MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

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High-pH/Dark Beef

Colour and pH are important factors in determining consumer acceptability of beef. Since dark beef has a low acid content (i.e. high pH), the meat does not develop the normal bright red colour of oxymyoglobin. The meat appears dark because of the prevalence of the purplish-red colour of the pigment deeper in the meat (reduced myoglobin) over the bright red colour of an unusually thin surface layer of oxymyoglobin, and because less light is reflected from the surface.

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 any further increase in ultimate pH. If meat has a pH of 6.0 or more at 30 hours after slaughter, it is classified as 'dark-cutting' or 'high-pH' beef. However, it is important to note that meat colour gradually darkens with increasing ultimate pH right through the pH range 5.4 to 7.0. This means that meat with an ultimate pH of 5.8 may be regarded as dark by some consumers, although it would not be classified technically as 'dark-cutting' meat.

What is pH?

The pH scale is used to measure the degree of acidity or alkalinity present.

The neutral point on this scale is 7, which is the pH of pure water. With increasing alkalinity, the pH number *increases*. Strong alkalis have a pH in the range of 12 to 14; weak alkalis have a pH of around 9. Increasing acidity is indicated by *lower* pH numbers, with weak acids being about 5 and strong acids between 2 and 3.

Importance of pH

The 'ultimate' pH of meat, i.e. the final pH achieved by the muscles when the rigor processes have ceased, influences meat tenderness, colour, flavour and shelf-life. Under normal conditions, this pH will be in the range of 5.4 to 5.8. When meat has an ultimate pH above this range:

- meat toughness increases (the present MSA pathways require an ultimate pH of 5.7 or less);
- the 'bloom' colour of the meat is darker, and therefore less attractive;
- bacteria can grow more readily on these higher-pH surfaces, shortening the shelf-life of the meat (particularly important for vacuum-packed product);
- the flavour of the meat becomes less attractive; and
- whilst tenderness can improve above pH 6.2, this does *not* offset the above disadvantages.

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What causes dark beef?

At the time of processing, energy stored in the animal's muscles is converted into lactic acid, making those muscles slightly acidic, i.e. lowering the muscle pH. Well-fed and well-rested animals normally have sufficient muscle energy reserves at processing to yield enough lactic aid to reduce the pH of muscles below 5.8. Animals that have been too stressed before slaughter and had insufficient time to re-establish the resultant depleted muscle energy reserves will yield dark meat. Highly stressed animals will yield 'dark-cutting' meat.

Because electrical stimulation speeds up rigor mortis, ultimate pH is reached much sooner when this procedure is used. With unstimulated carcases the pH of the meat falls more slowly after slaughter. For example, the meat pH measured at 40 hours after slaughter may be 0.1 pH units lower than that measured at 20 hours. Colour measurements made before the ultimate pH has been reached will be darker than those made afterwards.

Meat also becomes darker with increasing animal age. Meat from bulls has a higher myoglobin (muscle pigment) content than meat from steers, heifers or cows of the same age, but is not necessarily tougher.

Very rapid chilling of the sides will produce darker meat than that from the same sides slowly chilled. However, this is not a pH effect.

How to minimise the incidence of high-pH dark beef

Anything that uses up muscle glycogen whilst the animal is still alive - for example, stress, cold weather, disease and strenuous muscle contractions - can cause animals to produce dark-cutting meat.

Psychological (emotional) stress appears to be as important as physical stress. Some animals are more susceptible to psychological stress than others (i.e. are more excitable). The intensity and duration of the stress, as well as the susceptibility of individual cattle to stress, will determine the prevalence of dark-cutting carcases.

Temperament is genetically linked. Selecting for cattle with calm temperament may result in benefits in meat quality by indirect selection against stress-susceptible animals.

Handling and transport

There is no doubt that mustering, loading, transporting and unloading of animals all lead to stress. Although there is no single, simple way of overcoming these problems, a better understanding may encourage people to consider ways of dealing with them.

The degree to which animals are stressed during handling and transport depends on their temperament, handling during the journey, condition of the animal, and duration of the journey.

If steps are taken to allow animals to settle down after mustering, and if care is taken during loading, transport and unloading, there is every chance the animals will arrive at the abattoir in an acceptable condition. If animals arrive at the meatworks in a stressed condition they rarely have an opportunity to quieten down prior to slaughter. Animals in good condition and therefore with available glycogen reserves on which to draw, have a much better chance of coping with the rigors of handling and transport, especially during long journeys.

