MEAT & LIVESTOCK AUSTRALIA

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MEAT STANDARDS AUSTRALIA

Meat Standards Australia beef information kit

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Meat Standards Australia beef information kit

Contact:

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MSA01 MEAT STANDARDS AUSTRALIA

What is MSA?

Meat Standards Australia (MSA) is a valuable asset to the Australian beef industry, providing opportunities to differentiate product in the market. Unlike existing industry description systems, MSA accurately predicts eating quality for individual beef muscles.

The complex series of factors which result in the eating quality of a beef meal are taken into account in the MSA production and grading process. This solves the long-standing consumer problems of selecting beef and choosing an appropriate cooking method.

Key points

- MSA removes the need for consumers to have specialist beef knowledge.
- MSA retail labels advise the correct cooking method for every piece of beef to assure the eating quality result.
- MSA product must meet consumer set standards at one of three quality levels: MSA 3, MSA 4 or MSA 5.
- MSA involves all sectors of the beef production chain, from paddock to plate.
- MSA provides detailed feedback on eating quality to the processor, feedlot and the producer.

Beef purchasing by consumers

The MSA labels provide a consumer assurance of eating quality at three levels, MSA 3, 4 and 5 in conjunction with cooking method.

This is all the consumer needs to know to purchase and prepare beef with confidence.

Application of the system can provide a dynamic new consumer focus and drive positive change in beef industry trading systems. At retail, description by final eating quality result can be linked to price and replace the complex and often misleading system of cut names and quality descriptions now used. Relating MSA grade results to price along the production chain can encourage and reward production systems that aid in improving consumer acceptance of beef.

Replacing variable quality with accurate eating quality grades can underpin branded beef programs and provide a basis for improved demand with an associated shift in price and volume.

How did MSA begin?

MSA began as an industry program in 1996 following detailed consumer research investigating the continuing decline in beef consumption.

The key problems identified in MSA research were a reduced level of cut and cooking knowledge among consumers and the degree of quality variation in the beef available. The period of beef consumption decline coincided with growth in competitive products offering greater consistency and less demanding product knowledge. While relative pricing had also changed, consumers stated they would buy more beef, even at higher prices, if it was reliable.

The consumer standard

A total consumer focus has been the foundation of MSA development. The objective has always been to accurately establish and satisfy consumer set standards. Early MSA research investigated consumer taste parameters to establish the degree of variation between consumers. Grading could not be effective without a reasonable consensus view of eating quality. The findings established that there was very strong agreement on beef eating quality among consumer groups. From this, protocols were established to utilise consumers in testing the full range of beef produced. The scoring system and boundaries to define grades have been strictly set from analysis of the consumer results.

All MSA beef is graded on the basis of the consumer test score predicted for a particular beef muscle cooked by the nominated method. Further information on consumer testing and grade standards is available in *MSA Tips & Tools: How MSA grades are determined.*

How is the MSA grade established?

The MSA grade is established by calculating the direct and interactive effects of all factors established as affecting eating quality. More than 100,000 consumers, across nine countries have participated in MSA consumer testing providing scores on more than 800,000 beef samples. A very large database contains details of the consumer scores for each cut in conjunction with product information. This includes the animal's breed, sex, age and growth history, detailed processing and chiller assessment data together with the individual cut and muscle, days of ageing and cooking method tested.

Analysis of this data has established a series of factors which, when used in combination, allow the consumer score to be predicted with reasonable accuracy. No single factor is all-important, which is why grades based entirely on breed, dentition, marbling or other single attributes fail to assure eating quality. Virtually all steps in the production process have some impact on the eventual consumer result.

The MSA-accredited graders collate information provided from the cattle supplier, through the MSA vendor declaration, with abattoir information and chiller assessment detail. The data is entered into a handheld computer that enables a complex statistical calculation to be made estimating the interactive effect of all factors on eating quality. Information on each carcase is provided to the abattoir and the supplier in MSA feedback.

The program then produces an eating quality score specific to each muscle for each applicable cooking method, covering ageing periods from 5–35 days. This determines how the product can be identified to the consumer. Individual carcases are sorted into eating quality groups. Eating quality groups collate carcases that share cuts within specified eating quality ranges to enable accurate carton labelling. Further details on the eating quality calculation process, the grading procedure and each grading input may be obtained in other MSA tips and tools.

How is MSA integrity maintained?

MSA is a voluntary cooperative program requiring coordination and rewarding best practice across all industry sectors. Producers and feedlots are registered and provide required information via an MSA vendor declaration. Abattoirs, wholesalers, retailers and foodservice outlets are licensed and incorporate MSA requirements into their quality assurance programs. The licence conditions require indepedent auditing to demonstrate total product integrity. MSA grader accuracy is monitored through frequent analysis and MSA graders are required to complete regular correlations against the grading standards. Consumer complaints are monitored and investigated as required.

For more information

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

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MSA02 MEAT STANDARDS AUSTRALIA

How MSA grades are determined

Why grade beef?

The aim of MSA grading is to assure consumers that a cut of beef will eat to the quality shown on an MSA label when cooked by the method shown. This simple description system can form a basis for retail pricing and generate product confidence. This removes the guesswork for consumers, enabling them to reliably select beef of the desired quality.

What is beef quality?

For an eating quality grading system to work, consumers have to agree on a definition of 'quality'. If individual opinions differed widely then grading would not be effective. MSA research has examined consumer beef quality judgements in detail using the results of more than 100,000 consumers and scoring more than 800,000 beef samples. This has proven that groups of consumers have a very consistent opinion on beef eating quality.

How does MSA test consumers?

MSA has developed detailed testing protocols to ensure that the scores obtained relate only to the individual consumer and the beef sample, and are not affected by random influences such as irregular thickness or cooking variation. The protocols also detail issues of sample preparation, order and method of serving. For example, every consumer is served seven samples, which include a high and low quality product. The first sample is common to provide a standardised benchmark with the following six presented following a 'Latin square' arrangement as shown opposite.

Key points

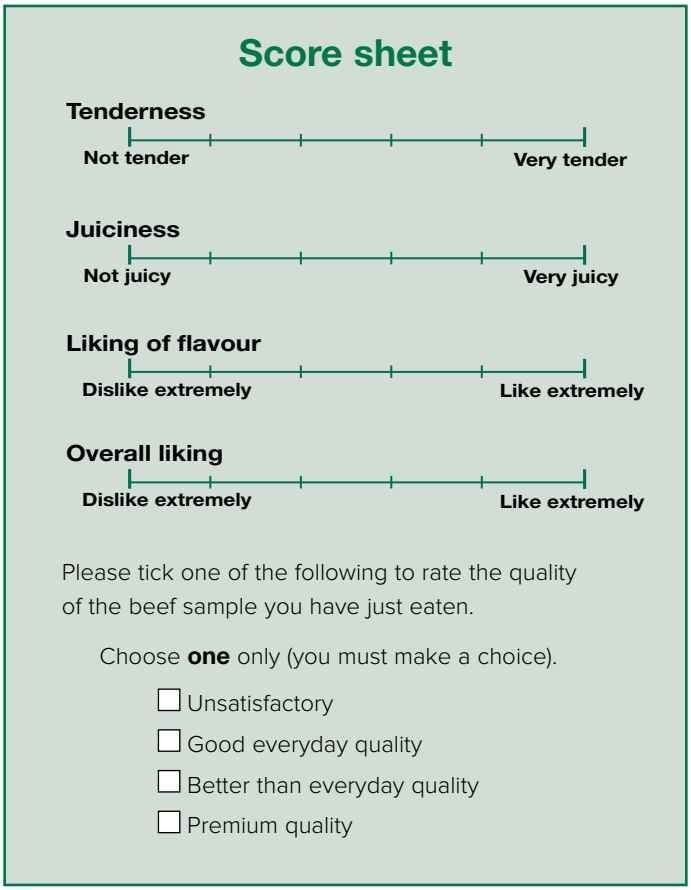
- MSA grades are set from analysis of consumer test results.
- Grade standards are independent of all production factors.
- The MSA eating quality score is a composite of tenderness, juiciness, flavour and overall liking scores.
- The MSA grade score boundaries reflect consumer judgement.

Common link product					
1	2	3	4	5	6
2	4	1	6	3	5
3	1	5	2	6	4
4	6	2	5	1	3
5	3	6	1	4	2
6	5	4	3	2	1

This ensures that each product is served an equal number of times in each position and that each is served an equal number of times before and after each other product.

Consumers are recruited from the community to represent diverse backgrounds and areas. Selection criteria are: 18–65 years of age, eat beef at least once per two weeks and prefer their beef cooked medium.

Each consumer completes a score sheet for every sample tested. This involves marking lines to score tenderness, juiciness, flavour and overall liking and ticking one of four boxes to indicate whether the sample was of unsatisfactory, good everyday, better than everyday or premium quality.



How is the MSA eating quality score calculated?

The MSA score, out of 100, is calculated by adding a percentage of the individual consumer scores for each sensory component as follows:

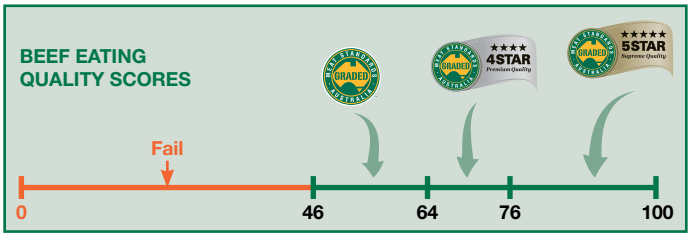
Tenderness	30%
Juiciness	10%
Flavour	30%
Overall liking	30%

These percentages have been established from statistical analysis and provide the best relationship between the 'lines and boxes' marked on the consumer score sheets.

How are the MSA grade standards set?

Each cut x cook combination within the carcase is allocated a score out of 100. These scores will determine the eating quality grade (MSA 3,4,5 star) they achieve and can be identified as to the consumer.

The MSA score that forms the cut-off point between each grade is also set from analysis of the consumer test data. The MSA eating quality score is compared statistically to the quality rating box ticked to determine the grade boundaries. A beef cut must achieve a minimum of 46 points to be certified as MSA.



How are consumer results used to develop the MSA grading model?

The grading model predicts how each cut will eat.
The system has been developed from more than 100,000 consumers testing more than 800,000 beef samples. Ten consumers have tasted each individual cut. The samples tested represented a wide range of cuts, cattle breeds, systems, processing practices, ageing times and cooking methods. The highest and lowest two scores are 'clipped' and the middle six averaged to produce the MSA eating quality score used in the database.

Maintaining the system

Consumer standards are continually reassessed through the consumer taste-testing program.

By continually monitoring consumer scoring, grade standards can be adjusted over time in line with any evident change in consumer preference to maintain eating quality satisfaction as well as continual improvement of the MSA model to increase accuracy with further research.

For more information

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MSA03 MEAT STANDARDS AUSTRALIA

MSA requirements for handling cattle

How you handle your cattle affects their eating quality

An important element contributing to predictable eating quality performance is the management of cattle on farm or in the feedlot prior to slaughter. For this reason MSA has produced guidelines to optimise the eating quality potential of the animal.

The long period of care and investment in producing an animal with high eating quality potential is most at risk in the two weeks pre-slaughter and the first few hours post slaughter. The best meat cuts can be reduced to a low quality, unacceptable product by inappropriate action in this period.

The damage is caused by changes in muscle glycogen (blood sugar) levels. Glycogen is in essence the energy reserve of the muscle. The muscle glycogen level is increased by feeding (a process taking days) and rapidly reduced by stress (which may only take minutes) or activity in the live animal. At the point of slaughter, the glycogen is converted to lactic acid that steadily decreases the pH of the muscle.

Mustering and good feed is important

The production of MSA graded product is consequently a partnership between the producer and the abattoir. An abattoir cannot rectify poor cattle handling practices or nutritional problems. Cattle should be mustered as quietly as possible, as it can take up to 14 days for the muscle glycogen levels to be restored, once they have been depleted. To maximise glycogen levels, and consequently eating quality, it is recommended that cattle are on an increasing plane of nutrition for at least 30 days prior to dispatch.

