High rigor temperature and toughening in beef

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Results for today; Ideas for tomorrow

Much has been written about cold shortening and about electrical stimulation as a way to prevent it. For instance, CSIRO first issued information to industry on electrical stimulation in 1978. Much more recently it has been recognised that inappropriate application of electrical stimulation can actually contribute to toughening and changes in colour and texture similar to that observed in PSE pork.

Cold shortening

It is well known that if an unrestrained muscle is exposed to low temperatures before it is in rigor then it will shorten and the resulting meat may be tough or very tough. This is called cold shortening induced toughness. In practice, its effect is minimised in the abattoir, either by the application of electrical stimulation, by use of the Tenderstretch process, or in a few abattoirs, by use of the rinsing and chilling technique, which involves the intra-arterial infusion of a solution of electrolytes at slaughter.

Shortening only occurs before muscles have gone into rigor, which means, in practice, before it has reached its ultimate pH.

Cold shortening is likely to occur if the muscle temperature falls below 12°C while the muscle pH is still above 6.0. Electrical stimulation reduces the pH rapidly, hastens the onset of rigor and hence minimises the incidence of cold shortening. Electrical stimulation is often only one of the electrical inputs applied on the slaughter floor. Other inputs may occur on application of:

- Electrical immobilisation; or
- Hide puller electrical rigidity probes.

The combined effect of these electrical inputs may lead to a very rapid drop in pH such that a value of 6.0 is reached by the time the beef sides enter the chiller. Therefore, there is no chance of cold shortening. However the possibility of toughening can still occur through high rigor temperature.

High rigor temperature

The combination of rapid glycolysis (i.e. rapid pH fall) and slow cooling leads to high rigor temperatures. This in turn can cause toughening. Previously, this has been referred to as heat shortening.

However it is now believed that the degree of shortening that occurs in beef muscles at high rigor temperatures is relatively small. Rather, the toughening effect is due to a loss in proteolytic potential (due to inactivation of the proteolytic enzymes), which subsequently leads to reduced tenderisation during ageing. In practice, this toughening may occur if the muscle pH falls below 6.0 when the temperature is above 35°C (see stippled area in Figure 1 below).

Meat Standards Australia requires that the loin muscle of beef carcases fall within the ph/temperature Abattoir Window (Fig. 1).

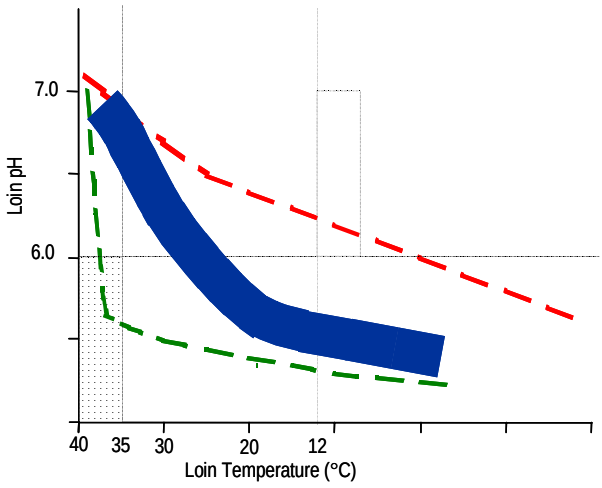

Figure 1. The pH/temperature window showing heat toughening (■), cold shortening (■), and acceptable decline of pH/temperature (■)

Muscles of carcases where the rates of pH and temperature decline are within the window are unlikely to either heat shorten or cold shorten.

A recent study conducted by staff of Murdoch University, W.A. is reported here. A group of heifer carcases destined for the domestic market was divided into 2 groups, one of which received 40 seconds of low electrical voltage stimulation, while the other group was not stimulated. All carcases were placed in the same chiller and because the stimulation caused

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a rapid drop in their pH, the treatment group had markedly different temperatures when the muscles were at pH 6.0 (Table 1).

Table 1. Temperature at pH 6.0 of stimulated and unstimulated muscle.

Muscle	Temperature at pH 6.0 (°C)	
	No stimulation	Stimulation (40 sec)
Rump (gluteus medius)	33	39
Striploin (longissimus)	19	31

After 15 days of ageing in vacuum packs the rump and loin muscles were grilled and submitted to an MSA consumer panel. The MQ4 scores, which represent the overall acceptability of the meat (higher scores represent superior acceptability), are shown in Table 2.

Table 2. MSA MQ4 scores of stimulated and unstimulated muscle.

Muscle	MSA MQ4 scores	
	No stimulation	Stimulation (40 sec)
Rump (gluteus medius)	70	58
Striploin (longissimus)	69	66

The results showed that the rapid pH fall at high temperature due to electrical stimulation decreased the overall acceptability of the product, particularly with the rump. Also, the rump of the stimulated carcasses was in the region of heat toughening in the pH/temperature window (Fig. 1).

Therefore, heat toughening can have an undesirable effect on meat quality.

It is interesting to note that meat scientists have often found that meat from heat-toughened muscles is not particularly tough when measured by the Warner-Bratzler instrument. This is a mechanical device, which measures the shear force of meat, and it usually correlates reasonably well with taste panel or consumer panel scores. Thus, it would appear that consumers downgrade meat from heat-toughened muscles for reasons other than lack of tenderness. It is possible that there is a difference in the fibrous and cohesive qualities of these muscles and people, but not the instrument, can detect the difference.

While electrical stimulation is important in preventing tough meat due to cold shortening, care must be taken that the total electrical inputs (immobilisation + hide puller rigidity probes + electrical stimulation) do not cause a drop in muscle pH so great as to produce heat toughening.

Pale, soft, exudative (PSE)

The description 'pale, soft, exudative' (PSE) has been applied to a condition that occurs in pork and, less frequently, in beef. It is associated with a fast rate of post-mortem pH decline. With pork, the combination of high muscle temperatures and low pH values leads to the development of pale soft exudative meat, two characteristics of which are a propensity to exude excessive amounts of drip and a poor water holding capacity – i.e. a poor ability to retain moisture during further processing and cooking.

A similar condition, although usually milder in degree, can occur with beef. It is particularly likely to occur in the larger, slower cooling muscles in the butt.

Electrical stimulation has been associated with PSE in beef carcasses. A Canadian study found that low voltage electrical stimulation, applied to beef for 40 s, exhibited the PSE condition in 10% of carcasses (Aalhus *et al*, 1994).

Acknowledgement and references

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Aalhus, J. L., Jones, S. D. M., Lutz, S., Best, D. R., Robertson, W. M. (1994) The efficacy of high and low voltage electrical stimulation under difference chilling regimes. Canadian Journal of Animal Science. 74: 433-442.

Further Information

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