MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

Meat technology update

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Sheep meat eating quality

Almost all consumers who buy sheep meat expect it to be tender and flavoursome. Toughness is caused by four major factors—advancing age of the animal, 'cold shortening' (the muscle fibre contraction that can occur during chilling), animal stress [unfavourable meat acidity (pH)], and the cut (i.e. connective tissue content/structure). Meat quality can be improved by careful selection of pastures, correct pre-slaughter handling and carcase processing.

Does breed influence quality?

The practical answer is 'no' because any difference is slight. More important are the other factors mentioned above. Meat from suitable animals of all breed can be acceptably tender if processed correctly.

There is some evidence that Merinos may be more susceptible to dark cutting – this will increase the risk of toughness at intermediate elevations of pH.

'Callipyge-like' genes may result in increased toughness.

Animal age

Age-related toughness depends upon the amount and strength of connective tissue in muscles in the various cuts. Within the one carcase, there will be differences in tenderness, with some leg muscles (e.g. the *semimembranosus* and *semitendinosus* muscles) frequently being tougher than the loin muscle (the *longissimus dorsi*). In general, forequarter cuts from a carcase are tougher than hindquarter cuts because they contain more connective tissue.

In the absence of other influences, the younger the animal (even within the category of lamb), the more tender the muscle will be. As an animal gets older, the connective tissues become more resistant to breakdown during cooking. This manifests itself as toughness. Because toughening due to connective tissue increases progressively with age, it is important to recognise the age at which the level of this inherent toughness is likely to be considered undesirable.

However, it is still not clear just when the 'age' effect on toughness becomes significant for consumers, especially when other factors are controlled (particularly cold shortening, pH). The impact on eating quality of lambs cutting their teeth is poorly understood and the subject of current research.

Connective tissue toughness can be minimised by an appropriate cooking method, e.g. slow, moist cooking rather than grilling.

Generally speaking, eating quality declines with age; however, the rate

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varies between muscles. Flavour becomes stronger.

Growth pattern and nutrition

In a 1995 study, meat tenderness was comparable (and acceptable) for all growth paths studied except for that in which lambs were held at slaughter weights for approximately five weeks prior to slaughter.

Recent studies have indicated that, with some sires, there are relationships between growth rate and tenderness. As growth rate increases, there is an increase in tenderness. NZ work suggested slow growth lambs were tougher than high-growth lambs (killed at the same final carcase weight) but this was almost entirely as a result of an elevated pH effect. Feed intake immediately before slaughter may also affect tenderness. Studies with beef suggest that continuous feeding almost until the time of slaughter may improve meat quality.

High growth rate means that animals can be slaughtered at optimum carcase weight(s) at younger ages─the younger the age, the more tender the muscles with a high connective tissue content will be.

There is little objective information on the impact of grain feeding on eating quality.

Flavour

Some people avoid sheep meat because they object to its odour during cooking and to its flavour, particularly the meat from mature animals with its apparently stronger odour and flavour. This effect will vary with country and within country, depending on traditions and prior exposure. Both trained taste panels and consumer panels can detect an increase in flavour with increasing animal age (lambs→hogget→mutton).

Taste panels can also detect flavour differences arising from lambs being fed on different pastures or supplements. Feeds that have been shown, on occasions, to produce less acceptable flavours include lucerne, forage rape and an oat-lupin grain ration. It is not clear whether these less desirable flavours would always be detected by consumer panels.

In a 1993 New Zealand lamb study, the sensory properties of meat of two breeds common in New Zealand—the Coopworth and the Merino (a fine wool breed)—were studied. Although the work showed breed effects, it is argued that pH rather than breed might be the dominant effect on flavour and odour characteristics. The higher-pH meat of the Merino breed (pH 6.2) in this trial gave negative sheep meat flavour and foreign flavour descriptors (bland, fishy, stale, grainy, bloody) and this is consistent with other reports in the literature on high-pH meat.

Other NZ work has shown several compounds associated with flavour and, as we progress our knowledge, the possibility of specific feeding and/or lairage protocols to influence flavour becomes more likely.

A Canadian lamb study revealed that ram and ewe lambs had a superior flavour to wether lambs. There are, however, numerous other reports that indicate ewes and wethers, and rams and wethers, are similar in flavour.

Animal Stress

A significant factor affecting meat tenderness is meat acidity (pH). Toughness increases as the ultimate pH (i.e. the pH value reached after post-mortem chemical reactions in the meat have ceased) increases from 5.4 to 6.0, then decreases with further increase in ultimate pH. In beef, it is generally acknowledged that the cut-off point for optimum acceptability is maximum pH 5.7. The figure for lamb is similar.

Any stimulus which causes use of muscle energy (glycogen) whilst the animal is still alive, e.g. transport and other stress, method of marketing, time off feed, lairage management, extremes in weather conditions, disease and muscular activity, can cause animals to produce high pH (and therefore potentially tough) meat. Also, the size of the glycogen level or ‘tank’ on-farm is important—good nutrition pre-slaughter

helps assure the glycogen ‘tank’ is full on-farm and means the animals can better cope with the stresses of consignment.