Key points

Cattle dispatched for slaughter must meet with the following requirements:

- All cattle must reside on the property of dispatch for a minimum of 30 days prior to dispatch.
- Do not consign male cattle exhibiting secondary sexual characteristics
- Do not consign any cattle of poor temperament or with signs of severe stress.
- Do not consign cattle that have been severely sick or injured.
- Direct consignment cattle to be processed within 48 hours from dispatch to slaughter, with a maximum of 36 hours in road transport, which can also include a rest period of up to 12 hours.
- Cattle transported by sea or rail are processed no later than day after dispatch.
- Cattle sold through an MSA accredited saleyard to be processed within 36 hours of dispatch from farm.

To optimise the eating quality of beef, the following recommendations should be observed:

- Cattle should be managed as a single mob for a minimum of 14 days prior to dispatch for slaughter, this includes no mixing or drafting.
- Cattle should be continually grazed or fed rations to a level that is adequate for growth for a minimum of 30 days prior to dispatch.
- Handle and muster animals quietly to reduce stress.
- Cattle to have access to water outside of transport.
- Provide free access to feed until dispatch, other than a minimum period required for preparation through cattle yards.
- Load cattle quietly, preferably with no use of goads and electric prodders.
- Load cattle at the recommended densities set out in the trucking industry code of practice.

Temperament is also important

Temperament is also an important issue, with work in the United States by Dr Temple Grandin demonstrating that calm cattle show a reduced incidence of dark cutting, defined as carcases with an ultimate pH above 5.70. Cattle with poor temperament can lose more glycogen during the period leading up to slaughter. These cattle also have the tendency to stir up other cattle in the pen, which can lead to a higher overall incidence in dark cutting meat and high pH carcases.

The benefits of recommended sound practices however are much broader and deserve inclusion in professional property and herd management.

Impact of climate

Other stress factors such as weather should be taken into account when planning mustering and transport to improve animal welfare and minimise risk to eating quality. Dramatic changes in temperature (such as a cold snap or heavy rain while trucking) can cause undue stress to animals.

Damage is irreversible

Once the animal has been slaughtered, pH fall in the carcase is irreversible and continues post rigor mortis to a final value, known as ultimate pH, generally within 24 hours of slaughter, depending on the conditions. The optimum ultimate pH is below 5.71. MSA consumer eating quality tests show lower scores as ultimate pH rises above 5.70.

Where live animal glycogen levels are very low at slaughter a higher ultimate pH results, which may be accompanied by a dark meat colour. This is referred to as dark cutting and is a major industry problem. Dark cutting carcases tend to be an indicator of stress to the animal
pre-slaughter, but can be a result of other factors such as the chilling process and the age of the animal (meat colour gets darker as the animal ages).

Abattoirs have an important role

In addition to ultimate pH, the rate of pH decline (from around 7.10 at slaughter) in relation to muscle temperature, is of critical importance to eating quality. If the temperature fall is rapid and the pH fall slow, carcases will cold shorten, resulting in extremely tough meat. If the pH fall is rapid and the temperature fall slow, heat shortening results. This also creates slightly tougher and less juicy beef with eating quality problems relating to colour changes, excessive drip loss and lack of improvement with ageing. The abattoir has a responsibility to monitor this process. Further information about the rate of pH decline can be found in the *Tip & Tool – The effect of pH-temperature decline on beef eating quality.*

Processing time requirements

In addition to on farm responsibilities, there are processing time frames for MSA cattle.

For direct consignment cattle (road transport):

Slaughter within 48 hours from the property of dispatch providing the following requirements are met;

a) The total truck transport time from property dispatch to arrival at the abattoir is not to exceed 36 hours;

b) Up to a 12 hour rest period can occur during this 36-hour period, however, if a 12-hour rest period is taken then the maximum time cattle can spend on a truck is 24 hours; and

c) This pathway allows for up to 12 hours in lairage prior to slaughter.

For direct consignment cattle (sea or rail transport):

Slaughter no later than the day after dispatch from the property

For saleyard cattle:

Slaughter within 36 hours of dispatch from property.

For more information

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

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MSA04 MEAT STANDARDS AUSTRALIA

How to supply beef in the MSA system

Consumer taste-tests have determined the factors that affect eating quality resulting in accurately established grade standards. The factors that affect eating quality are set as minimum requirements for MSA. Producers supply cattle following the minimum requirements as outlined in *MSA Tips & Tools: MSA requirements for handling cattle.*

Cattle are consigned to an MSA licensed abattoir to be slaughtered within the required time frames. MSA accredited graders check MSA vendor declaration details prior to grading at the abattoir.

Producers can receive detailed feedback on the eating quality outcome of their cattle by consigning through MSA licensed participants.

MSA is a 'paddock to plate' pathway approach that rewards best practice operations to assure acceptable eating quality for the consumer.

Replacing variable quality with accurate eating quality grades can provide a basis for improved demand with an associated shift in price and volume.

The following steps can assist with supplying cattle to meet MSA requirements and improve your understanding of MSA.

Step 1

To supply MSA beef direct or through an MSA underpinned brand you must be registered as an MSA producer. The easiest way to become registered is to use the online registration program at **www.mla.com.au/msa**. Following a short training program, you will have instant access to MSA electronic vendor declarations.

Step 2

Alternatively, a registration form can be downloaded from **www.mla.com.au/msa**.

When registering by paper-based form, allow two weeks to receive your registration number and producer pack containing information on how to obtain your MSA vendor declarations.

Key points

- Producers wishing to supply cattle for MSA must be registered.
- An MSA vendor declaration and a Livestock Production Assurance National Vendor Declaration (LPA NVD) must accompany cattle to the MSA licensed abattoir.
- The MSA vendor declaration confirms that MSA guidelines for cattle handling and trucking have been followed and that tropical breed content is recorded.
- MSA feedback is available on cattle consigned and graded for MSA.

Step 3

Check that you meet the list of requirements shown in the box on the *Tips & Tools: MSA requirements for handling cattle.* Once you have received your MSA producer registration number, access to MSA vendor declarations and are satisfied you meet the MSA requirements, you can consign cattle through the MSA system. Visit the MSA website for a list of MSA licensed abattoirs.

Step 4

If you are supplying through an MSA underpinned brand or to an MSA licensed abattoir make sure you are familiar with the purchaser's specifications. The processor or brand owner may have company specifications in addition to MSA minimum requirements. While these may not impact on eating quality, they are commercially important to your purchaser and should be taken into consideration before consigning MSA cattle. Carcases outside the nominated specifications may be discounted regardless of their MSA grading result.

MEAT STANDARDS AUSTRALIA GRADED

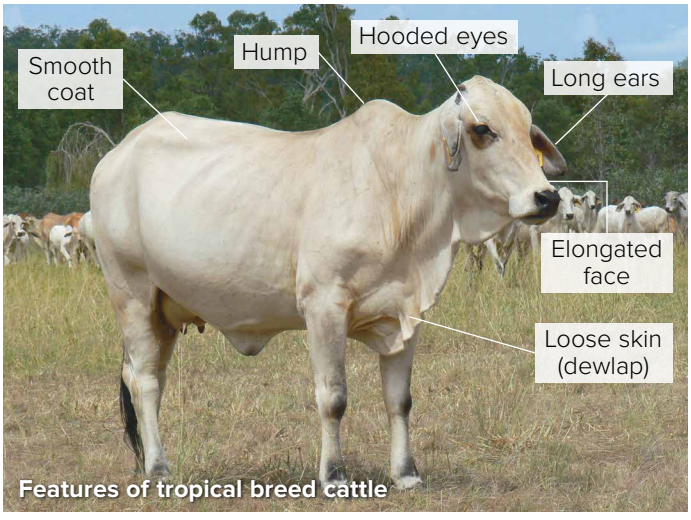
A butcher showing MSA quality meat.

Step 5

You should liaise with the abattoir to ensure cattle are slaughtered within the required time frames. When consigning cattle to an abattoir consider trucking distances and seasonal considerations. In extreme heat it may be necessary to truck cattle at night. Likewise in very cold conditions avoid trucking cattle at dawn. If possible avoid trucking through wind and rain. During high risk periods use trucks that have relatively closed in sides to minimise wind chill. For more information on the importance of these measures (see *MSA Tips & Tools: The effect of pH on beef eating quality*).

Step 6

Fill in both the Livestock Production Assurance National Vendor Declaration (LPA NVD) and the MSA vendor declaration to accompany the consignment to the abattoir. It is important that all the details are filled in correctly on both forms. MSA accredited graders use the information from the MSA vendor declaration in the grading process.
Declare any tropical breed content (TBC) in your consignment by ticking the appropriate box that represents the TBC of your cattle. The box selected is determined by the animal in the group that has the highest TBC. Livestock personnel at the abattoir are trained in determining and verifying tropical breed content. MSA graders will also measure hump height on the carcase to verify tropical breed content. For more information on hump height measurement (see *MSA Tips & Tools: The effect of tropical breeds on beef eating quality*).



Features of tropical breed cattle

Step 7

Ensure you receive your carcase feedback sheets from the abattoir or alternatively download them from the MSA feedback program, myMSA. Go to **www.mymsa.com.au** and use your MSA registration number and password to access your feedback.

Check your compliance rates and eating quality performance. Note any common factor in the non-compliant carcases. For example if most of the carcases failed to meet the rib fat requirements, the cattle require more finish. If ossification levels are high but the carcase weights and rib-fat measurements are ample, the cattle may be better turned off earlier.

Compare each consignment with the one previous, particularly where production changes have been made in an effort to improve compliance.

A small management change can significantly improve compliance without the extended generation time associated with genetic improvements.

Step 8

Talk to other MSA producers to share the knowledge they have gained from using the system. At times of seasonal risk you may want to discuss strategies for minimising pH and stress risk (see *MSA Tips & Tools: The effect of pH on beef eating quality*).

MSA feedback will enable you to gauge the performance of the cattle you produce.

Link other sources of information into your production objectives. EDGE*network*® workshops, your state Department of Agriculture or Primary Industries, local or preferred consultants can all assist in improving your management system to improve your product.

For more information

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

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MSA05 MEAT STANDARDS AUSTRALIA

The effect of tropical breeds on beef eating quality

What are tropical breed cattle?

Tropical breed cattle or *Bos indicus* are genetically adapted to tropical environments, excelling in their ability to survive and produce under adverse conditions including heat and poor quality pastures. Tropical breed cattle are also resistant to some parasites. They are an important breed option for the climate of northern Australia. Breeds include the Brahman and crosses of the Brahman such as Brangus and Santa Gertrudis.

Temperate or Bos taurus breeds include British and European cattle such as Angus, Hereford and Murray Grey.

The effect on eating quality

MSA research has shown that tropical cattle breeds have a negative impact on the eating quality of many cuts. The major effect is on the striploin, cube roll, tenderloin and oyster blade. In the cuts with high levels of connective tissue – such as the brisket, topside, outside flat and eye round – the effect of tropical breeds on eating quality is reduced. This can be seen in the table below where hump height measurements predict tropical breed content.

Hump height (mm)	TBC	Striploin		Eye of knuckle	
		MSA Score	MSA Grade	MSA Score	MSA Grade
120	100%	42	Ungrade	44	Ungrade
90	50%	48	3	46	3
45	0%	55	3	48	3

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg, male, AT (Achilles tendon) hang, ossification 150, MSA marbling 270, rib fat 7mm, pH 5.55, loin temp 7.0˚C, ageing 5 days, cooking method grill, non HGP-treated.
The above hump height measurements are indicative only.

Key points

- Tropical breed content as a single attribute has a negative impact on the eating quality of many cuts.
- Hump height and carcase weight, together, can accurately estimate the tropical breed effect.
- Cuts from tropical-breed cattle can still grade MSA 3, 4 or 5 star.
- Good management is the most important factor in all breeds particularly nutrition and stress minimisation as well as optimising carcase traits that have a positive impact on eating quality.

