MEAT TECHNOLOGY UPDATE
Cutting-edge technology for the meat processing industry

Meat technology update

6/05 – December 2005

Processing factors affecting sheep meat quality

Careful selection of processing procedures can do much to optimise the retail acceptability and tenderness of lamb.

A survey of sheep meat from Australian retail outlets in the late 1990s indicated that there was considerable variation in tenderness. A key finding was that 20% of lamb samples purchased during the study were likely to have been unacceptably tough to consumers. Encouragingly, surveys indicated that 75% of consumers would purchase more lamb if they had access to tender and tasty product.

Consequently, Meat & Livestock Australia and the Sheepmeat Council of Australia initiated a series of research projects under the Sheep Meat Eating Quality (SMEQ) program. The projects covered sheep meat production from animal breeding through production, processing, retailing and cooking methods. A feature of the SMEQ program was that the meat acceptability was assessed by consumer taste panels, as the consumer was considered to be the ultimate arbiter of overall product eating quality.

Post-slaughter factors have a significant influence on the eating quality of sheep and lamb meat. This Meat Technology Update provides information for processors on how to optimise sheep meat eating quality and covers factors such as electrical stimulation (ES), hanging and cooling, and meat ageing. Some factors that influence retail display life are also discussed.

The application of best practice based on research results from the sheep meat eating quality program, including application of ES or tenderstretch, has resulted in improved tenderness of lamb purchased by the consumer (Figure 1). Far fewer tough samples are encountered meaning that consumers are less likely to have a poor eating experience.

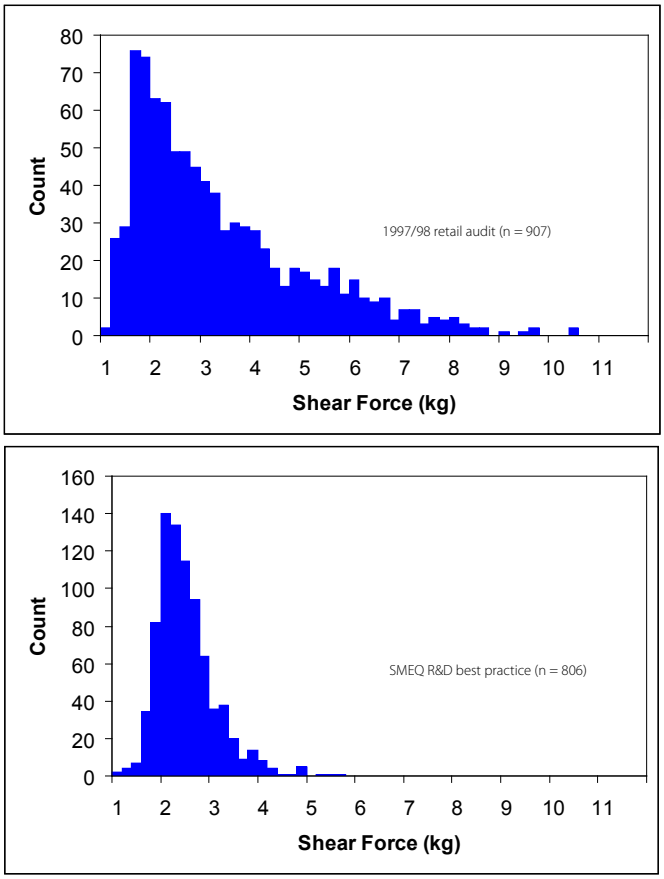

Figure 1: Improved lamb loin tenderness resulting from SMEQ R&D (After Pethick, 2005)

Electrical stimulation

Post-slaughter electrical stimulation (ES) of sheep and lambs has been available for many years, but its use has been limited because the recommended high voltage systems required expensive safety housing and barriers. The high voltage systems used an alternating wave form with peak voltages of 1100 volts at a pulse rate of 14 pulses per second. New waveforms have been developed which use short-duration pulses (at 14 per second) with a peak voltage of about 300 V (Figure 2). The effective voltage (RMS) is considered safe and no special protection is required.

ES results in a rapid fall in muscle pH and allows carcases to be rapidly cooled without inducing toughening due to cold shortening; however, carcases can be over-stimulated and enter rigor too early resulting in toughening due to heat shortening, increased drip loss and pale meat colour. The new technology systems will allow the amount of stimulation to be tailored to the application.

