Department of Agriculture

Sheep Updates 2003

SHEEP UPDATES

Sheepmeat eating quality - affects of animal age, finishing and processing

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KEY MESSAGES

This paper summarises some of the research and development being undertaken as part of the Meat and Livestock Australia's sheepmeat eating quality program.

A system for describing the consumer defined quality of sheep meat has been developed and this relates directly to failure rate.

With the exception of the topside there is a relatively small effect of cut in lamb such that most perform well under grill cooking given optimal processing. The topside, when consumed after roasting as an easy carve leg, also performs well.

Over a broad range of animal age, loin tenderness declines with increasing animal age in a predictable way but liking of flavour, juiciness and overall liking are less affected resulting in acceptable consumer scores even for older sheep (mutton). This is in part driven by the intramuscular fat levels found in older well finished sheep.

Grilled leg muscles of mutton and hogget tend to decline more sharply in consumer acceptance than the loin when compared to lamb.

The definition of lamb could be changed to include lambs with erupted teeth but not in wear with no associated decline in eating quality of the loin.

Finishing (or growing) sheep pre-slaughter is an important component of assuring eating quality as it affects intramuscular fat, muscling and glycogen levels in muscle.

The type of finishing system should be dictated by cost of production and seasonal constraints and not perceived affects on the flavour of sheepmeats.

Processing and product aging is an important determinant of sheepmeat quality.

REVIEW

This paper summarises some of the findings resulting from Meat and Livestock Australia's (MLA) research program that investigates the eating quality of sheepmeats. The research began with an Industry consultation process involving producers, processors, wholesalers, retailers, food service and scientists who developed a series of 'best bet' critical control points that might determine consumer acceptability of sheepmeats (Figure 1).

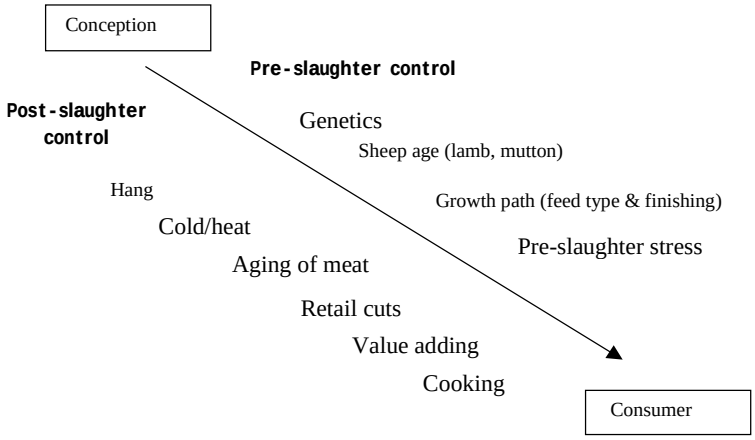


Figure 1. Critical control points for the consumer acceptance of sheepmeat.

After this a range of experiments were designed and undertaken with the overall aim of producing a model which could be used by supply chains to optimise and continuously improve product quality. The paper below focuses on the effects of animal age, finishing system and processing as it effects the eating quality of sheepmeats.

Establishment of sheepmeat eating quality measurement protocols

The ultimate way of measuring consumer perceptions of lamb and sheepmeat eating quality is consumers. Untrained, consumer taste panels are the closest we have to 'the real thing' in terms of assessing the quality of lamb and sheepmeat products. The measurement of eating quality in this program has been based on consumer taste panels very much along the line of MLA's Meat Standards Australia research. The word consumer means people selected from the community with the only requirement that they are between 20-50 years old and eat sheep meat at least once every two weeks. For any muscle/cut 10 consumers will have given their opinion of the eating quality attributes. The attributes scored by the consumers are:

Attribute	**Scale**
Tenderness	0-100 (very tough - very tender)
Liking of flavour	0-100 (dislike - like)
Juiciness	0-100 (very juicy - dry)
Overall liking	0-100 (dislike - like)

After this the consumer is then asked to give an 'overall rating' for the product consumed by ticking one box only, e.g.

- . Unsatisfactory
- . Good every day
- . Better than every day
- . Premium.

The consumer scores for tender; juicy etc were then related to the rating (good every day, etc.) and to our surprise most sheep meat fell into the good every day/better than every day categories - this included both lamb and mutton. Given this, one approach is to use the consumer score data to predict the risk of product failure. Thus the higher the consumer score the lower the risk of failure (Figure 2).