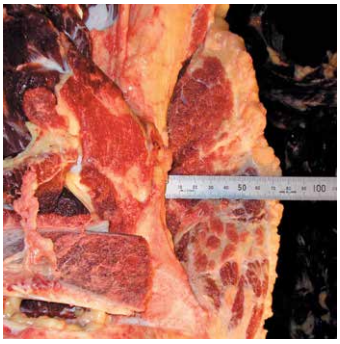
The tropical breed content of cattle is taken into account by the grading model in combination with other factors. All cuts from 100% tropical breed cattle can still meet MSA consumer grade standards if appropriate management strategies are applied throughout the production chain.

A distinctive physical characteristic of tropical breeds is a hump. In crossbred cattle the hump size relates reasonably to the percentage of tropical breed content.

MSA research has found that an equivalent 'tropical breed effect' on eating quality can be calculated by relating the carcase hump height to carcase weight. This is done within the grading model as the MSA accredited grader enters the hump height for each carcase.

How is hump height measured?

Hump height is measured by holding a ruler parallel with the surface of the sawn chine perpendicular to the 1st Thoracic vertebrae. The ruler is moved to the position of the greatest hump width. Hump height is measured by the MSA accredited grader and is recorded in gradients of 5mm. It is primarily used to verify the tropical breed content indicated on the MSA vendor declaration.



Measuring hump height.

How can tropical breed content and tropical cattle be managed to improve eating quality?

Since tropical breed content has a significant influence on MSA grading, producers should consider the amount required in their herd for environmental tolerance. The use of *Bos taurus* cattle or cross-breeds where suitable, will enable better grading compliance. As with all cattle, management practices that result in cattle being heavier and fatter at a younger age will improve grading results. Many successful operators incorporate feedlot or supplementary feeding strategies to finish a younger and superior quality product (see *MSA Tips & Tools: Maximising eating quality with tropical breed cattle*).

Post-slaughter, many cuts from tropical breed cattle can be improved through the use of tenderstretch and longer ageing (see *MSA Tips & Tools: How tenderstretch affects eating quality*).

What is required of the producer?

Where tropical breed content cattle or their crosses are being consigned for MSA grading, the tropical breed content must be declared. This can be done by ticking the appropriate box representing the TBC of the group on the MSA vendor declaration. If the mob being consigned has varying levels of tropical breed content, the highest TBC in the mob is declared. For example, if a lot of cattle are mainly Hereford (0% TBC) and Hereford-Droughtmaster crosses (25% TBC) with a few Brafords (50% TBC) in the mob, the vendor selects the highest TBC as 50%.

Hump height measurements will be used for verification of the declared tropical breed content and to determine the most accurate eating quality outcome.

It is recommended where possible, that cattle are consigned in groups of similar TBC to get the best grading result, as they cannot be drafted after arriving at the abattoir.

Abattoir livestock personnel are trained in determining tropical breed content. The following table lists examples of breeds of cattle and their tropical breed content declaration.

Table 1 Tropical breed content for various cattle breeds.

Breed	TBC
Hereford	0%
Angus	0%
Senepol	0%
Charolais	0%
Limousin	0%
Santa Gertrudis	38%
Droughtmaster	50%
Charbray	50%
Brangus	50%
Braford	50%
Brahman	100%

Table 2 Tropical breed content of common crossbreeds

Crossbreed			TBC
Euro/British	X	Brahman	50%
Santa	X	Droughtmaster	44%
Euro/British	X	Droughtmaster	25%
Santa	X	Braford	44%
Santa	X	Santa x Euro	28%
Angus	X	Santa	19%
Euro/British	X	Santa x Brahman	34%
Brahman	X	Santa x Euro/British	60%
Euro/British	X	Charbray	25%

For more information

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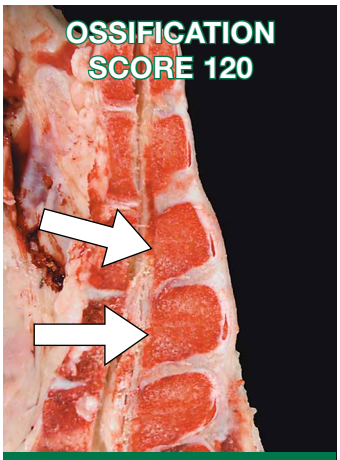
MSA06 MEAT STANDARDS AUSTRALIA

Ossification and beef eating quality

What is ossification?

Ossification is a measure of physiological maturity of the beef carcase. As an animal matures, cartilage present around bones gradually fills with blood and develops into bone. Although this development occurs in association with the animal's chronological age, it is affected by nutrition and development. Ossification is measured visually in the chiller by the MSA accredited grader.



In a young animal these bones (vertebrae) are separate.

As the animal matures these 'caps' begin to appear... and the individual bones begin to fuse together.

The scale of ossification runs from 100–590 in 10 point increments and follows the scale developed by the United States Department of Agriculture grading service.

The three areas of the backbone examined to determine ossification are the sacral, lumbar and thoracic vertebrae. The sacral vertebrae are the last five vertebrae on the tail end of an AUS-MEAT standard carcase. The lumbar vertebrae are the six vertebrae in the loin region of the carcase. The thoracic vertebrae are the 13 vertebrae to which the ribs are attached. Ossification begins in the sacral region (shown in the above pictures) and continues through the lumbar and then thoracic regions.

Key points

- Eating quality declines as ossification increases.
- Ossification increases as the animal ages but can also increase with nutritional or health stress.
- Producers can manage their animals to prevent accelerated ossification.
- MSA grading evaluates ossification in relation to carcase weight.

The following table shows the descriptions for the three vertebrae regions at selected ossification scores. It is important to note that the approximate age in months is only a guide in an optimum-condition carcase.

MSA score	Approx age in months	Sacral vertebrae	Lumbar vertebrae	Thoracic vertebrae
100	9	No ossification	No ossification	No ossification
110	10	Capping starts	No ossification	No ossification
130	15	Advancing capping; separation still visible	No ossification	No ossification
150	20	Capping completed but some cartilage still visible	No or minor ossification	No ossification
170	24	Capping completed; sacral closing	Ossification clearly evident	No ossification
200	30	Completely fused	Nearly completely ossified	Some evidence of ossification
300	42	Completely fused	Completely ossified	Partially ossified
400	72	Completely fused	Completely ossified	Outlines plainly visible
500	96	Completely fused	Completely ossified	Outlines barely visible

Why does maturity need to be determined?

Beef is made up of muscle fibre groups surrounded and supported by connective tissue. Connective tissue is made up of elastin and collagen fibres. Collagen fibres form crosslinks to stabilise and strengthen muscles. As the animal matures, the fibres in the meat become progressively stronger and more rigid and are less likely to break down during cooking. This results in tougher meat. This process of physiological maturation is not always reflected by chronological age.

Ossification measures the physiological age of the carcase and gives an indication of collagen fibre development.

The effect that physiological maturity has on eating quality is shown in the table below:

Ossification score	Eye rump side		Eye of knuckle	
	Score	Grade	Score	Grade
100	60	3	52	3
150	53	3	47	3
190	51	3	45	Ungrade

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg, male, 75mm hump, AT (achilles tendon) hang, MSA marbling 270, rib fat 7mm, pH 5.55, loin temp 7.0˚C, ageing 5 days, cooking method grill, non HGP-treated.

Ossification and growth rate

MSA grading relates carcase weight to ossification, effectively a weight for age measure. Cuts from carcases with lower ossification at the same weight are graded higher. Faster growth rates produce higher carcase weights without a significant increase in ossification levels.

Why not use dentition to measure age?

Actual age is not predicted accurately by either ossification or dentition. Tooth eruption is often delayed in cattle under nutritional stress which can lead to lower dentition scores in poorer quality carcases. In contrast ossification is accelerated by nutritional or other stress reflecting the associated lower eating quality.

Further advantages are that ossification can be assessed in the chiller during grading and described in 10 point increments from 100–590, a much finer option than the 0, 2, 4, 6 or 8 permanent incisor, dentition options.

What factors can influence ossification?

Ossification rates will vary slightly between animals, but all cattle can be managed to minimise the rate of increase. Nutrition plays a significant role. Cattle that are fed a poor diet are likely to have increased levels of ossification.

Ossification development cannot be reversed so if cattle suffer early nutritional setbacks and then have access to good feed they are still likely to show increased ossification, compared to animals of a similar age that had a steady growth rate. This is particularly evident in cattle that have come off scrub or low nutrition country into a feedlot. The carcase weight will improve considerably and the rate of ossification may slow but the effects of the early poor nutrition cannot be reversed.

Heifer carcases often have higher ossification scores than steers. This may partially reflect earlier sexual maturity and associated stresses. It often reflects management differences with steers being fed for maximum growth and early sale versus heifers being grown for joining weight targets. The heifers which fail to get in calf, or lose their first calf, are often sold as meat with much higher ossification scores than their more favourably treated steer counterparts.

Health may also affect ossification with chronically sick or injured animals showing higher rates. These animals will also have a restricted nutritional intake associated with their illness.

What can be done to keep ossification scores low?

Low ossification scores mean better eating quality and better compliance in cattle presented for grading. Cattle with fast growth rates will reach slaughter weight at a younger age and reduced ossification. Ensuring cattle have ample energy and protein for every stage of growth will assist ossification management.

Heifers selected as culls should be managed the same as steers going to the meat trade however it may be necessary to turn the heifers off early to avoid over fat carcases.

Sick injured animals should be isolated from the consignment and treated or sent separately as a suspect animal.

For more information

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

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The effect of marbling on beef eating quality

What is marbling and why does it vary between carcases?

Marbling is assessed from the 5th to 13th rib on the carcase, and seen as intramuscular deposits of fat within the muscle. It is deposited unevenly throughout the body, increasing through the carcase towards the neck and decreasing towards the tail. It is the last fat to be deposited and the first to be utilised by the animal as an energy source. Therefore, to maximise marbling, cattle must be on a high nutritional plane. Stress or fasting pre-slaughter can quickly reduce the marbling score. Beef CRC research indicates that marbling potential can also be adversely affected by growth restriction much earlier in life. Marbling is also affected by genetics. There are strong individual animal differences within each breed and breed type. Breeds such as the Wagyu, for example, are known for their extensive marbling. It should be remembered that there are strong individual animal differences within each breed and breed type.

Does marbling ensure eating quality?

Marbling has a very positive effect on the eating quality of some cuts but it is only one of the many factors affecting eating quality. High quality cuts from young cattle that have low marbling can have good eating quality, however cuts from high marbling carcases can fail to grade if other factors are poorly managed. All factors that interact to determine eating quality need to be managed together. However, where all else is equal, enhanced marbling will improve eating quality.

The effect of marbling on eating quality

MSA research has related increased marbling to higher eating quality scores for many cuts. The effect is greatest in the high value loin cuts. It is not clear to what extent this relationship is caused by improved tenderness versus juiciness.

Key points

- The term marbling refers to the small flecks of fat scattered throughout the muscle.
- Marbling has a positive effect on eating quality in many high-value cuts.
- Marbling is affected by genetics and nutritional management.
- It is possible to achieve good eating quality without marbling.

The table below shows MSA eating quality scores for three cuts from a carcase at a range of marbling scores. As can be seen, the marbling effect for each cut is different.

MSA marbling	Blade		Striploin		Outside flat	
	MSA score	MSA grade	MSA score	MSA grade	MSA score	MSA grade
200	56	3	50	3	41	Ungrade
400	59	3	58	3	44	Ungrade
600	62	3	64	4	46	3

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 75mm hump; AT (achilles tendon) hang; ossification 150; rib fat 7mm; pH 5.55; loin temp 7.0˚C; ageing 5 days; cooking method roast and non HGP-treated.

