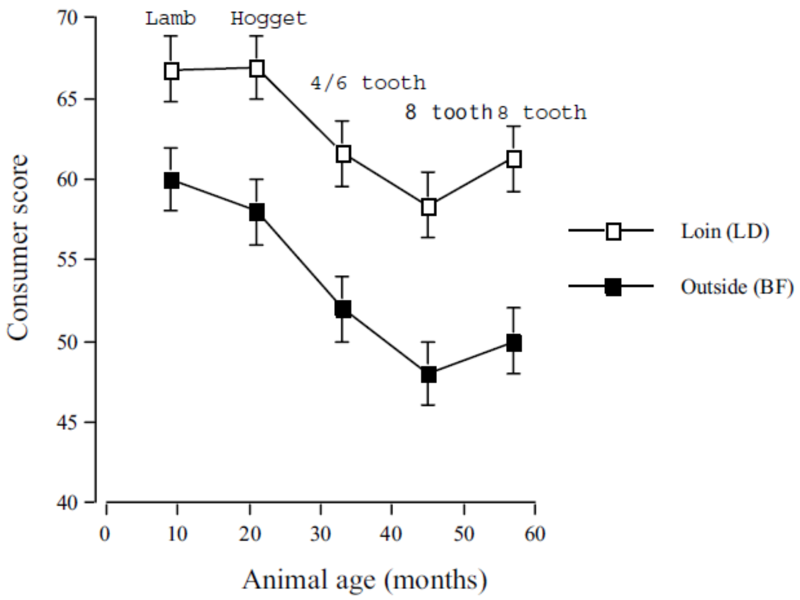

Figure 10.4: The effect of animal age in Merino ewes ranging from carry over lamb (9 months) to 5 year old mutton on the consumer score of 2 cuts. (LL = loin; BF = outside) (Hollick and Pethick 2001).

Merino's spanning carry over lamb (9 months old) to older mutton (3.5 - 5 years) were sourced from a commercial farm for the WA project and placed on a nutritionally balanced feedlot pellet for 4 weeks. All carcasses were high voltage stimulated and the meat aged for 5 days (optimal processing).

The change in consumer score of the loin (LL) and outside (BF, taken from the hindleg) with animal age is shown in Figure 10.4. For the loin there was little difference between hogget and lamb but the consumer score then declined by 6-8 points as the age of the ewe increased (4 years and older). Lamb and hogget loins were rated as "better than every day" while the mutton loins (4 through 8 teeth – 3-5 years old) were rated as "good every day". These results reveal that given the error around each mean that eating quality is similar between the 4/6 tooth and various age classes of 8-tooth animals.

The rating for the outside from old sheep (8 tooth) was unsatisfactory, but from lambs made "good every day". Further work in Victoria and NSW showed that overall hogget meat will provide a good level of eating quality that is slightly lower than lamb particularly for the loin. This is provided that "best bet" processing approaches such as electrical stimulation and ageing are applied.

10.5 Genotype of animal

In the past it has been established that there are differences between genotypes in the way they handle stress, with Merinos seemingly being more susceptible, resulting in higher pH meat. Although we don't expect large differences in the consumer score between genotypes some experiments to quantify this were conducted.

In NSW the experiment had the following design:
Second cross suckers, second cross carryover lambs, first cross carryover lambs, first cross hoggets and Merino carryover lambs were used in the experiment (total number 120). Each sub group of animals came from 2 properties and all animals were run together for 5 weeks before slaughter. At slaughter every carcass was subjected to high voltage stimulation and the product aged for 5 days. This was to minimise processing factors so the true impact of age/genotype on the consumer score could be determined.

The results showed that the meat from sucker lambs was the lightest in colour, with hogget meat the darkest (Table 10.2). There was a consistent pattern for pH with meat from first cross lambs and Merino lambs exhibiting a higher pH than meat from other types. This has been reported before. High pH causes a *variable* eating quality, and does not keep as well when chilled. However, if stress is minimised through careful pre-slaughter handling, the eating quality of the Merino can be as good as for other breeds. In a related Victorian experiment all genotypes were slaughtered in an experimental abattoir and there was no difference between genotypes for muscle pH.

Table 10.2: Means of loin lightness and ultimate pH for loin (LL), topside (TS), and eye round (ER) for animals according to genotype and age category (Hopkins *et al.* 2005).