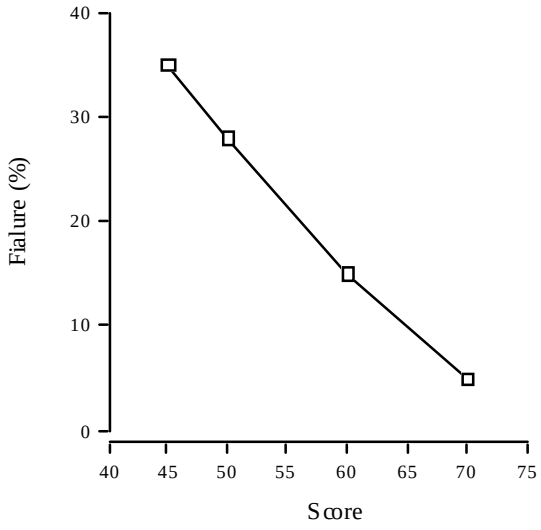


Figure 2. The relationship between consumer score and failure.

Effect of cut

Most of the previous work in sheepmeats has concentrated on understanding the eating quality of the loin since this muscle is both easy to use and prepare, plus it is high in value. However the message from Industry was to investigate other cuts in addition to the loin. The data in Table 1 summarises the average consumer score under a grill protocol for several muscle groups throughout the carcass in lambs, hogget and mutton under optimal processing conditions. There are clear differences due to animal age and muscle. A striking feature for lamb is that it performs well (failure rate about 10%) from the consumer perspective across the carcass with the notable exception of the topside.

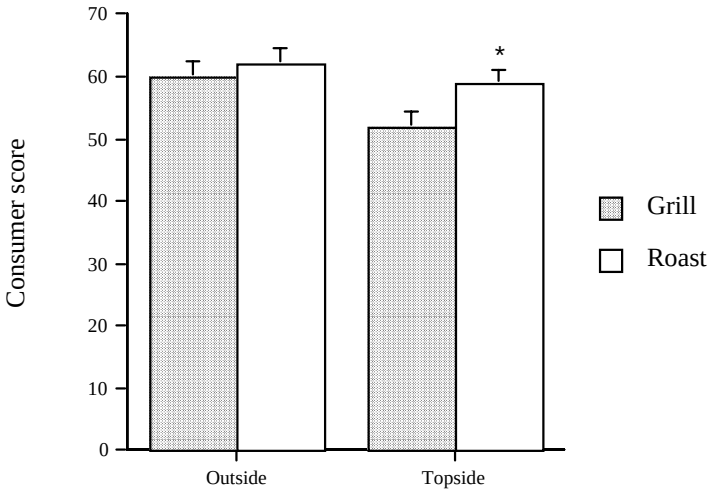
Table 1. Average consumer score (overall liking) for lamb, hogget and mutton muscle groups under a grill protocol and optimal processing. (Values are collated from a 4000 item data base - mean standard error 2.6. Only meat samples undergoing 'optimal processing' scenarios i.e. stimulated + 5 days aging; unstimulated + 10 days aging; Tenderstretch + 5 days ageing)

Muscle	Consumer score		
	Lamb	Hogget	Mutton
Loin	66	61	60
Rump	65	-	56
Outside	60	56	50
Topside	52	-	50
Chuck	68	-	56

Loin = *M. lonsissimus dorsi*, Rump = *M. gluteus medius*, Outside = *M. biceps femoris*, Topside = *M. semimembranosis*, Chuck = *M. serratus ventralis*.

The topside has an improved consumer score after roasting in the form of an easy carve led increasing from the low 50's to around 60 (Figure 3).

Figure 3. The relationship between cooking method and consumer score for grilled versus roasted outside and topside muscle groups. (Values are the mean of 18 animals. All carcasses received 'optimal processing' = electrical stimulation + 5 days).



Cut x animal age

The other striking feature from the data in Table 1 is the relatively high rating given to the hogget and mutton loin which ranks only some five to six points lower than the average lamb value. Indeed in controlled experiments where similar animals have been compared as older carryover lamb and as hoggets there is little difference between the two. The same cannot be said for the 'leg' cuts in older sheep. Except for the topside, the mutton 'leg' muscle groups eat some 10-12 points lower indicating a significant ($P < 0.05$) cut x animal age effect. Indeed the real value of the current lamb definition is that it assures eating quality of muscles across the carcass.

Animal age - lamb to mutton

In one experiment we examined animal age more closely. Merino ewes spanning carry over lamb (nine months old) to older mutton (five years) were sourced from a commercial farm and placed on a nutritionally balanced feedlot pellet for four weeks on farm. For the loin consumer scores did not decline until after 20 months of animal age (hogget). After this the loin scores significantly ($P < 0.05$) declined in a quadratic manner by 15, eight, seven and eight points for tenderness, juiciness, liking of flavour and overall liking respectively as animal age progressed to five year old mutton (Figure 4).