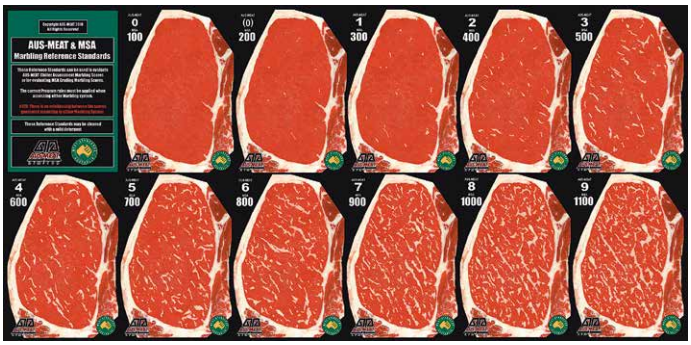
Assessing marbling

Marbling is assessed from the 5th to 13th rib on the carcase. The exposed rib eye is the assessment site used by the MSA accredited grader for marbling, pH, rib fat and meat colour measurement.

MSA-specific marbling scores are used to provide a finer scale than the AUS-MEAT scores. Each MSA marbling score is divided into tenths for grading, creating a score range from 100 to 1,190 in increments of 10. MSA

accredited graders carry visual standards for MSA and AUS-MEAT marbling and determine each score independently. Both the MSA and AUS-MEAT scores are provided on the carcase feedback. However, there is no formula to compare MSA marbling scores to AUS-MEAT marbling scores as the assessment criteria are different. The picture below shows an MSA accredited grader measuring marbling.

Marbling is assessed according to the AUS-MEAT requirements for chiller assessment when the rib eye temperature is below 12˚C. However, the lower the temperature the more solid the marbling fat will be, which may marginally improve the visual assessment.



Marbling and genetic improvement

Marbling can be improved by genetic selection. Many breeds now publish Estimated Breeding Values (EBV's) for IMF (intramuscular fat %) which can assist selection. Data from carcase feedback is also very helpful to identify genetic trends. The myMSA feedback system at **www.mymsa.com.au**, can assist in analysing marbling feedback.

On farm management

Detailed knowledge of farm management effects on marbling is lacking at present, although there is an indication that adequate and consistent growth in the phases from birth to weaning and weaning to feedlot entry is important. Suggested target growth rates for these periods are 0.9kg/day from birth to weaning and 0.6kg/day from weaning to feedlot entry. As stress is believed to have a negative impact on marbling, good temperament and management should also be considered. Marbling generally increases as an animal matures and lays down fat. While each individual animal will have more rib fat with increased marbling, the relationship is different between animals, ranging from virtually zero marbling at excessive rib and P8 fat depth to heavy marbling with moderate external fat. This creates huge differences in profitability for feedlots and others utilising long feeding regimes to target markets which desire heavy marbling.

Is rib fat important?

Rib fat is used in MSA grading as both a minimum requirement for grading and as a prediction input. The 3mm minimum standard aims at reducing temperature variation through the carcase muscles during chilling. Even chilling throughout the muscle produces more consistent and predictable eating quality as well as improved visual appearance.

A small eating quality improvement also occurs as rib fat increases from 3mm–18mm. This is in addition to the much larger effect of marbling.

Marbling in the feedlot

Accurate knowledge regarding the marbling potential of purchased feeder cattle will add considerable value when available. Rations, days on feed, HGP use, targeted growth rates and stress minimisation can all impact on marbling potential. Whereas most feedlot practices – including high energy intake, higher fat scores at exit and longer days on feed – improve marbling scores; HGP use will reduce them. Most feedlots will target their feed and management programs to maximise the marbling for the target market specifications.

For more information

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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.

pH reading	Eye round	
	MSA score	MSA grade
5.40	46	3
5.55	46	3
5.70	45	Ungrade

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 75mm hump; AT (achilles tendon) hang; ossification 150; MSA marbling 270; rib fat 7mm; loin temp 7.0˚C; ageing 5 days; cooking method grill and non HGP-treated.

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.

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.

Due to the eating quality inconsistencies, dark cutting carcases are often heavily discounted.

In Australia 5.1% of cattle MSA graded in 2017-18 had pH levels exceeding 5.70.

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.

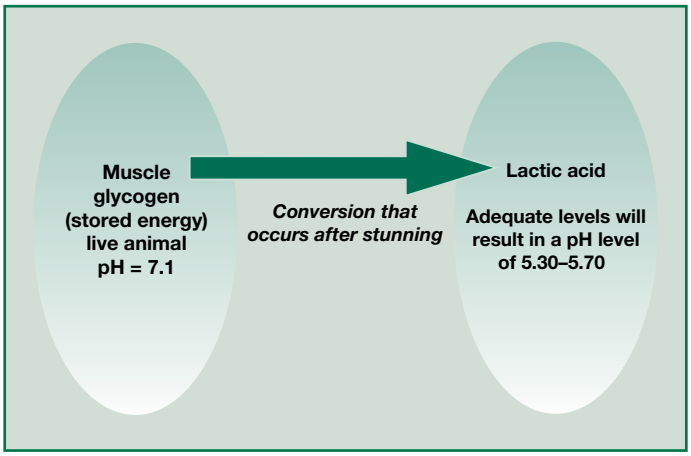
What is pH?

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

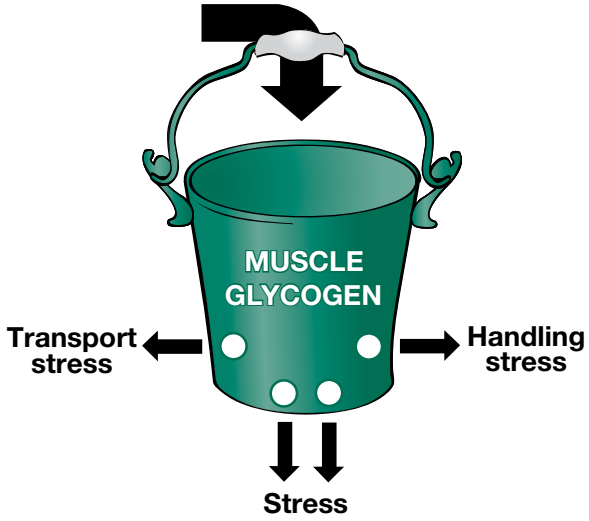
What impacts pH levels in the carcase?

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 diagram below:



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. 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 first-class pasture will have high glycogen levels. Restricted intake or low quality feed will significantly reduce glycogen, often below the critical level.

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 transport 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 loss by making the transport to slaughter time as short as possible and paying attention to transport, lairage conditions and practice.

Minimising stress caused by adverse weather conditions

Weather extremes also create stress and increase glycogen use. In cold weather cattle expend a lot of 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.

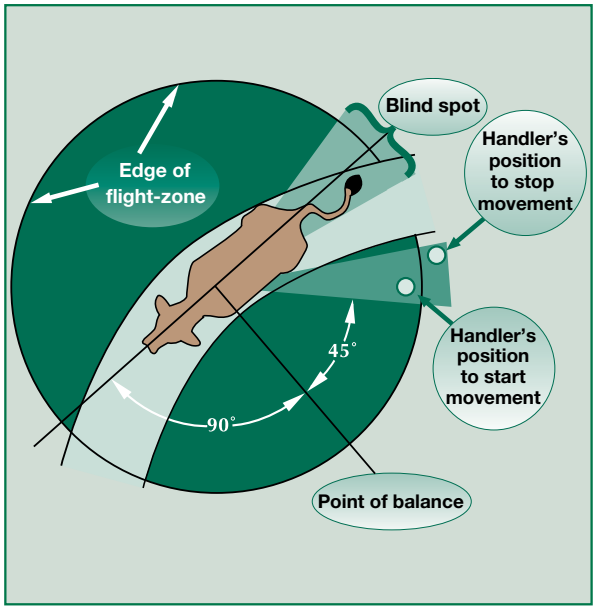
At times of seasonal risk make sure cattle are adequately finished. Cattle are most at risk of dark cutting during autumn or winter when the amount of available pasture is limited. Cattle at this time often have only minimal energy reserves so cold snaps or frost can have a critical effect. The cost 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 strong enforcers such as electric prodders or dogs. 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 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.

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.

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?

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.

For more information

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How MSA beef is graded

Licensing an abattoir

Abattoirs that process cattle for MSA must be licensed. Prior to obtaining an MSA licence, all processing critical control points of the abattoir are assessed as each can impact on the eating quality of the final product. This includes:

- Livestock receival areas to ensure cattle will not be stressed or injured.
- The slaughter floor and chillers to determine the requirements for meeting the pH-temperature window (see *MSA Tips & Tools: The effect of the pH temperature decline on beef eating quality*).
- Conduct trial carcase grading to determine likely eating quality outcomes.
- The boning room to determine packing and labelling capabilities.

A list of of MSA licensed abattoirs can be found at **www.mla.com.au/msa**.

Sending cattle to the abattoir

Cattle to be graded for MSA are consigned to an MSA licensed abattoir. A Livestock Production Assurance National Vendor Declaration (LPA NVD) and an MSA vendor declaration, which is checked by the MSA accredited grader and livestock personnel, are sent with the cattle (see *MSA Tips & Tools: How to supply beef in the MSA system*).

Procedures prior to grading

Carcases are split down the spine on the slaughter floor and the sides are placed together in the chiller overnight. Grading is generally carried out the next morning prior to commencement of the boning process.

The beef sides are cut at the loin prior to grading to expose the rib eye and a minimum of 20 minutes is allowed for the meat to bloom to its optimum colour. The loin must be less than 12 degrees Celsius.

The information about each lot, carcase numbers and tropical breed content are taken from the MSA vendor declaration and the abattoir slaughter floor production sheet.

Key points

- Determining the eating quality of MSA beef requires standards to be maintained from paddock to plate.
- Cattle that meet the MSA requirements are graded at MSA licensed abattoirs.
- Each carcase is graded by an MSA accredited grader with an eating quality score assigned to each individual cut.
- Cuts with the same eating quality are packed together with the MSA grade, recommended cooking method(s) and ageing requirements specified on the carton label.

The MSA model, which calculates the grading outcome for each carcase, is held on a data capture unit (DCU). This is a small handheld computer that the MSA accredited grader uses to record the information from each individual carcase during grading.

How carcases are graded

Each carcase is identified with a carcase ticket and the following information is recorded in the DCU:

- Carcase number and lot number – cattle from individual vendors will be kept in separate lots.
- Carcase weight – important in determining weight for maturity.
- Sex – male or female.
- Tropical breed content – recorded from the MSA vendor declaration. The hump height is measured to determine the most accurate eating quality grade outcome.
- Hanging method – determined as being either Achilles hang or tenderstretch.
- Ossification – measured to determine carcase maturity.

- Marbling – using both the MSA and AUS-MEAT measurement systems.
- Rib fat – a minimum of 3mm is required, measured at the AUS-MEAT standard site, to ensure that the carcase has adequate fat cover to protect the carcase during the chilling process. Overall fat cover is also assessed including any hide puller damage. A primal that has an area greater than 10cm x 10cm affected by hidepuller damage will be ineligible for MSA.
- pH and temperature – pH is measured using a pH meter and must be below 5.71. Temperature should be below 12˚C according to the AUS-MEAT standards.

Information on each of these factors and their impact on beef eating quality is available in other MSA Tips & Tools.

Other measurements that do not impact on eating quality but collected for feedback purposes include:

Brandowners may implement company specifications for some of these attributes based on their customer or market requirements

- Eye muscle area (EMA) – measured in square cm using an AUS-MEAT grid.
- Fat colour – recorded using AUS-MEAT chips from 0 (white) to 9 (yellow).
- Meat colour – recorded using AUS-MEAT standard meat colour chips in a range of 1A (very pale) to 7 (very dark purple).

If the carcase does not meet all the MSA minimum requirements it is given a reason for non-compliance code that indicates which of the specifications were not met.

Reasons for non-compliance	
a	subcutaneous fat depth inadequate
b	fat distribution inadequate
c	pH above 5.70
e	miscellaneous (can include bad bruising)
f	outside chiller assessment parameters
g	Fails to meet hide puller damage specifications

Note: The code ‘d’ was previously used to identify carcases that failed a now defunct MSA meat colour requirement.