Studies on pre-slaughter supplementation to boost glycogen levels are under way

Chilling treatment

A major cause of meat toughness is the contraction of muscles during chilling. If a muscle is chilled rapidly before the onset of rigor mortis (‘setting’), the muscle fibres contract (cold shorten).

Rapid chilling of pre-rigor carcases results in cold shortening if unrestrained muscles are cooled below 10°C before the on-set of rigor. More emphasis is now placed on achieving lower meat temperatures at load-out and this can result in loin temperatures being reduced to below 10°C within three hours of slaughter, which can cause tough meat, due to shortening, if corrective measures are not implemented. Muscles already in rigor, however, will not shorten, regardless of the temperature at which they are held.

Ageing

Holding meat in a chilled state for an extended period is known as ‘ageing’ and is a traditional way of tenderising meat.

Ageing, unlike the Tenderstretch process and electrical stimulation, achieves the tenderising role through the attack of natural enzymes on muscle fibres. Unfortunately, ageing is not effective in overcoming toughness arising from connective tissue, so meat from old animals and cuts containing a high proportion of connective tissue do not respond well to ageing. It is also important to realise that ageing is less effective where severe cold shortening of muscle has occurred. Cold-shortened meat may need a longer ageing period than unshortened meat.

Ageing of ‘tenderstretched’ or electrically stimulated meat produces a further slight improvement in tenderness (Figure 1).

In a study in Victoria, chilled non-stimulated lamb samples obtained from butchers, wholesalers and boning rooms between 1991 and 1993 were found to be of good, although variable, quality. It was reported that ageing lamb in commercial chillers for three or more days prior to retail sale could significantly improve tenderness. A similar result was obtained in another study for lamb loins purchased from shops in Sydney and Melbourne. It was calculated (based on modelling) that 27 per cent of one-day-old samples would be tough, while only 6 per cent of three-day-old samples would be tough. Thus both surveys indicated that an ageing period of at least three days was necessary to ensure adequate tenderness in unstimulated lamb.

However, there is evidence that a considerable amount of lamb reaches the consumer less than three days after slaughter. This is not surprising, as there are economic incentives for both processors and retailers to minimise storage times. Consumers are therefore quite likely to purchase unstimulated lamb that has been inadequately aged.

In summary, lamb, unless severely cold shortened, ages rapidly. Ageing meat for a period of 3—5 days generally increases tenderness. Longer term ageing (to 14 days) has little further effect on tenderness. However there is a need for further work to redefine ageing profiles.

Electrical Stimulation

It has been accepted for many years that electrical stimulation of beef carcases prevents cold shortening and leads to an improvement in tenderness, and many Australian abattoirs processing beef carcases routinely use electrical stimulation (ES). Similarly, many New Zealand plants routinely use ES on sheep and lamb carcases. There are, however, very few Australian abattoirs that use ES on lamb carcases.

During ES a pulsed electric current is passed through each carcase soon after slaughter. It greatly increases the rate of the natural processes leading to rigor mortis. This, in turn, substantially reduces the ability of the

muscle to shorten (and hence toughen) when cooled rapidly.

One of the objectives of a 1997 MRC project was to develop a lower-cost ES unit for treatment of lamb carcases (see Further Reading). Extra low voltage (ELV) ES applied to individual, dressed carcases via rubbing bars in commercial works resulted in a statistically significant improvement in tenderness, even when applied up to 25 minutes after slaughter. MRC trials also indicated that the application of ES to the carcases would reduce the overall quantity of tough product. As seen in Figure 1, high-voltage electrical stimulation of lamb carcases reduced the WB shear force by 50%. Some muscles of lamb that had been electrically stimulated (high voltage) were twice as tender as those that had not been stimulated at all. This single management change transformed lamb that was likely to have been unacceptably tough into an acceptable, tender product.

Tenderstretch has similar effects in hindquarter and loin primals. Neither ES nor Tenderstretch has much effect on the tenderness of muscles restrained from shortening by their carcase attachments.

Electrical stimulation of lamb may improve meat colour (especially in the short term) as well as tenderness.

The tenderness of muscles from non-stimulated lamb carcases may be quite variable. In some cases the muscles may be so tender that ES causes little improvement in tenderness. In other cases, the muscles may be so tough that, even though ES has a marked effect, the muscles from the stimulated carcases are not particularly tender. Therefore the use of ES on its own, without regard to animal variability and other processing factors, cannot be relied upon to produce product of superior tenderness consistently.

Hot-boned lamb, whether subsequently stored chilled or frozen, is likely to be tough unless the carcases receive electrical stimulation.

