Meat technology update

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Pre-slaughter aspects of beef eating quality

MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

FOOD SCIENCE AUSTRALIA
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Losses of both product quality and quantity during the critical pre-slaughter period are inevitable. These losses are the result of social, physical, environmental and nutritional stresses imposed on the animal between the farm/feedlot and the abattoir knocking box. In the interests of animal welfare and beef quality, it is essential that effective management strategies be implemented to minimise adverse pre-slaughter effects.

Weight Loss

The combination of fasting plus the associated stress during the pre-slaughter phase results in losses in both live and carcase weight. Animals deprived of both feed and water will lose approximately 0.75% per day in initial liveweight. This will vary, depending on the prevailing conditions (e.g. duration of fast, transport conditions etc.) and the condition of the animal. Furthermore, weight loss is not linear with time with the majority of it occurring within the initial 24 hours post-farmgate. The associated losses will be lower when water is made available. In fact, a 48-hour fast with access to water may have only negligible effects on carcase weight loss.

Therefore, it is essential that adequate water be provided to cattle in lairage. However, it is worth noting that not all animals will drink during this period.

Dark Beef

The most serious consequence of severe pre-slaughter stress is the condition known as ‘dark cutting’. Dark cutting or *dark firm and dry* (DFD) beef occurs when the pre-slaughter muscle glycogen levels fall below a critical threshold. In well fed, non-stressed cattle and sheep, normal resting glycogen concentrations range between 1% and 2% of muscle weight. In simple terms, glycogen is the reserve energy tank in muscle. It is utilised during stressful events or when the muscle’s energy demands cannot be met during normal aerobic metabolism (i.e. presence of oxygen). After exsanguination (bleeding), glycogen is utilised as the primary fuel source and the by-product of its metabolism is lactic acid. Consequently, the muscle pH typically falls from around 7.1 (prior to death) to 5.5–5.6 at rigor. When the pre-slaughter glycogen levels fall below 1%, there is less energy to utilise; therefore less lactic acid is produced and the ultimate pH is higher.

Beef classed as dark cutting has the following characteristics:

- Higher ultimate pH (typically $\geq$5.9)

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- Darker ‘bloom’ colour, therefore less appealing to consumers
- Higher water-holding capacity
- Reduced shelf life since bacteria grow more readily owing to the higher pH and available moisture
- Reduced tenderness (pH 5.9–6.2). Tenderness can, however, improve above pH 6.2 although it is unlikely it will offset the other disadvantages.

It is also worth noting that dark-coloured meat may not always be related to inadequate pre-slaughter glycogen levels. For example, beef darkens in colour with increasing animal age. Meat from bulls typically has a higher myoglobin (muscle pigment) content than that from steers, heifers or cows at the same age. Another factor is the rate of pH fall and chilling conditions. Where rapid chilling conditions are applied and no electrical stimulation is utilised, the rate of pH decline can be quite slow. As a result, at 24 hours after slaughter, the ultimate pH has not been attained; therefore it is incorrectly assessed as dark cutting. Effective electrical stimulation will overcome this effect by accelerating the rate of pH decline.

Ultimate pH

Under Meat Standards Australia (MSA), there is a requirement that the ultimate pH of the *longissimus dorsi* at the quartering point is $\leq$5.7. This threshold was established based on consumer data and in the interests of minimising the risk of an unsatisfactory eating experience. The relationship between pH and tenderness tends to be curvilinear peaking around 5.9–6.2 (most tough). Whilst the threshold of 5.7 could be challenged for its stringency, it must be kept in mind that the principal goal of MSA is to provide the consumer with a guarantee of eating quality.

It should also be remembered that there are differences in ultimate pH between muscle, which tends to reflect inherent differences in the fibre type and function. A good example here is the *semimembranosus* (topside) which has a slightly lower ultimate pH compared to striploin.

It is also important to note that meat colour gradually darkens with increasing ultimate pH right through the range 5.4 to 7.0. This means that some consumers may regard beef with an ultimate pH of 5.8 as dark, although it would not be classified technically as dark cutting.