Product identification and boning

To simplify the logistics of the MSA system to produce cartons of beef at the abattoir, while maintaining eating quality, carcases are classified into groups of ‘like’ eating qualities. The groups may be aligned with the brands packed by the processor.

The eating quality groups used within the abattoir are based on the requirements of their markets and customers and can be based upon the:

- eligible cuts
- recommended cooking methods
- eating quality scores
- ageing requirements.

All MSA products are identified on or within the primal packaging. Carton labels on each box of MSA product identify the MSA eating quality level, ageing periods and cooking methods for those cuts.

Carcases sent to butchers are broken down and sold according to MSA cut by cook method tables.

How grading feedback reports are generated

All information from the data capture unit is uploaded directly to the myMSA online program. Detailed grading reports and summaries are printed onsite for distribution back to the producer.

Producers can also access their feedback electronically through at **www.mymsa.com.au**

Registered producers are encouraged to attend MSA workshops to increase understanding of the factors that affect eating quality and best management practices.

Integrity of the MSA standards

Licensed abattoirs are periodically audited by an independent third party to ensure the MSA standards are maintained. MSA trained operatives assist on the slaughter floor to ensure the pH temperature window requirements are met.

Accredited MSA graders are regularly correlated against set standards to ensure consistency between all abattoirs.

For more information

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The effect of the pH–temperature decline on beef eating quality

What is the pH–temperature decline?

The pH decline is the rate at which the carcase pH level falls from 7.10 (live animal pH) to the level at which it will not fall any further (this is known as the ultimate pH). Temperature drops as the carcase is processed and then chilled. The ideal 'window' is a specification used to describe the relationship between carcase pH and temperature from slaughter to when ultimate pH is reached. If the rate of pH–temperature decline does not fall through the ideal window, then carcase eating quality can be severely compromised. With over 400 meals produced from every carcase it is an important consideration. The ultimate pH alone is also important for eating quality (See *MSA Tips & Tools: The effect of pH on beef eating quality*).

Where is the pH–temperature window assessed?

The window is assessed at the abattoir as part of MSA licensing conditions. The pH temperature decline begins on the slaughter floor and finishes in the chiller when the carcase has reached its ultimate pH. It is assessed by taking sequential pH and temperature readings using a combined pH/temperature meter. Readings are taken from a number of carcases as they come off the slaughter floor and then at timed intervals until the pH reading is at the ultimate level in the chiller. The time the carcase takes to reach its ultimate pH level determines the rate of pH decline.

The pH–temperature window is periodically checked at every MSA licensed abattoir to ensure that it is always maintained for MSA cattle.

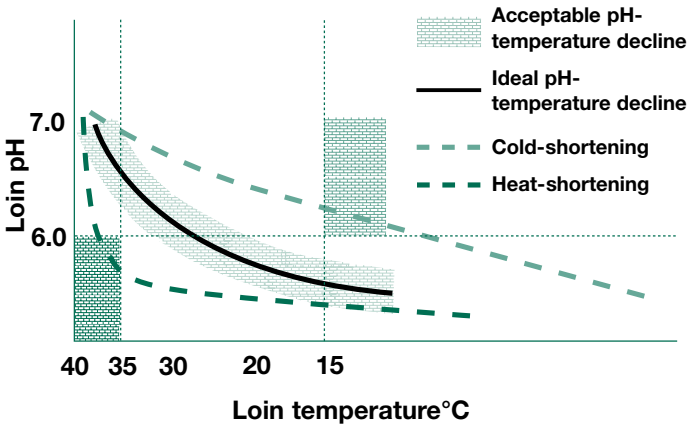
Key points

- The pH–temperature decline must fall through the ideal 'window' for eating quality.
- A pH–temperature decline that falls above the window will result in cold-shortening.
- A pH–temperature decline that falls below the window will result in heat-shortening.
- Both heat and cold-shortened meat are tough and unsatisfactory for the consumer.
- Electrical stimulation is a tool that can be used to manipulate the pH–temperature decline.

What is the pH-temperature decline specification?

The window requires the carcase pH to pass through 6.0 between 15°C and 35°C. This is shown in Figure 1 (over the page). The readings taken on the carcases at the abattoir are plotted into a graph to determine the rate of the pH-temperature fall. If the current rate of pH-temperature decline falls through the window, no adjustments to the system are required. If it does not fall through the window, then a number of alterations can be made including the use of electrical stimulation, which accelerates the rate of pH decline. The rate can be adjusted by varying stimulation frequency and application duration.

Figure 1 pH-temperature decline window.



What happens if the decline does not fall through the ideal window?

If the pH decline is too slow, remaining high while the temperature falls, the carcase will cold-shorten. This is detrimental to the quality of the meat and will result in:

- Extremely tough meat (cold-shortened meat is described as inedible).

The widespread use of electrical stimulation has reduced the likelihood of cold-shortening in most processing plants.

If the pH decline is too fast and the ultimate level is reached while the temperature is still high, heat-shortening will result. This does not make the meat as tough as cold-shortening but has undesirable effects including:

- An increase in toughness
- Pale and sometimes watery meat (known in industry as Pale Soft Exudative – PSE – meat)
- 'Two-toning' in some cuts leading to unattractive retail appearance
- The prevention of ageing (the enzymes that enable meat to become more tender with age are denatured and will no longer work)
- Reduced water-holding capacity.

How does electrical stimulation work?

Electric currents applied to the carcase make the pH fall faster. It is not a tenderisation process by itself. In fact, if too much stimulation is used, the pH falls too fast resulting in heat-shortening. There can be a number of electrical inputs on the slaughter floor, all of which need to be taken into account. For example, rigidity probes apply an electric current to the carcase to keep it rigid while the hide puller removes the hide.

This in itself can begin to increase the rate of pH fall. When determining abattoir requirements to maintain the ideal pH-temperature window, the amount of stimulation is varied to meet the window specifications.

Does anything else need to be considered?

The rate of pH decline varies with the pre-slaughter state of the animal, the number and type of electrical inputs used during processing, the speed of the slaughter-floor chain, chiller conditions and carcase weight and fatness. The amount of glycogen in the animal is very important in the pH-temperature relationship (See *MSA Tips & Tools: The effect of pH on beef eating quality*). It is also important that the abattoir has handling and receival facilities that minimise the amount of stress the animals' experience. MSA accredited graders consider all of these inputs in determining the requirements for the abattoir to maintain an ideal pH temperature decline and optimise the eating quality of the beef produced.

Can the producer play a role in keeping the pH-temperature decline in the window?

Yes! It is important that the animals reach the abattoir in as normal condition as possible. Minimising stress and ensuring animals have enough energy reserves will assist in achieving an ideal pH-temperature decline. By following the MSA guidelines (see *MSA Tips & Tools: MSA requirements for handling cattle*) and ensuring the cattle have adequate finish, producers can give their consignment the best possible opportunity to provide a satisfying eating experience for the consumer.

For more information

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

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MSA11 MEAT STANDARDS AUSTRALIA

How tenderstretch affects beef eating quality

What is tenderstretch?

Tenderstretch is an alternative means of hanging the carcase during chilling. While carcases are traditionally hung by the heel (Achilles tendon or AT), tenderstretch carcases may be hung either from the pelvic bone (TX) or through the ligament (TL) that runs down the back and over the tail of the animal (illiosacral ligament).

How does tenderstretch work?

As the carcase is chilled, and the conversion of glycogen to lactic acid is complete, the muscle fibres contract slightly and become rigid. This process is known as rigor mortis. After rigor mortis has occurred, the muscles are referred to as meat.

Tenderstretching can be done by a variety of methods. The most common is by positioning the hanging hook under the ligament that runs down the back of the animal (illiosacral ligament) or under the Aitch bone of the pelvis.

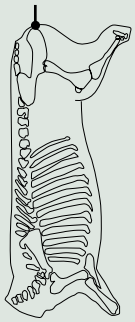
When a carcase is tenderstretched, and suspended by the pelvis, the leg drops down at a 90˚ angle. As a result, a number of muscles are held in a stretched position so they cannot contract during rigor mortis. This is shown in Diagram 1. Tenderstretch is most effective in the hindquarter and has a varying effect on each cut.

Traditionally, the carcase is suspended by the Achilles tendon. In the Achilles hung carcase, shown in Diagram 1, the spine is curved and the rear leg muscles have less tension on them. As a result, when these muscles go through rigor mortis they can contract. When this occurs the muscle fibres overlap resulting in slightly tougher meat.

Key points

- Tenderstretch hanging improves meat tenderness by preventing muscle shortening.
- The tenderstretch effect varies by muscle, with the eating quality of most hindquarter muscles improved.
- Producers may consider using abattoirs that utilise tenderstretch hanging as it will improve MSA grading results.

Does tenderstretch improve all cuts?



Tenderstretch (TS)

Achilles tendon (AT)

Diagram 1.

The tenderstretch effect varies by muscle according to the position on the carcase and degree of stretching. This is shown in the following table.

Cut	Achilles		Tenderstretch	
	MSA score	MSA grade	MSA score	MSA grade
Cube roll	61	3	66	4
Striploin	51	3	59	3
Rump	50	3	57	3
Tenderloin	76	5	74	4
Eye round*	45	Fail	46	3

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 80mm hump; ossification 150; MSA marbling 270; rib fat 7mm; pH 5.55; loin temp 7.0˚C; ageing 5 days, cooking method grill and non HGP-treated.

Although the tenderstretch effect is slightly negative in the tenderloin, (which is stretched in an AT carcase), it is strongly positive in most other hindquarter cuts and largely neutral in forequarter cuts other than the cube roll (ribeye).

Tenderstretch is often a key factor in grading compliance for high tropical breed content cattle (see *MSA Tips & Tools: The effect of tropical breeds on beef eating quality*).

The effect of tenderstretch on ageing

In addition to altering the MSA score, tenderstretch also affects the degree and rate of ageing. Quantifying the impact of ageing on each cut is a complex calculation.
The MSA grading model calculates this and all other variables for each individual cut.

The table below shows the values for the cube roll tenderstretch and Achillies hung. Tenderstretch significantly improves the five-day score of the cut, but alters the impact of ageing over time. This relationship is variable for each cut and the characteristics of the carcase.

Days age	Cube roll MSA score	
	Achilles	Tenderstretch
5	61	66
14	63	67
21	65	68
28	66	69

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 80mm hump; ossification 150; MSA marbling 270; rib fat 7mm; pH 5.55; loin temp 7.0˚C; cooking method grill and non HGP-treated.

Why is tenderstretch not used more widely?

Although tenderstretch was proven to be effective in improving tenderness twenty years ago, it was not widely adopted due to the perceived inconvenience, extra costs and the lack of financial incentive for improved eating quality. MSA grading quantifies the benefit of tenderstretch, offering the potential to increase returns. This has resulted in several MSA abattoirs adopting the process.

A tenderstretch carcase.

For more information

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

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MSA12 MEAT STANDARDS AUSTRALIA

How ageing affects beef eating quality

What is ageing?

Just as wine or cheese can mature with age, beef eating quality can also improve with time. Ageing is a process that occurs as the muscle fibres in meat are slowly broken down. Naturally occurring enzymes continue to act in the meat resulting in a slow breakdown of the proteins that make up the muscle fibres. This leads to the muscle fibres being weakened and, as a result, aged beef tends to be more tender. The appearance of beef does not change with ageing, as the breaking down of the muscle fibres happens on a microscopic level.

The influence of ageing on eating quality

MSA research has shown that ageing can improve eating quality. The ageing effect is different for various muscles as shown in the table below. The rate of ageing also decreases over time with most improvement occurring in the first 21 days.

	Cube roll		Tenderloin	
Days aged	MSA score	MSA grade	MSA score	MSA grade
5	62	3	77	5
14	64	4	77	5
35	67	4	77	5

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 75mm hump; AT (achilles tendon) hang; ossification 150; MSA marbling 270; rib fat 7mm; pH 5.55; loin temp 7.0˚C; cooking method grill and non HGP-treated.