Genotype/category	Lightness	pH (LL)	pH (TS)	pH (ER)	Overall liking
Second cross sucker	38.5	5.56	5.57	5.78	65.8
Second cross, lamb	37.6	5.56	5.62	5.83	60.5
First cross, lamb	36.6	5.68	5.68	6.10	62.9
First cross, hogget	34.2	5.58	5.59	5.86	59.7
Merino lamb	36.4	5.68	5.70	6.04	59.7

10.6 Sire of the animal/growth rate

The meat and eating quality of 140 female lambs sired by 9 different Poll Dorset sires (3 selected for growth, 3 selected for muscling and 3 control) and fed either a low or high plane of nutrition from birth to slaughter was examined (see Hopkins *et al.* 2005). All carcasses were electrically stimulated and portions of loin aged for 5 days before freezing.

Plane of nutrition did not have a significant effect on eating quality attributes, although the effect on tenderness approached significance, with loin from low plane animals scoring lower than high plane animals (Hopkins *et al.* 2005). Low plane animals did have lower muscle pH values. However an objective measure of tenderness – shear force did show loin and topside to be tougher from low plane animals (Hopkins *et al.* 2005). Based on these results the recommendation is to ensure lambs grow at 100 g/h/d or better from birth to slaughter.

There was an effect of sire on tenderness, juiciness and overall liking. Of the sires it was 2 of those selected for muscling which produced loin meat of the lowest eating quality (i.e. lowest overall liking score). It remains to be verified whether selection for muscling per se has an effect on sensory traits. The magnitude of the sire effect (up to nine points) was greater than many of the previous effects detected in the SMEQ program highlighting the importance of the finding. Some screening system will be required by the industry to make sure that the genes responsible for this effect do not spread throughout the industry in the name of increased production.

10.7 Finishing systems

An increase in intramuscular fat has a beneficial effect on juiciness and flavour. It was found that 'finishing' lambs for 2 weeks pre-slaughter on straw reduced intramuscular fat concentration, which resulted in reduced liking of flavour and juiciness (Pethick *et al.* 2005). Research has shown that an animal with a fat score between 2 and 3 will have adequate intramuscular fat, considered to be the high side of the range 4 to 5%.

If animals are fed for positive growth a simultaneous increase in the glycogen concentration occurs, reducing the chance that at slaughter they will develop the high pH condition. Glycogen is animal starch and is held in reserve for vigorous muscular activity in the flight-or-fight response. The high and normal concentration in sheep is around 1.5g/100g of lean muscle weight. If the concentration of glycogen falls below a threshold concentration – around 0.8 g/100g – because of poor nutrition or other factors, the pH of the resulting meat becomes higher than normal. None of the finishing diets used in this study resulted in a reduction of muscle glycogen below 0.8g/100g (Pethick *et al.* 2005).

It should be noted that the composition of a diet can also affect the quality of flavour, but in the SMEQ program feeding different diets pre-slaughter had no effect on eating quality (Pethick *et al.* 2005). This is likely to reflect the fact that all meat tested was denuded of external fat prior to testing.

10.8 Animal handling pre-slaughter

The eating quality of the best finished animals can be decreased by poor handling in the days and hours prior to slaughter. The objective is to deliver unstressed animals from farm to the abattoir slaughter line so as to avoid the high pH condition.

Bad animal handling – which is also a welfare issue – increases the incidence of high pH meat. Nervous and physical stress in the hours and days leading to slaughter causes a loss in muscle glycogen in the live animal leading to an elevated pH in the meat after slaughter (this depletion is depicted in Figure 10.5). A recent survey of lamb loin on sale throughout Australia showed 10% had a pH above 5.8.

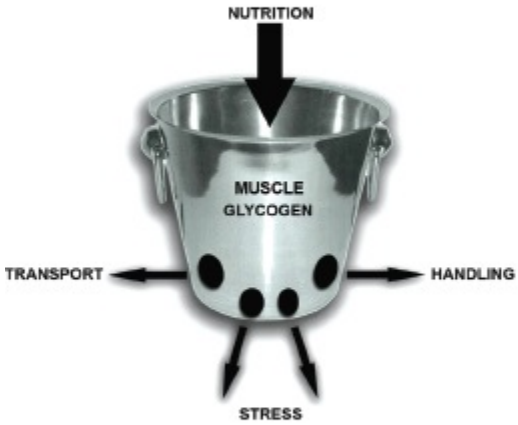

Figure. 10.5: The muscle glycogen 'bucket' is topped up by adequate nutrition as a buffer against losses that occur through 'holes' in the bucket around the time of slaughter (MLA MSA sheep information kit 2007).