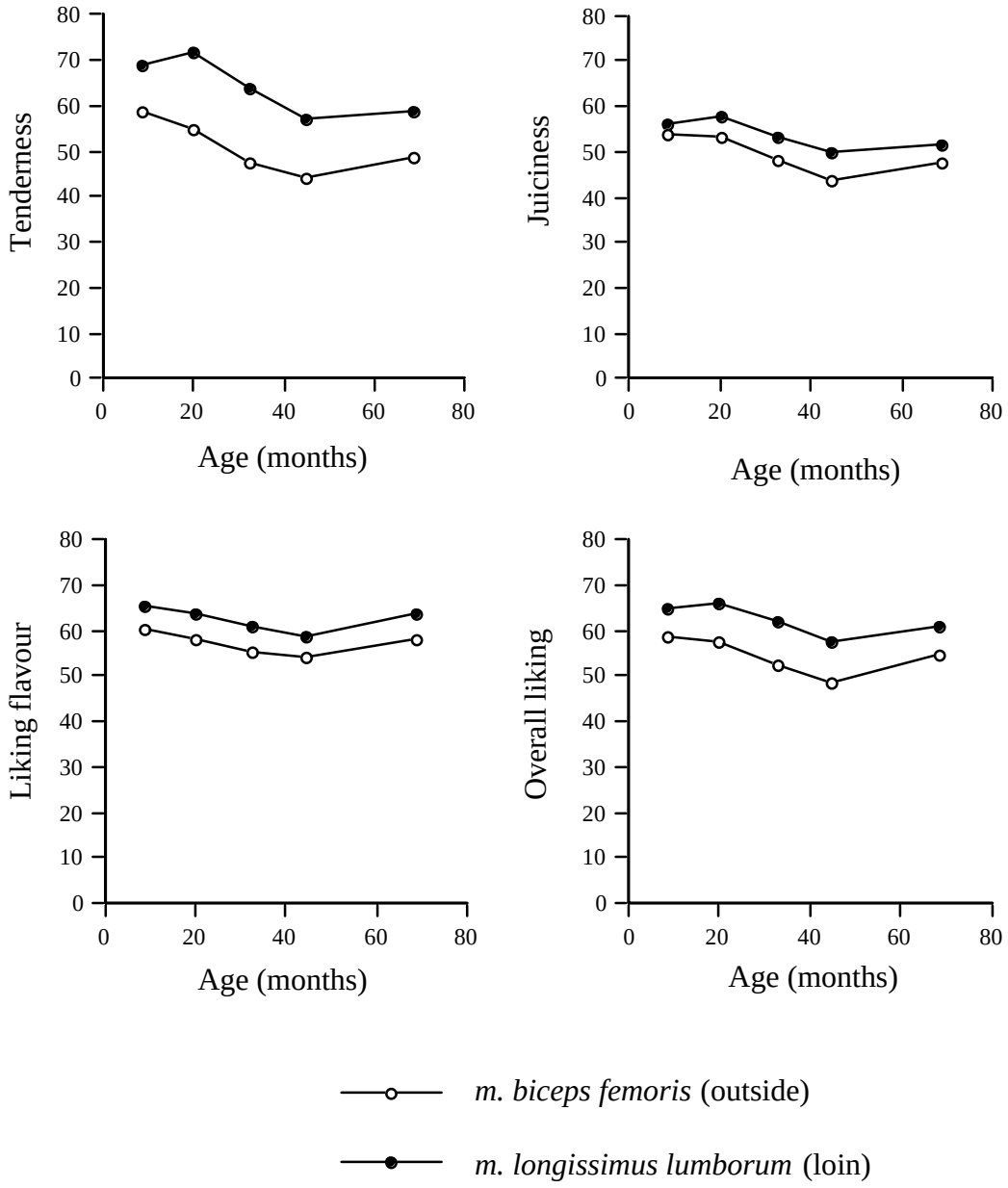


Figure 4. The relationship between animal age and consumer score for grilled loin and outside muscles. (Values are the mean of 18 animals and the average standard error of the mean was 2.1. All carcasses received 'optimal processing' = electrical stimulation + 5 days aging.)