Mid-voltage ES (i.e. approx. 36 V RMS) can be applied to dressed carcases at the end of the slaughter line (Figure 3). The

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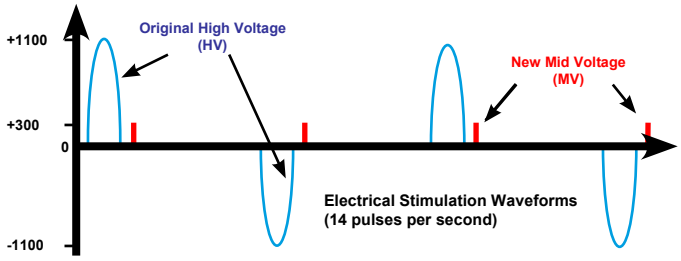

Figure 2: Electrical stimulation waveforms

application electrode can be divided into individual sections to enable control of the stimulation dose to individual carcases and it is relatively safe, so it is easier and cheaper to install. New systems are also available for application to pelt-on carcases at the beginning of the process chain.

Hanging and cooling

Carcases may be hung by either the traditional Achilles tendon method or suspended by a hook placed under the pubic symphysis - tenderstretched. In the tenderstretch method many of the valuable muscles of the loin and hindquarter are restrained and prevented from contracting due to cold shortening during chilling. After rigor mortis, the carcases can be hung again by the Achilles tendons.

The effect of tenderstretching on sensory scores of three different muscles (Table 1) showed that tenderness and overall liking scores were increased for the *longissimus* (loin muscles) and *biceps femoris* (major leg/silverside muscle), but there was little effect on the *serratus ventralis* (brisket).

Table 1: Effect of Tenderstretch on mean sensory scores

Muscle	Tenderness	Overall Liking*
longissimus		
Normally hung	60.0	59.4
Tenderstretch	65.2	62.7
biceps femoris		
Normally hung	52.5	55.8
Tenderstretch	57.0	58.2
serratus ventralis		
Normally hung	59.4	55.8
Tenderstretch	59.1	58.2

* Overall liking included juiciness and flavour as well as tenderness

Figure 3: Mid voltage stimulation of the dressed carcase

The relationship between meat temperature at pH 6 (temp@pH6) and overall liking for tenderstretch and normally hung carcases is shown in Figure 4. In normally hung carcases the highest scores occurred at a temp@pH6 of about 21°C. In contrast, scores for the tenderstretched carcases were relatively insensitive to a wide range of cooling conditions.

At low temp@pH6 (<10°C), muscles from the normally hung carcases would presumably have 'cold-shortened' and the meat was therefore tougher. If the temp@pH6 was high (>30°C), then the normally hung carcases would presumably have 'heat-shortened'. High temp@pH6 results in exhaustion of protease activity which reduces the tenderising effect of ageing and in some cases toughens the meat.

If processing conditions are managed such that extremes in temperature at pH 6 are avoided (temp@pH6 between 10°C and 30°C), the benefit of tenderstretching is small. However tenderstretching provides a measure of insurance for eating quality of loin and leg muscles.

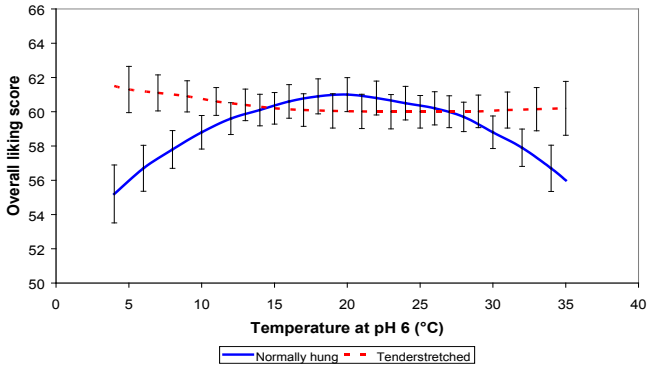

Figure 4: Relationship between overall liking and temperature at pH 6

Meat ageing

Holding meat for an extended period in a chilled state is known as ageing. Ageing is the sum of a number of biochemical reactions, principally proteolysis, which can continue at chilled temperatures. It is particularly affected by two easily monitored inputs—temperature and time.

