TIPS & TOOLS

MEAT STANDARDS AUSTRALIA

The effect of pH on beef eating quality

Why is high pH meat a problem?

MSA research has found beef with pH levels above 5.70 to be of lower and more variable eating quality. Accordingly 5.70 has been set as the maximum pH level for MSA grading. In line with eating quality, a slight adjustment is made within the acceptable 5.30–5.70 range, as shown in the table below.

In addition to unacceptable eating quality, high pH meat has the following features:

- It is often known as dark cutting meat, as it generally has a purple appearance.
- A coarse texture.
- Higher water holding capacity (so the meat loses a lot of moisture during cooking).
- Reduced shelf life (bacteria grow more rapidly due to the higher pH and moisture).
- It appears undercooked remaining pink in the centre despite extensive cooking.

Does meat colour alone indicate eating quality?

Meat Colour is defined as the predominant colour of the rib eye muscle (M. longissimus dorsi). Meat colour is assessed on the chilled carcase at the bloomed rib eye muscle area (M. longissimus dorsi) and is scored against the AUS-MEAT colour reference standards. Meat colour is affected by the amount of myoglobin in the muscle, as well as how well oxygen diffuses in the muscle. In carcases with high pH meat (greater than 5.70) the meat does not allow oxygen to diffuse as far into the muscle causing a dark appearance. However dark meat colour that has an acceptable pH level can also result from an animal that has a large amount of myoglobin, causing the muscle to appear 'redder'. So while high ultimate pH meat and darker meat colour often go hand-in-hand, it is possible to have one without the other.

MSA research has confirmed that along with having no effect on eating quality, consumers do not visually discriminate against meat colours greater than AUS-MEAT MC 3 at the point of sale, where pH is an acceptable level. While meat colour is not an MSA requirement, supply chains may choose to apply company specifications related to meat colour.

Key points

- The acceptable pH for MSA carcases is less than 5.71.
- Eating quality is reduced and more variable above 5.70.
- Dark cutting is defined as carcases with an ultimate pH greater than 5.70. These carcases will generally also have a dark purple meat colour.
- Energy (glycogen) levels in the animal are important in obtaining a pH within the acceptable range.
- Stress or exertion will result in cattle losing energy.

What is the cost of high pH meat?

Carcases that have a high pH, (above pH 5.70) are rejected under MSA grading and are excluded from many meat brands, food service operations and markets.

Annually in Australia, non-compliance due to high pH fluctuates around 5% of MSA graded cattle and this percentage of failed carcases represents a substantial economic loss.

	5.30		5.50		5.70		5.90	
	CMQ4	MSA Index	CMQ4	MSA Index	CMQ4	MSA Index	CMQ4	MSA Index
Tenderloin	77	59.99	77	59.99	77	59.99	Ungrade	Ungrade
Cube Roll	60		61		61			
Striploin	55		57		57			
Rump	53		53		53			

Non-compliant carcases due to pH (dark-cutters) are often heavily discounted and this comes at a cost to both the processor and the producer. As MSA carcases can receive a premium price above non-graded carcases, carcases that fail to meet minimum requirements are often destined for manufacturing beef, returning less to the processor and often with penalties passed onto producers.

Expected price penalties passed onto producers due to non-compliant carcases can range from 20c to 80c per kg of hot standard carcase weight (HSCW), with an average expected penalty of $0.60/kg HSCW. Based on an average carcase weight of 290kg, this could cost producers $174/hd.

It is expected these price penalties cost producers in excess of $20million annually, without taking into account the costs incurred at the processor level.

The good news is that high pH meat can be prevented. And it's worth it. By improving handling and care in marketing livestock, there are other benefits such as:

- reduced bruising
- improved animal welfare
- reduced weight loss.

What is pH?

pH is a measure of the acid or alkaline level of the meat. Just as you might measure the acidity of the soil for optimum growth and productivity, MSA measures the acid level of the meat to ensure eating quality. MSA accredited graders measure the pH of the carcase at grading using a pH meter. This measurement is known as the ultimate pH. pH can be measured on a scale, from 0, which is very strong acid, to 14 which is very strong alkaline.