10.9 Electrical stimulation/ageing/tenderstretch

Processing factors such as the use of electrical stimulation can improve the consumer score by up to 10 points and ageing the meat (holding post-rigor for several days before consumption) can also improve the score by as much as 7 points. Five days ageing is considered the optimal ageing time for the domestic market. Electrical stimulation increases the rate of pH decline and as a result meat enters rigor at a higher temperature and thus exhibits less shortening. Tenderstretch results in a 5-point improvement in consumer score at any period of product ageing. Tenderstretch hanging, where carcasses are suspended by the pelvis or aitch bone (Figure 10.6), allows antagonistic muscles on the anterior and posterior sides of the leg to balance one another thus avoiding shortening-induced toughening. At the same time the loin is either stretched or no longer able to contract.

Figure 10.6: Conventional Achilles hanging (left) and Tenderstretch hanging (NSW Agriculture 2004).

One of the important outcomes of the work on processing factors to emerge from the SMEQ program was the ability to describe the relationship between sensory traits and the temperature at pH 6.0 (this pH is used as the commencement point for rigor).

For tenderness score the relationship with rigor temperature was curvilinear in carcasses hung by the Achilles tendon, whilst there was no significant relationship evident for tenderstretched carcasses. This suggests that at the extremes of both low and high rigor temperatures there was a penalty of up to 6 tenderness units (Figure 10.7). The penalty in tenderness at the low rigor temperature was likely a result of 'cold shortening' and at the other extreme the decline in tenderness at the higher rigor temperatures was likely a result of 'heat shortening'.

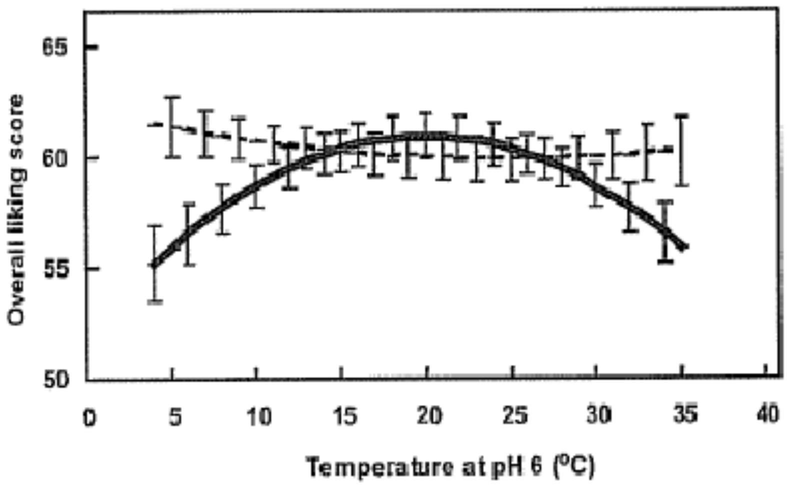

Figure 10.7: The relationship between overall liking score and rigor temperature (pH 6.0), for normally hung (_____) and tenderstretch (_ _ _ _) carcasses (Thompson *et al.* 2005).

Another important outcome which emerged from the work was identification of the optimal temperature at which to hit a pH of 6.0. This temperature is ~18°C ± 4°C and this provides the target window for processors to manipulate pH decline so as to maximise eating quality. The most convenient way to 'hit' the target is to use electrical stimulation.

A summary of the options for product used in different ways is given in Table 10.3.

The SMEQ R&D program has generated results on the critical control points that affect sheep meat eating quality as defined by real consumers. This research work has now been incorporated into Meat Standards Australia (MSA) for lamb and sheepmeat and is based on a supply chain approach. MSA provides the opportunity for differentiation of lamb and sheepmeat products in the market to provide consumers with a consistent product.

Table 10.3: Processing and ageing conditions for optimum eating quality in different markets (Chris Shands and NSW DPI Colleagues 2006).

	Domestic chilled trade (short time to market)		**Domestic chilled trade (medium time to market)**	**Domestic or export chilled trade (long time to market)**	**Frozen**
Hanging method	Tenderstretch	Achilles	Achilles	Achilles	Achilles
Electrical stimulation needed	No	Yes	Yes	No	Yes
Enter rigor (pH 6) at:	8 - 30°C	18 - 25°C*	18 - 25°C*	8 - 18°C	18 - 25°C*
Minimum ageing period	5 days§	5 days§	5 days	10 days	5 days before freezing
Storage temperature	1°C	1°C	1°C	-1°C	1°C then -18°C

¶ This is an outline only. Processes need to be tuned to match abattoir facilities and specific market needs

* Provisional result. Lower temperature may be reduced.

§ This is the optimum time to maximise sheep meat eating quality. This is not practicable for most domestic markets. Three days ageing will achieve much improvement, but optimum quality will take five days.

Readings

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