In one SMEQ trial, ageing at 1°C for 5 or 14 days (Table 2) resulted in an improvement in tenderness when compared with holding for only 2 days. The major improvement occurred between 2 and 5 days, with little subsequent improvement up to 14 days.

Table 2: Effect of ageing on mean sensory scores

	Tenderness	Overall Liking*
longissimus		
2 days	58.1	58.5
5 days	66.4	62.6
14 days	65.9	62.0
biceps femoris		
2 days	52.8	55.8
5 days	57.3	59.0
14 days	54.2	56.2
serratus ventralis		
2 days	57.1	60.8
5 days	58.9	60.5
14 days	61.7	59.9

* Overall liking included juiciness and flavour as well as tenderness

The temperature at which lamb is aged will depend on the particular market. The time-temperature profile suited to export markets involves rapid carcase chilling, vacuum packaging, and maintenance of a chilled storage temperature as cold as possible (as low as -1.5°C) through to the point of preparation for retail sale. Although ageing may be slowed by the low temperature, good microbiological quality will be maintained and the time—normally several weeks—will be ample for ageing.

In the domestic market, where lamb may be sold within a few days of slaughter, carcase chilling may be slower and the storage temperature can be higher, say 0–2°C. This contributes to faster ageing to achieve optimum meat quality in as little as 3 to 4 days for tenderstretched or ES, Achilles-hung product.

Retail display life

The colour and colour stability of packaged fresh lamb are important qualities contributing to retail acceptability. Fresh meat is perceived to be red, preferably bright red, and certainly not brown due to the surface formation of metmyoglobin. Meat tends to brown more as storage time and storage temperature increase.

Lamb in the Australian market may be distributed to retail outlets as hanging carcases, or as primals or carcase parts that are:

- naked (unwrapped);
- wrapped in stretch film or permeable bags;
- packed in vacuum packs;
- packed in modified atmosphere packs (MAP) in a gas atmosphere that is solely or predominantly CO_2, or
- packed as retail cuts in high-oxygen MAP packs.

For export, primals and carcase parts are vacuum-packaged. Whole carcases or primals may also be packaged in high-CO_2 MAP.

When the product is handled as carcases or carcase parts, it is processed at the retail outlet into retail cuts. In most supermarkets it is then presented on plastic or expanded polystyrene (EPS) trays and over-wrapped with clear PVC film, which has a high oxygen permeability. A shortcoming of this approach is that retail display life may be short—limited to as little as one day if it has been stored for some time in vacuum or MAP packs prior to being prepared for retail sale.

The alternative to preparation of retail cuts in stores is centralised packaging of retail cuts in modified atmospheres that restrict microbiological growth and prolong retail display life by maintaining the attractive red colour. The modified atmosphere gas mixtures most frequently used for retail display of fresh meat contain 70–80% oxygen and 20–30% CO_2. High oxygen levels maintain the bright red oxymyoglobin bloom while the CO_2 slows microbiological growth. For the benefit of this atmosphere to be maximised, the packs have to be big enough. The ratio of gas volume to meat volume has to be at least 1:1; although 1.5:1 is better. The storage life of lamb in high-O_2 MAP is, however, limited to around 10 days at 0–1°C.

In one of the SMEQ experiments, lamb loin chops and leg steaks were prepared from primal cuts that had been aged for 7, 21 or 35 days and then either packed in high-O_2 atmospheres or overwrapped on EPS trays. They were assessed at the mid point (day 3 and 5 for overwrapped and MAP respectively) and end point (day 5 and 9 for overwrapped and MAP respectively) of their expected display life.

At the time of slaughter, the carcases were stimulated with either of two different wave forms, or unstimulated. It was found that electrical stimulation did not influence meat colour of bone-in loin chops or boneless leg steaks when assessed at the initial, mid and end of product display life.

The retail acceptability of lamb cuts displayed in MAP packs was superior to that of cuts packaged on overwrapped trays (Figure 5). It was also clear that after 3 and 5 days display, leg steaks (*quadriceps femoris*) were inferior to the loin chops regardless of the packaging method. The acceptability of both loin chops and leg steaks was limited by browning due to metmyoglobin formation.