How to minimise the incidence of dark beef

Factors such as stress, method of marketing, time off feed, lairage management, extremes in weather conditions, disease and strenuous muscular activity will result in some utilisation of glycogen prior to slaughter. Healthy, well-fed cattle can afford to lose some glycogen (20–30%) without affecting their ultimate pH. However, the primary aim is to reduce these losses because it is not possible at present to practically determine the pre-slaughter glycogen levels in slaughter cattle. Therefore, the approach is based on implementing simple, yet effective management strategies to reduce glycogen losses during the pre-slaughter period. Some examples of these include:

- Utilise skilled and experienced stock handlers and transporters
- Educate cattle to handling and transport
- Select cattle with calm temperaments (i.e. less susceptible to stress)
- Do not mix unfamiliar groups of cattle in lairage
- Utilise direct consignment selling of cattle
- Provide lairage pens with suitable space and water
- Rest cattle on arrival (min. of 4–6 hours)
- Provide nutritional supplements in lairage when required, especially after excessive periods of time off feed.

- Provide supplementation on-farm prior to slaughter during periods when pasture quality is low
- Minimise the use of electric goads during movement of cattle
- Avoid selling if extreme changes in the weather are forecast.

Another factor to be cognisant of is the sex of the animal. Bulls and mature cows have been shown to be quite problematic. Of more relevance is the data, although not conclusive, that suggests that heifers may be more predisposed to dark cutting than steers. This is thought to be associated with the increased physical exertion due to mounting or 'bulling' which occurs when one or more heifers are in oestrus. Generally, within groups of heifers, 5% would be expected to be in oestrus on any given day. Transport stress increases the prevalence of oestrus and the percentage may be as high as 12%. As a practice, it is recommended that those heifers that are clearly showing signs of oestrus should be removed from slaughter mobs.

Time in lairage

It is generally recommended that cattle should be allowed to rest for a short period prior to slaughter. A minimum of 4–6 hours is recommended but once again this will depend on the background of the animals, notably the transport history, time off feed and condition of the stock. A longer period of rest (24–48 hours) is more desirable for cattle that have travelled extensive distances (>1000 km).

Another factor to consider here is that for cattle to be eligible for MSA grading, there is a requirement that they be slaughtered within 24 hours of leaving the property.

Slaughtering cattle directly off the truck is practised in North America. Cattle are typically well conditioned and do not travel large distances. The results to date indicate that this practice may lower weight losses and improve eating quality.

Electrolytes

Water-soluble and feed-based supplements containing a mixture of sugars and electrolytes have also been investigated as a means for reducing the stress experienced during the pre-slaughter phase. They can be provided on-farm prior to trucking or in lairage. In Australia, two commercial products**,** Glucotrans (Pfizer, Animal Health) and Nutricharge (STS Agriventures Ltd)**,** have been tested as part of a joint Western Australian and Victorian study. The results were encouraging but somewhat inconclusive. In contrast, Canadian investigators have shown that the strategic administration of electrolyte preparation not only reduced the incidence of dark cutting but also minimised the carcase shrink during chilling.

Nutritional supplementation in lairage

As ruminants, cattle and sheep rely on bacteria in the rumen to convert carbohydrates into glucose. Consequently, unlike monogastrics (e.g. humans and pigs), it takes considerably longer to replenish lost glycogen reserves in muscle. The glycogen replenishment rates in muscle in cattle that have been exposed to a stressful event followed by nutritional supplementation (typically grain-based ration) is approximately 0.2–0.3% per day. As a comparison, the rates of recovery in man are some 5–10 times faster. It is also important to note that the rate of recovery will depend on factors such as the energy status of the feed, the level of depletion (i.e. the lower the glycogen level, the faster the repletion rate) and the type of muscle.

From these results, some conclusions can be drawn about the effect of feeding in lairage when animals' pre-slaughter glycogen levels fall below that required to achieve a normal ultimate pH. In general, it would take at least 36 hours for lotfed cattle supplemented with grain and at least 72 hours for pasture-fed cattle supplemented with pasture hay to replenish their glycogen reserves sufficiently to avoid dark cutting.

The decision to feed in lairage is not simple. Firstly, there is the obvious difficulty of knowing when slaughter mobs have been unduly stressed on arrival at the abattoir. Secondly, most abattoir lairage facilities were not designed with feeding in mind. Notwithstanding these constraints, there may also be other benefits associated with feeding in lairage in addition to avoiding dark cutting and minimising weight loss (see below).

Can eating quality be enhanced via alternative pre-slaughter management strategies?