The large effect of animal age on tenderness was expected since it matches the known biological mechanisms which reduce tenderness in older animals (due to changes in the properties of connective tissue). The remaining scores for juiciness, liking of flavour and overall liking declined to a smaller extend and this suggests that any negative aspect of sheep meat flavour associated with animal age must have been less than for tenderness in determining the final consumer rating of the meat. The mechanism behind the relatively smaller decline in the overall liking of mutton might in part reside in the increased levels of intramuscular fat found in the older ewes which peaked at about 9%. In support of this there

was the positive correlation between intramuscular fat, animal age and juiciness, liking of flavour and overall liking (r^2 = 0.08-0.11, P < 0.008) but not tenderness.

Teeth eruption

An experiment involving three very different commercial flocks (different breed mix, environment, pasture) has been conducted to evaluate the changes in the consumer score of meat derived from sheep over the teeth eruption period when young sheep change from lamb to hogget. The sheep were selected into three dentition classifications: milk teeth (i.e. normal lamb), partially erupted but new teeth close to the gum and fully erupted teeth but not in wear. This period of teeth eruption represented about six weeks in total. All carcasses were electrically stimulated and the product aged for eight days.

The consumer score for the loin derived from sheep over the teeth eruption phase did not vary (in fact there was a small but significant increase). This is not surprising given the above data and the narrow time frame of just six weeks between the milk and fully erupted dentition classes. Importantly fears relating to stress placed on the animals due to the teeth eruption would seem unfounded at least with respect to eating quality. The New Zealand definition of lamb takes advantage of this since the first two teeth can be erupted but not in wear; however there is an important extra constraint that lamb must not be greater than 12 months old.

Finishing system

Our work has shown that finishing system has little effect on eating quality providing sheep are gaining weight before slaughter and that they are finished to a fat score of two. Thus consumers could detect no difference between finishing on an actively growing clover/rye grass sword versus balanced grain (barely, wheat, lupin) based diets. Thus the finishing system should be set by cost of production or seasonal constraints and not bias regarding effects on flavour.

The need to finish sheep pre-slaughter is based on three different premises at least from an eating quality point of view.

(i) Guarantee intramuscular fat levels

Intramuscular fat is an important sensory component of meats affecting flavour and juiciness. The level of intramuscular in the loin of prime lambs finished to a fat score of 2/3 sits at around four to five per cent. This is relatively constant and is even unaffected if terminal sires selected for heavy muscling are used. Work in other species suggests that if the level of intramuscular fat falls below two per cent then the consumer will perceive the meat as dry and less flavoursome. Given this it would appear that prime lambs have adequate levels of intramuscular fat. The factors which affect this level in lambs are thought to be driven by carcass fatness and so long term nutrition is clearly important. However even a short period (two weeks) of severe under nutrition pre-slaughter can dramatically reduce the level of intramuscular fat in lambs.

(ii) To optimise the amount of muscle fibres

Muscle tissue is comprised of relatively soft muscle fibres which are surrounded by a matrix of stronger (tougher) connective tissue fibres which increase in toughness as animals age. Poorly nourished animals which are loosing weight will mobilise muscle fibres to nourish the rest of the body but the connective tissue fibres remain largely unchanged. Thus poorly finished mutton with a low condition score will likely be tougher since they will have relatively more connective tissue and less softer muscle fibres particularly in the 'leg' muscles. Combining this with lower than expected levels of intramuscular fat will reduce the potential eating quality score of the animal.

(iii) To optimise the level of muscle glycogen at slaughter

Glycogen within muscle in the living animal represents a store of sugar which is used particularly during exercise. After slaughter the glycogen is converted to lactic acid and assuming adequate levels of glycogen are available the pH of the meat will finally be reduced to around 5.5. Low pH meat has many associations with high quality including:

- a bright cherry red colour rather than dark;
- more consistent cooking characteristics;
- improved flavour;
- better keeping quality.

Thus it is imperative that there are adequate levels of muscle glycogen in sheep at the point of slaughter. The control of muscle glycogen level is best thought of in terms of a leaky bucket (Figure 5).

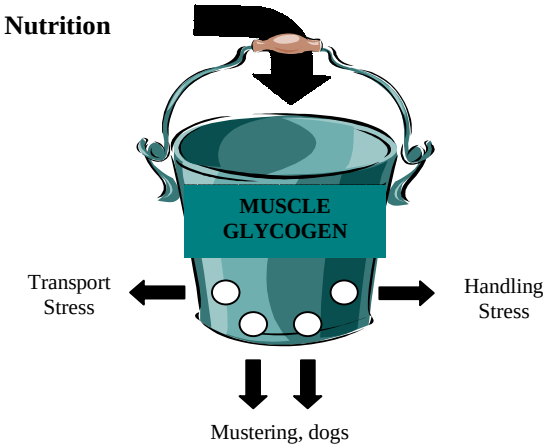


Figure 5. The muscle glycogen bucket.