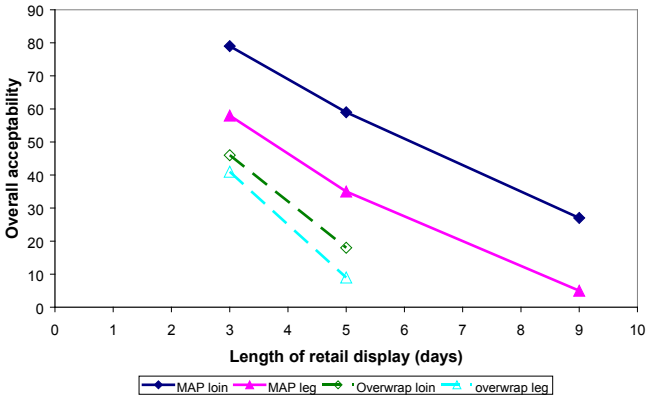

Figure 5: Effect of packaging method on retail display life

The ageing period as primal cuts also affected the acceptability at the nominated mid-point of display life. The acceptability of the over-wrapped retail cuts from lamb primals aged for 21 days was superior to that of cuts from primals aged for 35 days (Figure 6). On this basis it appears that for optimum results, lamb primals can be aged for 21 days in vacuum bags at 0°C before preparation into retail cuts. The trial results support previous findings that when lamb is stored in vacuum packs for six weeks or longer, the subsequent retail display life will be reduced. This has clear implications for lamb that is exported.

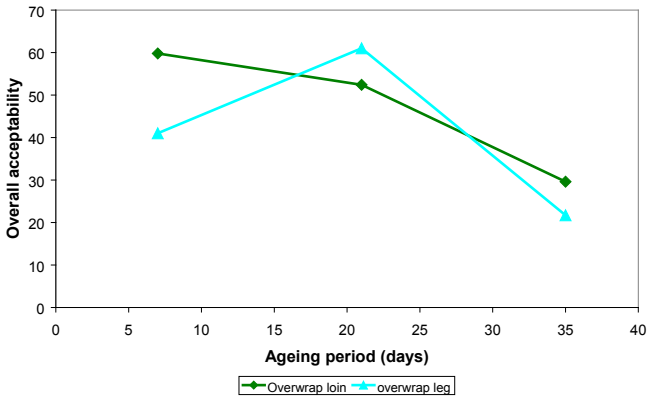

Figure 6: Effect of ageing period on acceptability at the midpoint of display life

To achieve the multiple benefits of centralised packaging of retail cuts—a storage life longer than two weeks and good retail display life—it is necessary to go to systems where the retail packs can be held in a high-CO_2 environment until needed for retail display. The oxygen-impermeable film is then removed, allowing oxygen to reach the meat surface so the meat blooms. Examples are the peelable vacuum skin pack and the 'mother' pack.

Table 3: Key outcomes from SMEQ trials

Processing Factor	Impact on Eating Quality
Electrical stimulation	• Electrical stimulation, applied correctly, will ensure sheep meat enters rigor at the correct temperature. • New generation mid-voltage electrical stimulation applied via a rubbing rail to skin-off carcases is recommended. • When correctly applied, electrical stimulation has no effect on display-life colour. • Where lamb is aged for longer than about 3 days, electrical stimulation may not be required where carcases enter rigor between 8 and 30°C.
Carcase chilling	• Rapid chilling can increase toughness. • For optimal acceptability, conventionally hung carcases should enter rigor (pH 6) at between 13 and 27°C. • The temperature at rigor has little effect on eating quality of tenderstretched carcases.
Hanging method	• Tenderstretch is particularly beneficial to the eating quality of loin and hindquarter cuts. • Tenderstretch is an alternative to electrical stimulation for achieving good eating quality.
Ageing	• Ageing takes place progressively and occurs more rapidly at higher temperatures. • Ageing at low temperatures (-1.5°C) is suited to the chilled export trade. • Ageing at a temperature of 1–2°C for 5 days will achieve optimum eating quality for the domestic market.
Retail packaging	• MAP packs have a longer retail display life than PVC overwrap packs. • Ageing in vacuum packs for periods longer than 21 days can reduce subsequent display life for both MAP and overwrap packs. • The display life of some cuts, such as the leg, may be shorter than cuts from the loin.

Further reading

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Contact us for additional information

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