Holding

Holding periods depend on mustering and transport schedules at the property, and on animal condition and slaughtering schedules at the meatworks. It is true that resting and feeding reduce the ultimate pH of the muscle by allowing the glycogen reserves to return to normal. However, a resting period of two to three days would be necessary to restore some exhausted or stressed animals to normal and to reduce the proportion of dark-cutting meat.

Handling prior to slaughter

Preslaughter excitement has an effect. This is because there is no time at all to allow muscle glycogen levels to replenish, and it is therefore of great importance that animals are not unduly excited at this stage. Some degree of stress cannot be avoided because stock has to be moved through yards, races and washes. However, this stress can be minimised. Careful design of facilities to exploit properly the behaviour patterns of cattle ensures a smooth flow of animals, minimises man-animal and animal-animal confrontations, and so reduces stress. Personnel in these areas should be patient, experienced and informed. They should be made aware of the results of improper handling of animals at this stage.

All cattle should be cleared from restraining races and knocking boxes before breaks are taken by personnel.

Disturbing influences such as excessive noise, dogs and electric prodders should be avoided.

Stock which have been subjected to exposure to unfamiliar surroundings or the stress caused when animals are mixed (such as may happen with stock bought from saleyards) are more likely than those sent directly to slaughter to give dark-cutting meat.

In fact, dark-cutting meat is often due to a combination of factors.

Consideration should be given to prompt processing of animals travelling only short distances to avoid the stress of re-establishment of ‘pecking orders’.

Climate

It has been shown that the prevalence of dark-cutting beef increases as ambient temperatures decrease. When animals shiver to maintain their body temperature, muscle glycogen is rapidly used up and soon becomes inadequate to allow normal acid production after slaughter. The effects of cold weather are greatly increased if it is unseasonal (a cold snap in autumn or spring) or accompanied by wet and/or windy conditions, or if there are temperature differentials, e.g cold nights and hot days.

Washing of animals before slaughter should be done strategically and carefully to minimise this cold stress. The longer the animals have been off feed, the greater the effects of cold stress.

Animals should be protected as much as possible from both high and low temperatures - extreme temperatures are distressing to them.

Feed

Adequate feed and water are necessary to minimise stress. Sudden withdrawal of feed after feeding on high-energy rations is stressful.

Social stress

Social stress is caused by the mixing together (and subsequent fighting for social dominance) of animals unfamiliar with each other. For example, in one study when cattle were regrouped several times during a two-day period before slaughter, each regrouping increased the incidence of dark-cutting beef. Fighting can continue to physical exhaustion.

Once the social order has been established, the animals stop fighting. However, recovery from the stressed state may take several days, because muscle glycogen depletion can be more rapid than replenishment. If just one new animal is introduced into a group, fighting to establish a new social order may begin again. Animals that are especially aggressive should be isolated if prolonged fighting occurs.

Avoid mixing mobs of animals just prior to slaughter. If this is unavoidable, mixing is best done in larger paddocks 2-7 days prior to slaughter.

Sex

Bulls tend to be the most aggressive and quite frequently yield dark-cutting meat. Cows - particularly old, pregnant ones in poor condition - give a higher prevalence of dark-cutting meat than that occurring in

heifers and steers.

Other factors

Diseased animals, or animals recovering from disease, yield dark-cutting meat to a greater extent than do healthy animals.

Work at Colorado State University concluded that some growth promotant implant practices can contribute to dark-cutting problems.

Preventive Measures

As yet, there is no easy way known to prevent the occurrence of dark-cutting beef. Care should be taken to avoid or minimise all of the above factors.

If possible, records should be kept of source of stock, preslaughter transport, handling, holding and weather. These should be correlated with appraisal records of meat colour (e.g. AUS-MEAT colour scores) and/or pH. From such records it is possible to detect the occurrence of a higher than average proportion of high-pH carcases, and to take appropriate action.

Solving some dark-cutting meat problems

- Select cattle on temperament as well as performance.
- Look for animal management practices that could be improved.
- Check seasonal conditions. In some areas of Australia, early Autumn is a well-established 'high-risk' period for dark-cutting meat.
- Ascertain whether you are simply breaking the meat before sufficient rigor has occurred - perhaps the meat pH still has some way to fall.

Further Reading

An excellent publication is 'Principles of Abattoir Design to Improve Animal Welfare', by Temple Grandin, Department of Animal Science, Colorado State University, USA.

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Contact us for additional information

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