Frozen lamb

Lamb and mutton frozen soon after slaughter can be very tough as a consequence of cold shortening. As indicated above, toughness in such frozen carcases can be avoided if the carcases are chilled sufficiently and then aged at chiller temperature (before freezing), or by the use of electrical stimulation.

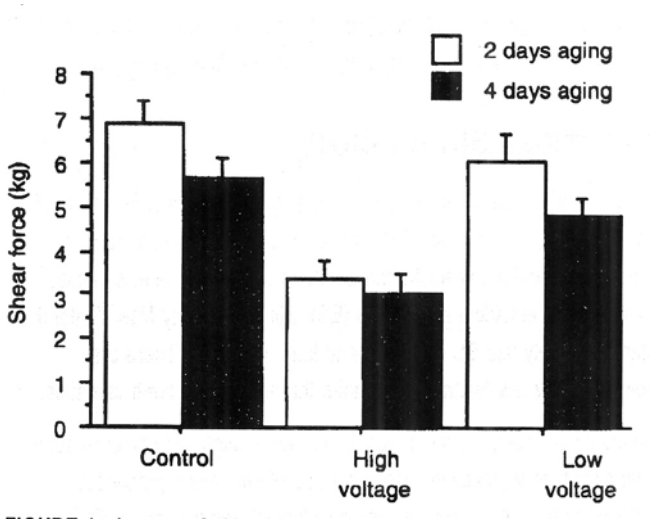

FIGURE 1 Impact of electrical stimulation and days ageing on Warner-Bratzler shear force (tenderness)

Tenderstretch

In this method, many of the valuable muscles of a carcase (i.e. the hindquarter and loin primals) are restrained and prevented from cold shortening during the rigor process by changing the suspension point of the hot carcase from the achilles tendon to the pelvic girdle. This process leads to a tenderness improvement in these cuts.

The carcases must be left hanging, suspended by the pelvic girdle, until rigor mortis is established. After this period the carcase can be hung again by the achilles tendon.

What is the eating quality of Australian lamb?

Recently, Meat & Livestock Australia Ltd (MLA) commissioned a survey to examine variation in the tenderness of lamb. Lamb was purchased randomly from retail butchers and supermarkets in four cities and also from

two branded lamb alliances. Lamb mid-loins were objectively measured for tenderness. There was a significant variation between capital cities in the tenderness of lamb available for sale. Lamb purchased in Perth and Melbourne was tougher than that purchased in Canberra and Sydney (Figure 2). Tenderness comparison between two branded lamb alliances also revealed significant variation.

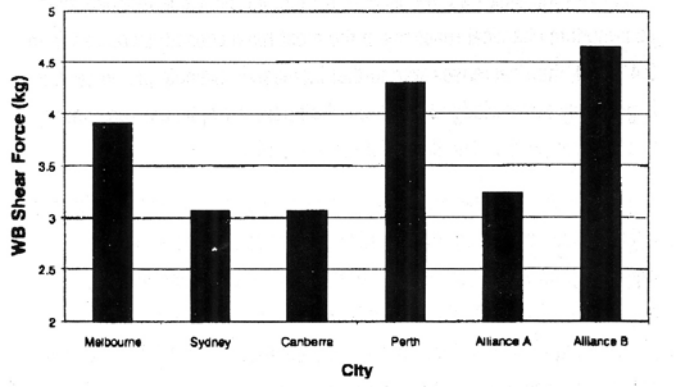

FIGURE 2: Difference between cities in lamb tenderness

Twenty per cent of lamb purchased in the study had WB shear force value of greater than 5 kg—a nominal and somewhat arbitrary estimate of the cut-off level for consumer acceptability. However, four in five samples in the study were likely to have been of acceptable tenderness.

Please note that WB shear force measurements are only an estimate of eating quality and it is now generally agreed that they need to be backed up by actual consumer studies. Warner-Bratzler shear devices measure tenderness, which is only one of the factors that a consumer considers when deciding the overall acceptability of lamb. Flavour and juiciness, neither of which is directly measured by the Warner-Bratzler, are attributes that may be important in the consumer's assessment of lamb.

The major aim of a trial carried out by Meat & Livestock Australia (MLA) in 1999 was to define the basis of consumer perception of lamb and sheep meat quality. MLA is carrying out another consumer attitudinal survey and this will be ready later this year.

The Future

MLA has a lamb and sheep meat eating quality research program underway. Key issues for further research will be determined following extensive consultation with industry.

The possible research scenarios include breed, age, fatness and finishing systems. Processing factors for investigation could include chilling regime, electrical stimulation (including extra-low voltage), hanging method and pre-slaughter stress with emphasis on optimal lairage protocols (in relation to previous on-farm nutrition). The main wholesale/retail factors considered to be of importance are the age of the meat and the cut. The consumer factor considered would be the cooking method.

The aim is to produce a simple consumer-driven model that will allow us to predict the eating quality of sheep meats. The model will be developed with close industry consultation, with final decisions on methods of adoption in the hands of industry.

Further Reading

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