Key point

- Ageing can improve the eating quality of beef by improving the tenderness.
- Ageing can occur on the carcase or in vacuum packaging.
- As all factors that effect eating quality interact, ageing rates and affects also differ. For example, tenderstretch carcases age at a different rate relative to those that are not tenderstretched.

As all factors that affect eating quality interact, ageing rates and effects also differ. For example, tenderstretched carcases age at a different rate relative to those that are hung by the achilles tendon (See *MSA Tips & Tools: How tenderstretch affects eating quality*).

How can beef be aged?

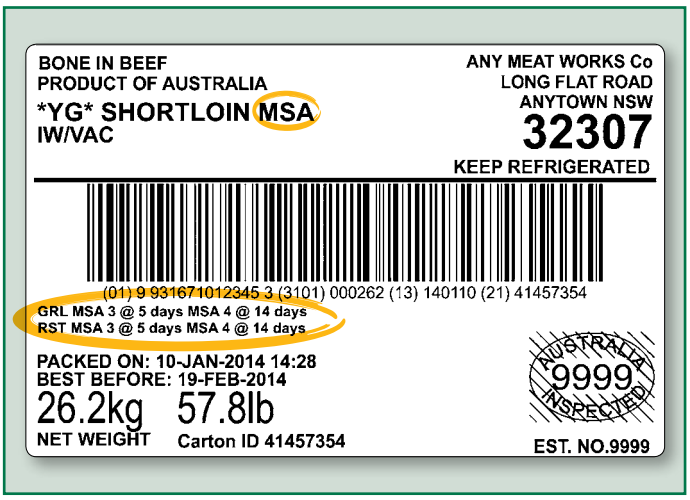
Beef can be aged in carcase form, on the bone in primals, or in vacuum packaging for long periods. In practice carcases tend to be aged only for five days. Further ageing can be carried out, but good chilling and food safety considerations need to be taken into account.

Product from a boning room is packaged in oxygen free, vacuum-sealed plastic bags. Meat can be safely stored this way, under refrigeration for up to 12 weeks. Meat that is aged beyond this time may develop ‘off’ odours and give the beef what is described as a ‘liver’ taint.

How ageing is applied in the MSA system

The MSA grading model determines the ageing effect for each cut. This establishes the date the cuts will reach the applicable MSA grade. Some cuts may achieve a higher grade with additional ageing. For example, if the cut grades as MSA 4 product after five days, the model will then determine if the cut can improve with ageing to reach MSA 5 and the date at which it occurs.

In abattoir boning rooms, carcases are often assigned into boning groups. This enables the carcases that have the same grades for the same cuts to be boned out and packaged together. Carton labels are produced showing the required ageing period. A sample carton label is shown below.



In this example, the shortloin can be released as:

- ✓ MSA 3 star, grill or roast after 5 days ageing
- ✓ MSA 4 star, grill or roast after 14 days ageing

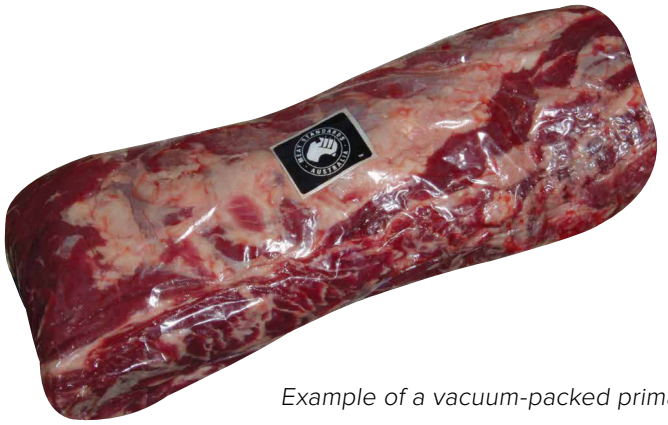
Who is responsible for ageing?

All MSA product has a minimum five-day ageing period before it can be sold and identified as MSA to the consumer. Ageing meat requires refrigerated storage, which adds cost. When MSA product has two grade options, it can be sold at either grade as long as the required ageing periods are met. In this way, the processor, wholesaler or retailer can determine the value of additional ageing.

It is the responsibility of the final end user to ensure the ageing requirements are met before they sell to the consumer.

Can anything affect ageing?

The pH temperature decline maintained at the abattoir can have a significant effect on the potential ageing of a product. Carcases that go through a rapid pH decline will be heat-shortened. When this happens the enzymes that enable the ageing process to occur are destroyed. This results in product with limited or nil ageing potential. (See *MSA Tips & Tools: The effect of the pH temperature decline on eating quality*).



Example of a vacuum-packed primal.

For more information

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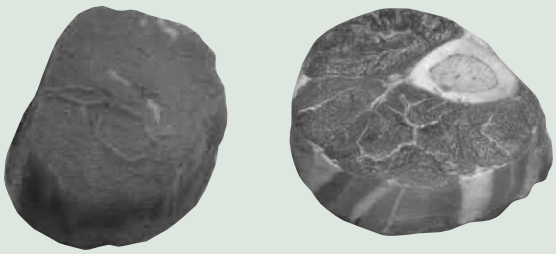
MSA13 MEAT STANDARDS AUSTRALIA

The effect of cooking on beef eating quality

How cooking method affects eating quality

Muscle is made up of muscle fibre groups, surrounded and supported by connective tissue which contains collagen fibres. Collagen fibres form cross-links to stabilise and strengthen muscles. Different muscles have varying amounts of connective tissue related to the amount and type of work the muscle has to do. For example the shin muscles, which are used constantly, have a high connective tissue content. This can be seen in the picture below which compares a cross section of shin with tenderloin.



Tenderloin Shin

The collagen and connective tissue can be partially broken down through slow or casserole cooking which use low heat and moisture over a long period of time. The broken down connective tissue provides the gelatinous or thickened texture of the casserole. This is why shin beef is best suited to casseroles and why it is commonly known as gravy beef.

By contrast, a muscle such as the tenderloin (fillet) which sits on the inside of the spine near the pelvis, does very little work, so contains almost no connective tissue. As a result this muscle is very tender.

The tenderloin would not be suitable for casserole cooking as its structure would be completely broken down. This cut is best suited to pan frying or grilling.

Key points

- The cooking method used is one of the most important factors in eating quality and can be used to optimise the performance of a piece of beef.
- MSA uses cooking method eating quality calculations.
- MSA provides up to 8 recommended cooking methods for each cut within the carcase

Why is it important to include cooking method on the label?

Different cooking methods can alter eating quality. A rump steak, for example, is a traditional BBQ meat in Australia. MSA research indicated rump was better utilised as roast, stir fry or thin slice. However other cuts, such as the tenderloin, were not improved by roasting. Some examples of these relationships are shown in the table below.

Cooking method	Eye rump side		Eye of knuckle		Tenderloin	
	MSA score	MSA grade	MSA score	MSA grade	MSA score	MSA grade
Grill	53	3	47	3	77	5
Roast	62	3	60	3	76	4
Stir fry	61	3	55	3	79	5
Thin slice	60	3	59	3	73	4
Slow cook	Not tested		48	3	Not tested	
Yakiniku	64	4	57	3	69	4
Shabu shabu	Not tested		Not tested		66	4

The above data is taken from a standard MSA carcase with the following specifications: HSCW 240kg; male; 75mm hump; AT hang; ossification 150; MSA marbling 270; rib fat 7mm; pH 5.55; loin temp 7.0˚C; ageing 5 days and non HGP-treated.

Today's consumers do not have extensive cooking knowledge. Beef is a particularly confusing subject as there are many different cut names and no clear direction as to the best cooking method for each of these. Consumers are reliant on the information from their butcher or on finding a label in a supermarket.

Using the correct cooking method with the correct cut of beef is the most important factor in maintaining eating quality. MSA grading predicts the eating quality of each carcase muscle when cooked by various methods. The retailer can use this information to prepare and sell each cut in the form, which provides the best eating experience.

The MSA retail label provides the required cooking advice to the consumer in conjunction with the grade. This provides the consumer with confidence and removes the need for them to have any knowledge of beef cuts and their usage.

MSA cooking methods

The following cooking methods are used as part of the MSA grade. Where MSA is used to underpin a brand, that brand can have its own cooking label but the corresponding cooking method for the cut and grade must be displayed.

ROAST

Roast

Cuts displaying this symbol are suitable for roasting in a moderate oven (180˚C). Accurate cooking is best determined using a meat thermometer. Internal temperatures should be as follows for the different degrees of doneness: Rare 60˚C; Medium 65˚C; Well done 75˚C. When the roast is removed from the oven, allow it to rest for 10 minutes prior to carving.

CASSEROLE

Casserole or slow cook

Cuts displaying this cooking method should be cooked in sauce or gravy on low heat for two hours. The product is prepared in 20mm cubes.

STIR FRY

Stir-fry

Cuts suitable for this cooking method can be purchased already cut into strips. If cutting is required, slice strips at right angles to the grain and approximately 10mm in width and depth, and approximately 75mm in length.

THIN SLICE

Thin slice

Products displayed as thin slice should be prepared by cutting the product to 2mm thickness.

GRILL / PAN FRY

Pan fry/grill

Steaks displaying either of these symbols are suitable for cooking in a pan, grill or BBQ. Must be sliced a minimum of 21mm thick.

SHABU SHABU

Shabu shabu

Products displayed with this symbol are suitable for wet cooking and should be prepared by cutting the product to 1.5-1.8mm thickness. To get the best result, chill the product and cut on a slicing wheel.

YAKINIKU

Yakiniku

Products displayed with this symbol are suitable for dry cooking methods and should be prepared by cutting the product to 4mm thickness.

CORN

Corn

Products displayed with this symbol are suitable for corning. The product is corned using a cure of the value-adder's choice and prepared by a slow, wet cook.

For more information

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MSA14 MEAT STANDARDS AUSTRALIA

Fat distribution and eating quality

What is fat distribution?

Fat distribution is the coverage and distribution of subcutaneous (external) fat on a carcase.

Why do we need fat cover?

An even coverage of subcutaneous fat leads to even chilling throughout the underlying muscles. The greater the fat depth on a carcase, the slower and more uniform the muscle-chilling rate will be. The coverage and distribution of subcutaneous fat over primals helps prevent dehydration and provides protection for the muscles from microbial contamination.

Uneven fat coverage causes the muscles with inadequate coverage to chill at a faster rate. An irregular pattern of pH-temperature decline occurs, which can create cold-shortening conditions near the surface and heat-shortening in the deep core. The rate of pH decline can impact on the predictability of eating quality, specifically by falling too slowly and increasing the potential for cold-shortening or by falling too quickly and increasing the potential for heat-shortening. *(See MSA Tips & Tools: The effect of pH-temperature decline on beef eating quality).*

Uneven fat distribution can occur due to cattle type, nutritional background of cattle or when fat is removed from a carcase during the mechanical removal of the hide, exposing the underlying muscle. This is known as hide puller damage and can lead to uneven chilling throughout the exposed muscles.

MSA grading requirements for fat distribution

The MSA accredited grader must assess the distribution of fat over primals to ensure coverage is sufficiently adequate to prevent severe chilling.

A minimum of 3mm of subcutaneous rib fat at the quartering site, or 5mm at the P8 site is required. Where parts of the carcase are void of fat coverage, affected primals or the entire carcase are ungraded.

Key points

- Fat distribution is the coverage and distribution of subcutaneous fat on a carcase.
- Even fat distribution is required to ensure the carcase chills at a uniform rate.
- Carcases may fail to meet MSA specifications if the fat distribution is inadequate.
- It is important that cattle have access to an increasing plane of nutrition for at least one month prior to slaughter to assist in even fat coverage.