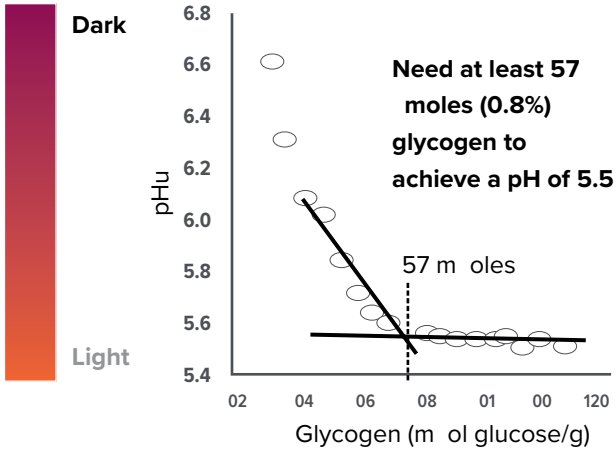
pH value	Description
14	Strong alkaline
9–12	Common household detergents
7.1	Living muscle (live cattle)
7	Pure water
5.71–6.90	**Meat classified as 'dark cutting'; shelf life decreased; not suitable for vacuum packaging; generally darker and tougher**
5.30–5.70	**Meat with good visual appeal and potentially good eating quality**
4–5	Orange juice, beer
2–3	Vinegar
0	Battery acid

What impacts pH levels in the carcase?

Every animal has a certain amount of energy contained in its muscles in the form of glycogen. Once the animal is dead, the muscle glycogen is converted to lactic acid, which causes the pH to fall. This is illustrated in the following diagram.

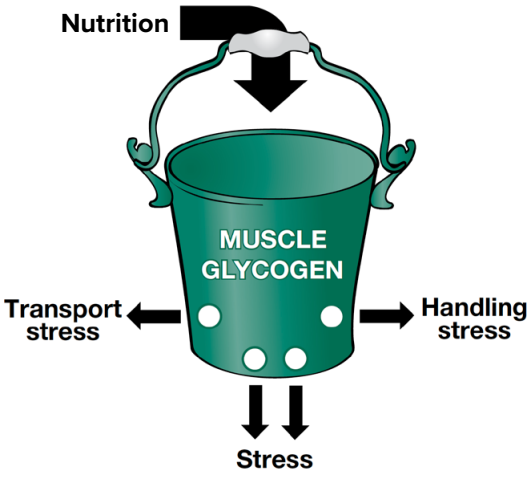
The more glycogen there is in the muscle, the more lactic acid will be produced. This will enable the pH to fall to within the acceptable range of 5.70 and below.

If there is not enough glycogen available in the animal, insufficient lactic acid will be produced and the pH will stay high, resulting in dark cutting.



Stores of muscle glycogen versus pH.
Image courtesy of the Beef CRC.

This relationship between livestock management, live animal glycogen and pre-slaughter depletion is shown by the 'bucket' diagram below:



Nutrition provided for the animal is the energy into the bucket. The holes in the bucket represent the factors that use up energy such as exercise or stress. These factors will always be present in some form, but it is important to minimise their impact. That is, to keep the 'holes' in the bucket as small as possible.

How are glycogen levels maintained?

Glycogen levels are influenced by the amount and value of the feed that the animal has been eating in the month prior to slaughter. Cattle receiving high levels of nutrition from feedlot rations or high energy pastures will have high glycogen levels. Restricted intake or low quality feed will significantly reduce glycogen, often below the critical level. To ensure cattle are receiving adequate nutrition, and that glycogen concentration in muscles is at the highest, cattle should be gaining at least 0.8kg/day leading into slaughter. Higher weight gains will ensure animals have as much energy available to grow, lay down fat and deal with stressors like handling and transport.

How is glycogen lost?

When an animal is exposed to a new environment, unfamiliar sounds or new animals in the social group, they become stressed. They will automatically try to act out one of two basic responses, 'fight' or 'flight'. As soon as either of these responses occurs the glycogen stored in the muscles is rapidly mobilised to enable the animal to either run (flight) or to attack (fight). In the case of severe stress or exertion, the 'holes' in the bucket get bigger and much of the energy is lost. When this occurs it will take a minimum of five days on good nutrition before these energy stores start to be replenished.