The muscle glycogen bucket is filled up by good nutrition which means animals gaining weight at ≥ 50 gm/day. Unfortunately the bucket is leaky since stress can cause the loss of glycogen from muscle. Thus optimising glycogen at slaughter is a combination of good pre-slaughter nutrition and reducing stress in the immediate pre-slaughter period. This includes careful mustering and handling in the yards, high standard road transport and good lairage conditions. Our studies suggest the most important commercial factors affecting low glycogen levels pre-slaughter are: (i) pre-slaughter nutrition; and (ii) the increased susceptibility of merino lambs to lower levels of muscle glycogen. We are unclear on the causes for the 'Merino' effect but it is likely related to temperament. However good nutrition and careful handing can readily overcome the merino effect.

Processing

Modern processing requires high throughput and strong chilling of carcases in order to maximise both profitability and carcase hygiene. Indeed this rationale can also apply to the retail sector. Given the desire for strong chilling and minimal product aging it would appear that sheepmeat could be tough due to a combination of cold shortening and minimal time for proteolytic based tenderisation.

One approach to strong chilling and cold shortening is electrical stimulation which was developed by New Zealand many years ago to improve the quality of frozen lamb being shipped to the Northern Hemisphere.

The data for the effects of aging and electrical stimulation across the sheepmeat eating quality data based has been summarised into a processing model shown in Figure 6. There are significant effects of electrical stimulation and meat aging ($P < 0.02$) on consumer scores. Clearly the domestic market has two options for maximising the eating quality of the product offered and these are to electrically stimulate and age the product for three to five days before sale.

One clear positive is that extended product aging assures good eating quality product and shows that cold shortening was not an irreversible process at least under the extremes of chilling tested in this program.

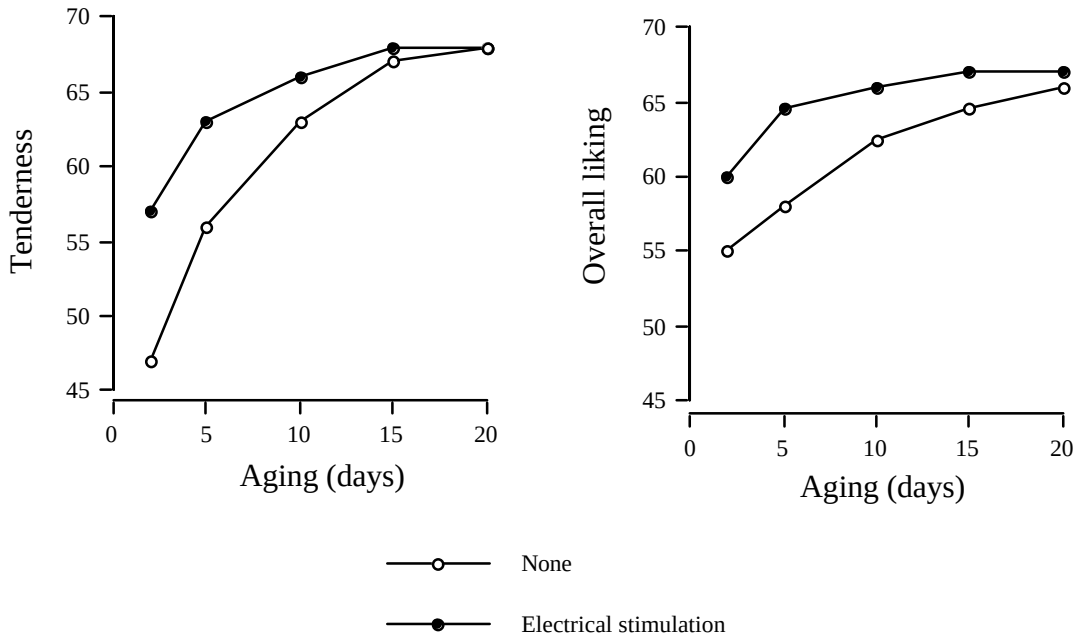


Figure 6. The effect of electrical stimulation and days of meat-ageing on the consumer score of the lamb loin.

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Paper reviewed by: James Skerritt, Department of Agriculture Western Australia

REFERENCES

Thus far the work has been reported as a series of final reports which are available from Meat and Livestock Australia, Walker St, Sydney, NSW.

The experiments will also be published as a special series in the Australian Journal of Experimental Agriculture which is due for publication in early 2004.