Fat distribution standards

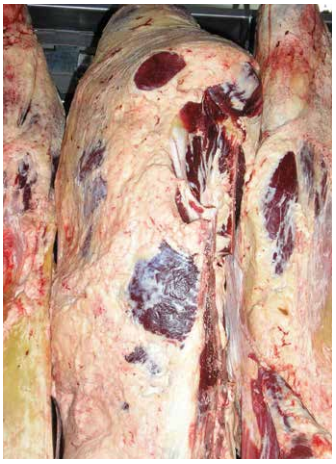
Rib fat	3mm minimum
P8	5mm minimum
Fat distribution	Must be even and adequate Void area <10cm x 10cm

Adequate fat distribution

Hide puller damage

Key points

- Hide-puller damage leads to uneven chilling of the exposed area of the carcase.
- Where hide puller damage of greater than 10cm x 10cm occurs on a single primal cut, the affected primal or the whole carcase is downgraded.



What is hide-puller damage?

Hide puller damage occurs when fat is removed during the mechanical removal of the hide, exposing the underlying muscle.

Example of unacceptable hide puller damage.

Why is it important to maintain even fat coverage?

A carcase that has patches of fat removed during the hide removal process will not chill evenly in the exposed muscles. These muscles will chill at a faster rate with a larger temperature difference within those muscles. An irregular pattern of pH-temperature decline occurs, which can create cold-shortening conditions near the surface and heat-shortening in the deep core. Commercially this is often seen as 'two toning' in cuts such as the rump where meat colour can be light in the centre and dark at the edges.
(See *MSA Tips & Tools: The effect of pH-temperature decline on beef eating quality.*)

MSA grading requirements for hide puller damage

The MSA accredited grader assesses hide-puller damage during grading, with the main focus over the major primals where effects are most severe, such as the cube roll, striploin and rump. The MSA standard will accept hide-puller damage less than 10cm x 10cm on a single primal or if the damage occurs over a cutting line, for example, the caudal end of the striploin and the cranial end of the rump.

Managing downgraded cuts for hide puller damage

Where a single primal is void of fat coverage (>10cm x 10cm), the primal or the carcase may be ungraded (fail to meet MSA requirements). Processors have the option of either ungrading the entire carcase or removing the primal affected by the hide-puller damage. When choosing to remove the primal:

- The MSA accredited grader must identify the affected primal at the time of assessment.
- The processor must be able to show MSA there is a process in place to exclude the affected cut, written in the enterprise quality manual.

For more information

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

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MSA15 MEAT STANDARDS AUSTRALIA

Selling cattle through an MSA saleyard

The MSA program is a valuable asset for the Australian beef industry as it provides opportunities to differentiate product in the market.

The MSA standards include the saleyards pathway for eligible cattle. More detail on the standards can be found in the *MSA Standards Manual for saleyards*, which is available at **www.mla.com.au/msa.**

Key points

- MSA eligible cattle can be sold through MSA licensed saleyards or livestock exchanges.
- Producers must be MSA registered to supply cattle to licensed saleyards.
- Agents must be registered to handle cattle through the pathways.
- Training requirement for agents and saleyard operators.
- Requirements detailed in *MSA Standards Manual for saleyards.*

Preparing cattle for sale

Cattle are exposed to stress during the selling process, caused by movement from the farm to the sale and the abattoir, unfamiliar sights, sounds and smells, and the actual auction process itself. These factors cause the animals to use up their energy stores to deal with the surrounding stress. It is important that cattle have sufficient energy stores to cope with these stressors. (see *MSA Tips & Tools: The effect of pH on beef eating quality.*)

Cattle carrying a lot of fat or in finished condition can still be energy deficient and can be draining their energy reserves well before they appear to be losing condition. The only way to ensure cattle have high energy reserves is to feed high energy feed for a period of 30 days prior to consignment.

Low energy feed such as poor quality feed or pastures are not adequate to maintain the energy reserves of cattle. Low energy levels in cattle will result in a high pH carcase, dark meat colour and reduced eating quality.

Cattle are not to be drafted or mixed with new mobs. When cattle are mixed with new mobs they go through a period of adjustment to the social group pecking order. While this period of adjustment is occurring the mob is subjected to increased stress. This is also the reason behind the MSA requirement for there to be no mixing of lots at either the saleyard or the abattoir (see *MSA Tips & Tools: MSA requirements for handling cattle).*

At the sale

Upon arrival of consignments at the saleyard MSA vendor declarations are verified as being correct and eligible in accordance with the standards. Cattle are penned in appropriate yards, importantly mobs must not be mixed or inter-lotted. Pens of eligible cattle are labelled with their eligibility under the standard, dispatch time from farm and maximum time until slaughter.

After the sale

The MSA vendor declaration (or a copy) must continue with the consignments where they are destined for MSA grading. The licensed saleyard will monitor the adherence of the standards at each sale and ensure ineligible cattle are excluded from the sale. The saleyard will maintain documentation to ensure the standards are controlled.

On farm responsibilities: all cattle production systems

- Producers must be registered with msa to supply cattle for grading.
- No cattle with secondary sexual characteristics.
- No cattle that have been severely sick or injured.
- No cattle of poor temperament.
- All cattle must reside on the property of dispatch for a minimum of 30 days prior to dispatch.
- Cattle are to be managed as a single mob for a minimum of 14 days prior to dispatch for slaughter.
- MSA vendor declarations must be delivered with the cattle *(as supplementation to other state-based requirements).*

Saleyard responsibilities

- Livestock exchange and saleyard to be licensed and have completed training as defined by the authorised authority.
- The livestock exchange or saleyard must have systems in place that will be monitored from time to time to verify compliance against the *MSA standards manual for saleyard consignment* as determined by the authorised authority.
- MSA vendor declaration to accompany cattle to and from livestock exchange and saleyard.
- MSA eligible cattle to be clearly identified at all times.
- Cattle groups are not to be mixed at any point from farm to slaughter, excluding split mobs.
- No cattle that have been severely sick or injured at the time of sale.
- Cattle shall be held on soft standing surfaces, within the livestock exchange or saleyard facility other than the minimum period of time required for the actual sale.
- Cattle within the livestock exchange or saleyard will have access to water at all times.

Agents responsibilities

- Agents must be registered.
- Adhere to the *MSA Standards Manual for saleyards.*

Processor responsibilities

- Cattle shall be slaughtered within 36 hours after dispatch from the farm or property.
- Five CMQ4 score point deduction for saleyard pathways.

For more information

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

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MSA16 MEAT STANDARDS AUSTRALIA

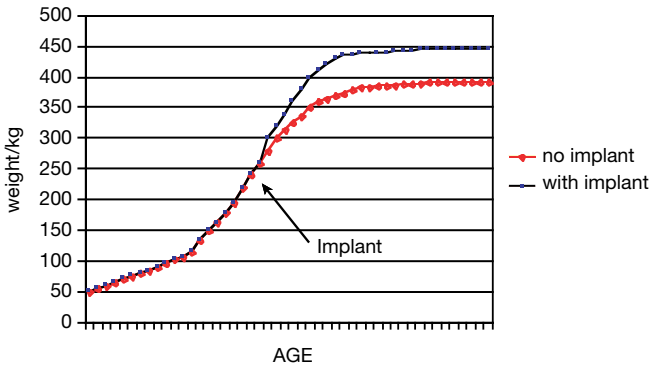
The effect of growth promotants on beef eating quality

What are growth promotants?

Growth promotants registered for cattle are pellets that are implanted under the skin of the ear. Growth promotants play a vital role in delivering the required productivity gains in various sectors of the beef supply chain through increased weight gain and improved feed conversion efficiency.

Growth promotants contain synthetic forms of oestradiol, progesterone and/or testosterone as the active ingredient. Their action is anabolic, that is, they increase nitrogen retention and protein deposition in animals. These compounds occur naturally in untreated animals; treatment simply increases the concentration and metabolic effect. The well-proven effects of growth promotants are heavier weights for age, a reduction in marbling at a constant carcase weight, or an increase in carcase weight at constant fat levels. A plentiful supply of good quality feed must be available to achieve this growth response.

The effect of using anabolic implants on growth



What is the impact on eating quality?

MSA research has established that growth promotants may have an effect on the eating quality of some cuts. The effect differs between muscles and is reduced with cut ageing. The striploin and cube roll are worst affected, the rump and topside intermediate, and other cuts are less affected. MSA research was conducted with product from male and female cattle produced in both northern and southern Australia utilising both grass and grainfed systems. Breeds included purebred Angus and *Bos indicus* composites sourced from commercial and research herds. A number of growth promotant products and combinations were used with between one and seven treatments at various stages of production.

Key points

- Growth promotants can have an adverse effect on eating quality.
- The effect varies across different muscles.
- The effect can be managed utilising other MSA pathways, eg ageing and or tenderstretching.
- Cattle treated with growth promotants are eligible for MSA grading.
- Growth promotant usage is to be declared on both the MSA and LPA national vendor declarations.

What is the effect on marbling?

The use of growth promotants reduces the amount of marbling at a constant carcase weight. With reduced marbling there is a reduction in MSA score for many cuts. (See *MSA Tips & Tools: The effect of marbling on beef eating quality*).

What is the effect on ossification?

Australian and US research has shown that ossification is increased by growth promotant use. This increase can be quite dramatic when the growth promotant is applied at a young age. The research concluded that the increase in ossification score is variable depending on the time of implanting. If ossification were constant, then the increased carcase weight gained from using the growth promotant would lead to a higher MSA score, however this is not the case in commercial application.

Hang method	Achilles (AT)		Tenderstretch		Achilles (AT)		Tenderstretch		Achilles (AT)		Tenderstretch	
Ageing	5 days		5 days		14 days		14 days		21 days		21 days	
Growth promotant treatment	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Tenderloin	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4	MSA4
Striploin	MSA3	ungrade	MSA3	MSA3	MSA3	ungrade	MSA3	MSA3	MSA3	MSA3	MSA3	MSA3
Cube roll	MSA3	MSA3	MSA4	MSA3	MSA3	MSA3	MSA4	MSA3	MSA3	MSA3	MSA4	MSA3
Rump	MSA3	ungrade	MSA3	MSA3	MSA3	ungrade	MSA3	MSA3	MSA3	MSA3	MSA3	MSA3
Blade	MSA3	ungrade	MSA3	ungrade	MSA3	MSA3	MSA3	MSA3	MSA3	MSA3	MSA3	MSA3
Topside	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade	ungrade

The above information is based on a carcase with the following carcase characteristics: 250kg male; 260 ossification; MSA marble 280; 90mm hump; rib fat 7mm; pH 5.55; loin temp 7.0 and cooking method grill.

How will my cattle grade?

Growth promotant use is to be declared on the MSA and LPA National Vendor Declarations. If a producer is unsure of the growth promotant history of the animals, the 'yes' box should be ticked.

Growth promotant use will not exclude cattle from MSA grading but it will affect the MSA score obtained for different muscles, depending on how close they are to the grade boundary. The MSA score for each cut is determined by a combination of variables. Some, such as marbling and carcase weight, are positive, while others, such as increased maturity, are negative. It is the combination of all these factors that determines the difference.

How can grading outcomes be improved?

There are two principal post-slaughter management procedures that can be utilised to improve the eating quality of animals treated with growth promotants. The first is to increase the ageing period, especially on cuts that have high-ageing rates. The second is to use the tenderstretch method of hanging carcases. The improvement with ageing correlates with the ageing potential of the muscles, so that cuts that improve significantly with ageing, such as striploin, will improve to a greater extent than cuts such as tenderloin.

Tenderstretch has a positive impact on eating quality (See *MSA Tips & Tools How tenderstretch affects beef eating quality*). The table above shows the effect of ageing or tenderstretch on the example carcase shown above from a steer implanted with growth promotants.

MSA's objective is to accurately predict the eating quality as judged by the consumer, not to be prescriptive as to how to raise, process or sell cattle. The decision on whether or not to include growth promotants in a management program rests with the producer and will be influenced by the mix of production and eating quality effects and their economic impact.

A tenderstretch carcase.

For more information

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

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Maximising eating quality with tropical breed cattle

The effect of tropical breed content on beef eating quality

MSA research has shown that as a single attribute, breed has around 12% effect on eating quality. The major effect is on the striploin, cube roll, tenderloin and oyster blade primals.