Poor mustering or handling during yarding and loading dramatically increases the rate of glycogen loss. As energy continues to be lost while animals are being transported and yarded, it is important to minimise the transport to slaughter time as much as possible while paying attention to transport, lairage conditions and handling practices.

Minimising stress caused by adverse weather conditions

Weather extremes also create stress and increase glycogen use. In cold weather cattle expend energy shivering and maintaining body temperature. Likewise when cattle are hot they will pant and sweat in an attempt to cool through evaporation, again using energy. To minimise the impact of cold weather, cattle should be sold and trucked in good condition. In cold weather feeding pre-transport is particularly important. Wind chill from rain, sleet and wind is often more detrimental than cold temperature alone. If there is a grazier's alert forecast, it might be an option to postpone trucking cattle until the weather has improved.

If the temperature is high, cattle should be trucked at night to minimise the risk of heat exhaustion.

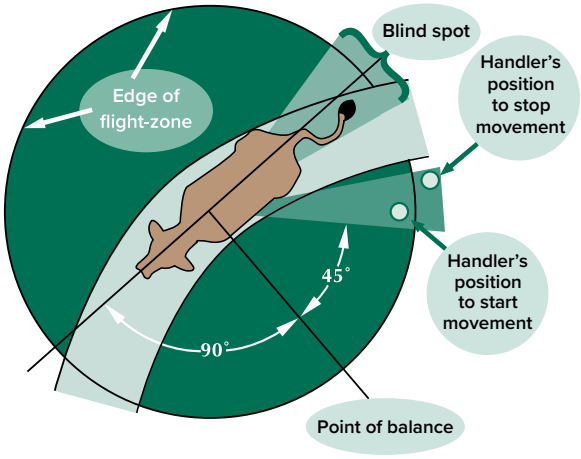
At times of seasonal risk make sure cattle are adequately finished. Cattle are most at risk of dark cutting during autumn or winter when the amount of available pasture is limited. Cattle at this time often have only minimal energy reserves so cold snaps or frost can have a critical effect. The cost of supplementary feeding must be weighed up in comparison with the lost income from dark cutting carcases.

If the cattle are being sold through an MSA underpinned market, the maximum pH allowed is 5.70. Carcases with a pH above this will not be MSA eligible.

Minimising stress by good cattle handling

To minimise the amount of stress when mustering, it is best to avoid using electric prodders or dogs, if possible. Rattles or flappers can be substituted and will result in less stress for the cattle. Any undue or excessive noise, including loud human voices will also increase stress.

Heifers coming into oestrus (heat) can cause significant stress in the mob by encouraging mounting. A heifer beginning to show signs of oestrus when mustering is likely to go into standing heat on the truck. This is likely to result in an increase in mounting, which will increase stress levels in the mob as well as causing a potential increase in the amount of bruising.



Principle provided by Dr Temple Grandin, Colorado State University.

Moving cattle easily: the flight-zone

Cattle have wide-angled vision in excess of 300 degrees. They are surrounded by what is termed their 'flight-zone'. Different animals will have different flight-zones depending on tameness and how handlers approach them. To move cattle easily, handlers should work the edge of the circle. To make the animal move, penetrate the flight-zone. To stop it moving, retreat from the flight-zone.

The point of balance at the animal's shoulder should also be used in moving cattle. Approach an animal from behind the point of balance and it will move forward. Approach it from the front and it will move backwards.

Guidelines to minimise your on farm dark cutting risk

By following these guidelines you will be able to assess the amount of exposure your animals have to the risk of dark cutting. This step-by-step approach will indicate any problem areas that you may not have previously considered. Good management and nutrition are vital in minimising the dark cutting problem.

Step 1: Review past performance. Assess your on farm management and handling practices

- Review past grading feedback results. Look at variation in pH levels.
- Identify financial losses or penalties you have incurred for dark cutting in the past.
- Remember that the maximum pH level acceptable for MSA is 5.70, so it is important to review those that did not meet this specification and think about reasons why this occurred.
- Use your feedback to look at compliance rates over time to identify any trends or problematic times of the year. Was there a seasonal effect?