Recent research by The Cooperative Research Centre for the Cattle and Beef Industry (CRC) has demonstrated that there may be additional advantages in feeding cattle in lairage other than to avoid dark cutting. In one joint study (CRC, MSA and Stanbroke Pastoral Company), feedlot cattle were trucked to the abattoir 4 days prior to slaughter and allocated to one of three feeding treatments:

Group1	Fed a grain ration for 4 days
Group 2	Fed a grain ration for 3 days and fasted for 1 day
Group 3	Fed a grain ration for 2 days and fasted for 2 days

A fourth group, representing current practice, was trucked the day before slaughter and fasted overnight. The results revealed that consumers rated the steaks from cattle that were fed either 4 days or 3 days in lairage significantly better than the other two groups. Interestingly, the difference was associated more with flavour and juiciness rather than tenderness (see Figure 1).

The research is on-going and the results will be reported in a subsequent newsletter.

Prevention rather than cure

The stresses that apply between farmgate and knocking box result in inevitable losses in weight and beef quality. Effective pre-slaughter management of cattle aims at minimising or better still, preventing the losses. Further improvements in our ability to prevent these losses will arise from the increased research focus on the pre-slaughter domain.

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- The Cooperative Research Centre for the Cattle and Beef Industry (Meat Quality)
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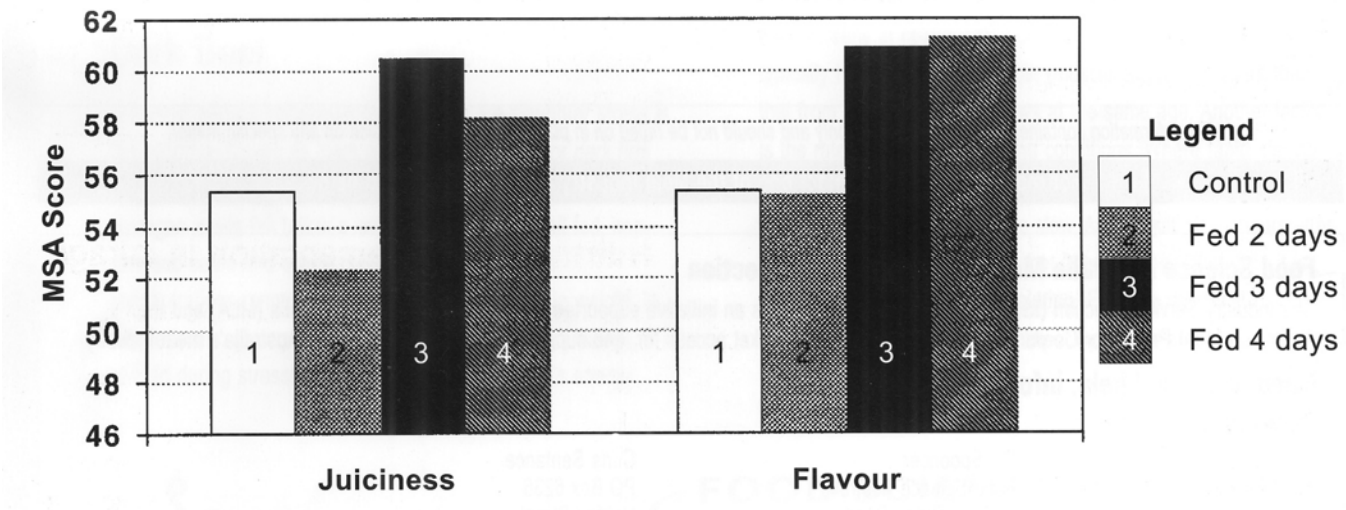
FIGURE 1 Effect of lairage feeding on MSA juiciness and flavour scores



Further Reading

Pethick, D.W., Cummins, L., Gardner, G.E., Knee, B.W., McDowell, M., McIntyre, B.L., Tudor, G., Walker, P.J. and Warner, R.D. (1999), 'The regulation by nutrition of glycogen in the muscle of ruminants', *Recent Advances in Animal Nutrition in Australia*, 12:145.

'Dark-cutting in Cattle and Sheep', *Proceedings of an Australian Workshop* (Australian Meat and Live-Stock Research and Development Corporation), August 1988.

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Contact us for additional information

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