- myMSA allows producers to view their compliance for individual consignments as well as over time. The benchmarking features within myMSA also allow producers to see if their compliance rates are higher, lower or in line with other producers on a regional, state and national basis. These features provide producers with information to easily see if they are improving, how they compare with other producers and if there are seasonal effects being experienced.

Step 2: Assess your current on farm management and handling practices

- Using the guideline tables in this publication, tick off those practices you are routinely doing and take note of those you're not. Cross out the ones that don't apply to your operation.
- Summarise and prioritise the practices you need to do. Develop an action plan (what you need to do and by when).

Step 3: Change your practices

- Plan your marketing operations carefully.
- Incorporate procedures in your on farm quality assurance system or management practices.
- Monitor improvements by comparing new feedback sheets with historical ones.
- If necessary, talk to your processor or MSA for further advice.
- Other sources of information to assist in pasture management or supplementary feeding can be obtained from your state Department of Agriculture or Primary Industries or nutritional consultants.
- If supplying cattle to MSA markets, refer to the *MSA Tips & Tools MSA requirements for cattle handling*). All of these requirements are set with the aim of minimising animal stress.

Look at the improvements to your bottom line. Heavy penalties can result from dark cutting carcases. Good management to minimise the potential damage can be a well spent investment.

Key points to remember

High ultimate pH can have a detrimental effect on texture, keeping ability and eating quality.

The following steps can help reduce stress in livestock prior to slaughter:

- Ensure livestock have good nutrition prior to slaughter.
- Muster and assemble stock as quietly and efficiently as possible.
- Handle livestock with care and avoid excessive force and noise.
- Familiarise animals to handling and train stock persons in handling skills.
- Maintain animals in their social groups.
- Ensure livestock have access to water at all times prior to consignment.

Further information

Visit www.mla.com.au/msa or contact MSA 1800 111 672

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On farm management and marketing

	Recommended practice	Why?	How?	✓ or x
1	Select cattle on temperament as well as performance characteristics.	Animals with poor temperament are stress-susceptible and can disturb others within a mob.	There are several tests that can be applied to determine temperament. Advice should be sought from your local Department of Agriculture advisor.	
2	Familiarise animals to handling and human contact.	Animals exposed to frequent positive handling and training move more easily and are likely to be more resilient to pre-slaughter stresses.	Familiarising means frequent and gentle handling and movement of your stock, and getting your animals used to yards and transport. Yard weaning is one way to achieve familiarity. Try exposing animals to different stimuli (in a positive way) such as motorbikes, people on foot and people on horses.	
3	Ensure cattle are on a rising plane of nutrition prior to marketing.	Good nutrition keeps the glycogen 'bucket' topped up. A low plane of nutrition will begin to deplete the glycogen even before you muster them.	Enable growth rates of at least 0.9kg/day. In some cases, supplementary feeding will be necessary during periods when pasture quality declines (eg during winter or drought). Note: Adequate fat cover does not necessarily indicate high muscle glycogen content.	
4	Provide susceptible slaughter cattle (those with a high value and potential for discounting for dark cutting) with a high energy diet prior to marketing.	Stock, such as bulls and heifers, on poor pasture are more likely to have low muscle glycogen levels, and may produce higher pH meat.	Cattle with suspected low glycogen levels can be given four weeks of carefully administered, full grain feeding prior to slaughter.	
5	Where possible exclude heifers in oestrus from slaughter consignments.	Heifers in oestrus will encourage increased mounting activity.	Separate heifers showing signs of oestrus from consignments.	
6	Don't market for slaughter too soon after purchase. Minimise drafting-off cattle just prior to transport.	Cattle need time to adjust to their new surroundings and herd mates. Extra movement and disturbance of animals causes glycogen depletion especially when rushed.	Don't market newly purchased cattle within 30 days of purchase. Draft cattle into slaughter lines at least two weeks prior to slaughter where cattle have to be mixed. Cattle selected for slaughter from within a management group should be drafted as close to transport time as practical.	
7	Comply with manufacturer's instructions regarding the use of HGPs.	Research has found that cattle consigned while under the influence of HGPs are at greater risk of dark cutting. The risk increases even more in heifers.	Check the long acting properties of the HGP on the label and ensure cattle aren't consigned while the HGP is still active. (Note: chemical withholding periods must be adhered to.)	
8	Avoid marketing in, or through, weather extremes.	Sudden climatic changes can increase the risk of dark cutting. This is particularly evident during periods of cold, wet weather.	Avoid marketing under extreme weather conditions (very hot, very cold, raining, or storms) or when there is the potential for sudden climatic changes (particularly cold weather).	
9	Only market healthy animals for slaughter.	Animals with visible signs of disease, or those recovering from disease or trauma are at high risk of dark cutting (marketing animals with obvious signs of disease/trauma is also in breach of the animal welfare code of practice).	Ensure sick animals are treated, well rested and recovered before marketing.	
10	Use well-designed and constructed facilities for slaughter stock preparation.	Animals do not move well through poorly designed yards. Additional force and contact is often required to shift animals which in turn increases the potential for stress and bruising.	Use yards built to a good standard and designed for stock behavioural traits. Consider implementing on farm QA programs, which address bruising and other dark cutting risk factors.	
11	Consider supplementary feeding before consigning.	When pasture quality declines, supplementary feeding is a useful strategy to minimise the risk of dark cutting. The use of electrolyte or mineral supplements may also prove quite effective (this strategy is still under evaluation and is no substitute for good nutrition).	Provide forage/grain supplements to cattle when on farm pasture conditions decline.	

Mustering and holding of stock

	Recommended practice	Why?	How?	✓ or x
12	Use only reputable transport companies.	Poor transport conditions increases stress levels.	Use transport companies operating under a quality assurance scheme and utilising good animal handling practices (eg Truckcare).	
13	Muster and assemble stock as quietly and efficiently as possible.	Cattle have sensitive hearing. Unexpected, loud or foreign noises and unnecessary movement can be highly stressful to livestock.	Refrain from using excessive and unnecessary yelling and whip cracking. Use skilled and trained cattle handlers. Work within the flight-zone and point of balance.	
14	Avoid running cattle to assembly areas.	Strenuous physical activity depletes muscle glycogen levels. Trotting cattle for 4km can remove around 30% of the muscle glycogen. It can then be difficult to raise the glycogen levels to an acceptable level before slaughter.	Set aside ample time for mustering.	
15	Minimise use of dogs.	Cattle view dogs as predatory animals. ie dogs can create stress, especially in confined spaces.	Try using noise or drafting flags to move cattle.	
16	Keep animals in their social groups and don't mix mobs of unfamiliar animals.	Cattle become stressed or agitated when separated from their herd. Lone animals are more difficult to handle. Similarly, mixing unfamiliar animals results in fighting to establish a new social order.	Avoid mixing unfamiliar mobs in holding paddocks prior to transport. If mixing of stock is unavoidable, do so at least 30 days before marketing and then remuster. Try to avoid isolating any animal. Don't draft out just one or two animals from a herd to meet an order.	

Drafting and loading for transport

	Recommended practice	Why?	How?	✓ or x
17	Reduce or eliminate the use of electric prodders and other goads.	As well as risking bruising, excessive use of jiggers and prodders will cause additional stress.	Use techniques such as working the point of balance and flight-zone. Try using flappers, rattles or drafting flags instead.	
18	Be patient, and allow time and space for cattle to move through the yards.	Hurrying animals can increase stress and deplete glycogen levels.	Use trained and skilled stock handlers familiar with quiet and efficient handling. Make sure gates are open before attempting to drive cattle.	
19	Use well designed loading ramps.	Loading ramps, if not designed correctly, can impede animal movement and cause injury.	Loading ramps should be non-slip and less than 25° slope, preferably with stepped incline and double deck loading facilities if two deck transports are loaded regularly.	
20	Avoid dehydrating animals.	Dehydration can lead to stress and glycogen loss.	Make sure water is freely available to stock before they are trucked.	

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