As tropical breed content increases, eating quality scores decrease, see Table 1 below for examples of MSA scores, ranging from 0–100.

The effect of tropical breed content on eating quality scores differs according to specific primal cuts. For example, in Table 1, as the tropical breed percentage increases, the eating quality scores for the rump primals barely change. However, the striploin primal score reduces significantly, decreasing to 49 in the 100% TBC animal.

Key points

- All breeds of cattle are eligible for the MSA program.
- Breed content has up to a 12% effect on beef eating quality.
- On farm management of genetics, nutrition and weight gain will maximise eating quality of beef from tropical breed cattle.
- Processors can further improve product by ageing primal cuts for extended periods or using tenderstretch hanging techniques.
- Hump height is measured on the carcase in conjunction with carcase weight to verify or determine the tropical breed effect.

Table 1. The effect of tropical breed content on eating quality scores.

Cut	Hump height and breed example							
	60mm		85mm		95mm		120mm	
	British/Euro (0% TBC)		Santa Gertrudis (38% TBC)		Brahman x British/Euro (50% TBC)		Brahman (100%)	
Tenderloin	79	MSA5	77	MSA5	75	MSA4	72	MSA4
Cube roll	69	MSA4	66	MSA4	65	MSA4	61	MSA3
Striploin	59	MSA3	58	MSA3	55	MSA3	49	MSA3
Rump	55	MSA3	54	MSA3	53	MSA3	51	MSA3

MSA 5 *MSA 4* *MSA 3*

Example animal: Male; no HGP; 270kg HSCW; ossification 170; MSA marbling 330; rib fat 5mm; pH 5.55; Achilles hanging method; grill cooking method and 28 days ageing.

MSA eating quality scores range from 0–100. According to consumer research, scores <46 fail eating quality expectations, therefore are classified as 'ungrades' and may not be sold as MSA certified product.

The tropical breed effect is calculated by measuring hump height in conjunction with carcase weight to verify TBC declared on the MSA vendor declaration.

The cattle breeds stated are examples only.

On farm management to maximise eating quality

To achieve higher returns on farm, producers should focus on meeting the specifications of the processor, to produce the best possible meat eating quality for consumers. Each processor may have specific breed requirements.

On farm management of genetics, nutrition and weight gain can maximise the eating quality of tropical breed cattle.

Nutrition

Cattle should be kept on a rising plane of nutrition for at least 30 days prior to processing. This is a vital stage of cattle production, where set-backs can have a significant impact on meat eating quality.

Ossification

Since northern cattle are generally subjected to more environmental stresses than southern cattle, maturity and ossification occur at a more rapid rate, adversely affecting meat eating quality. Therefore, while the 30 days prior to processing are important, good nutrition right through the life of the animal can slow the rate of ossification, therefore maximising eating quality.

Weight

In order to enhance eating quality, on farm management practices should focus on reaching the optimal weight at the youngest possible age of the animal.

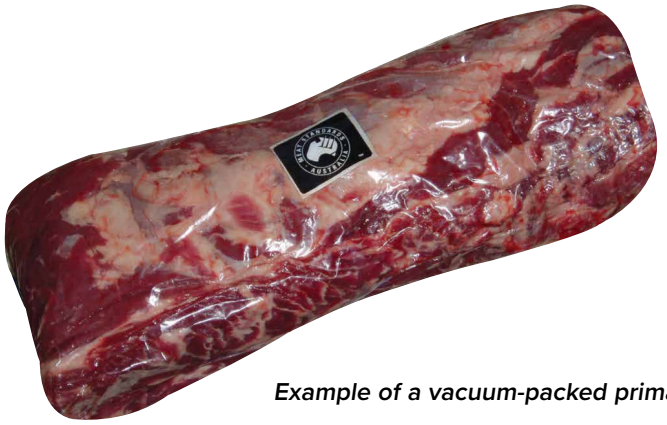
Tropical breed content is beneficial for cattle in harsh climates as they are genetically adapted to heat, can produce on low quality pastures, and are resistant to parasites. However, the introduction of European or British genetics to form composite breeds can significantly improve eating quality while maintaining an environmentally adapted herd.

Post slaughter management

Ageing primals to improve eating quality

Beef from tropical breed cattle can be further improved with ageing. Extended ageing of vacuum-packed primals improves eating quality in many cuts, as during storage in the bag under refrigeration, naturally occurring enzymes continue to break down muscle fibres in the meat. As the ageing period extends, the beef becomes more tender, with the most improvement occurring in the first 21 days.

See Table 2 which shows the effect of the ageing process on primals from an animal with an equivalent 50% tropical breed content. The striploin and rump primals improve to achieve MSA quality after 21 days ageing, while the ageing has minimal effect on the tenderloin.



Example of a vacuum-packed primal.

Table 2. The effect of ageing on eating quality scores.

Cut	Ageing period			
	5 days	14 days	21 days	35 days
Tenderloin	69	70	70	70
Cube roll	50	54	56	59
Striploin	41 (fail)	45 (fail)	48	51
Rump	43 (fail)	45 (fail)	47	50

MSA 5 *MSA 4* *MSA 3*

Example animal: Male; HGP treated; 250kg HSCW; ossification 170; MSA marbling 300; rib fat 5mm; pH 5.55; Achilles hanging method; 90mm hump (50% TBC equivalent) and grill cooking method.

MSA eating quality scores range from 0–100. According to consumer research, scores <46 fail eating quality expectations, therefore are classified as 'ungrades' and may not be sold as MSA certified product.

Tenderstretch

Tenderstretch can be used as an alternative means of hanging the carcase during chilling to improve meat tenderness. The process can reduce the meat ageing period required to achieve the same eating quality result.

Tenderstretching a carcase involves suspension from either the pelvic bone or through the illiosacral ligament, so the leg drops at a 90° angle. This differs from the mainstream method of hanging a carcase by the Achilles tendon.

When a carcase is tenderstretched, a number of muscles are held in a stretched position so they cannot contract, especially muscles in the hindquarter.

Table 3: The effect of achilles and tenderstretch hanging method on eating quality scores after 5 days of ageing.

	Achilles	Tenderstretch
Tenderloin	69	68
Cube roll	50	56
Striploin	41 (fail)	49
Rump	43 (fail)	50

MSA 5 *MSA 4* *MSA 3*

Example animal: Male; HGP treated; 250kg HSCW; ossification 170; MSA marbling 300; rib fat 5mm; pH 5.55; 90mm hump (50% TBC equivalent) and grill cooking method.

A tenderstretch carcase.

Table 4. Tropical breed content for various cattle breeds.

Breed	TBC
Hereford	0%
Angus	0%
Senepol	0%
Charolais	0%
Limousin	0%
Santa Gertrudis	38%
Droughtmaster	50%
Charbray	50%
Brangus	50%
Braford	50%
Brahman	100%

Table 5. Tropical breed content of common crossbreeds.

Crossbreed			TBC
Euro/British	X	Brahman	50%
Santa	X	Droughtmaster	44%
Euro/British	X	Droughtmaster	25%
Santa	X	Braford	44%
Santa	X	Santa x Euro	28%
Angus	X	Santa	19%
Euro/British	X	Santa x Brahman	34%
Brahman	X	Santa x Euro/British	60%
Euro/British	X	Charbray	25%

For more information

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Using the MSA Index to optimise beef eating quality

What is the MSA Index?

The MSA Index is a single number and standard national measure of the predicted eating quality and potential merit of a carcase.

The MSA Index is a number between 30 to 80, expressed to two decimal places (ie 54.62), to represent the eating quality potential of a whole carcase. The MSA Index is independent of any processing inputs and is calculated using only attributes influenced by pre-slaughter production. It is a consistent benchmark, which can be used across all processors, geographic regions and over time. It reflects the impact on eating quality of management, environmental and genetic differences between cattle at the point of slaughter.

How is the MSA Index calculated?

The MSA Model predicts the eating quality of 39 cuts in a carcase using the measurements collected by accredited MSA graders.

MSA eating quality scores are the combination of tenderness, juiciness, flavour and overall liking of beef. The MSA Index is a weighted average of these scores for the 39 MSA cuts for the most common corresponding cooking method. It is not a yield measurement.

The MSA Index is a tool to be used by producers and lot feeders. Inputs in the MSA model controlled by the processor, for example hang method, days aged, ultimate pH (within the acceptable range), and loin temperature are set as default values. The MSA Index is calculated for Achilles hung carcases with 5 days ageing.

A carcase with a higher MSA Index will have higher beef eating quality scores for many cuts compared to a lower MSA Index carcase. The changes in eating quality of individual muscles will depend upon the different combinations of carcase inputs affecting cuts in different ways. This is why the MSA Index is a measure of the average eating quality of the whole carcase.

Key points

- The MSA Index is a weighted average of the predicted MSA eating quality scores (MQ4) of 39 MSA cuts in a carcase.
- The MSA Index is a number between 30 to 80, expressed to two decimal places.
- It is a tool that producers and lot feeders can use to benchmark the impact of genetic and management interventions on eating quality, across time periods.
- Producers can monitor changes in eating quality between slaughter groups, seasons and years.
- It also provides a useful national and regional benchmark for beef eating quality, across time and seasons so changes in beef eating quality can be monitored.

Why is the MSA Index useful?

Producers are able to access MSA feedback for individual carcase traits including carcase weight, rib fat, MSA marble score, ossification score, HGP status, hump height and sex. However it is difficult to assess the importance of these individual traits on eating quality and how changes in breeding and genetics or management decisions impact on the eating quality of the carcase. The MSA Index combines the impact of all these inputs and allows producers to evaluate changes in their business, to drive a faster rate of gain in eating quality.

With the goal to improve eating quality for the consumer, the producer and lot feeder are faced with how to economically improve eating quality and the MSA Index through genetics and management interventions.

Do I have to do anything different on farm?

Producers are not required to do anything different on farm to prepare cattle and consign them for MSA. The MSA Index forms a feedback tool to monitor the changes that have occurred in the past as well as make predictions about future changes and how this will impact on the eating quality of your cattle.

What impacts on the MSA Index?

The key factors impacting on eating quality influenced by the producer are:

- Tropical breed content (TBC), verified or determined by hump height measurement
- MSA marbling score
- Ossification score
- Hormonal Growth Promotant (HGP) status
- Milk-fed vealer category
- Saleyard status.

These inputs have a very high or high impact on the MSA Index of a carcase (Table 1). The magnitude of effects shown in Table 1 are an indication only, as the relative importance of the different traits in changing the MSA Index will vary slightly for each producer.

Table 1: The effect of carcase attributes on the MSA Index.

Carcase input	Size of effect on the MSA Index (units)	Clarification of effect	Relative importance of these traits in changing the MSA Index*
HGP status	5	The MSA Index of carcases with **no** HGP implant is around 5 Index units higher	**Very High**
Milk-fed vealer	4	The MSA Index of milk fed vealer carcases is around 4 index units higher	**Very High**
Saleyard	5	Carcases which were consigned directly to slaughter and NOT processed through a saleyard have an MSA Index around 5 index units higher	**Very High**
MSA marbling	0.15	As MSA marbling score increases by 10, the MSA Index increases by around 0.15 index units	**High**
Hump height (for cattle greater than 0% TBC)**	-0.7	As hump height increases by 10mm, the MSA Index decreases by around 0.7 units In carcases which have no TBC, hump height has no impact on MSA Index	**High**
Tropical Breed Content (TBC)**	0% = 0 12% = -1.6 18% = -3.2 25% = -3.9 38% = -4.7 50% = -5.2 75% = -5.5 100% = -6.3	As declared TBC content increases from 0 to 100%, the MSA Index decreases by up to 6.3 units	**High**
Ossification score	0.6	As ossification score decreases by 10, the MSA Index increases by 0.6 index units	**High**
Rib fat	0.1	As rib fat increases by 1 mm, the MSA Index increases by 0.1 index units	Medium
Hot standard carcase weight (HSCW)	0.01	As HSCW increases by 1kg, the MSA Index increases by <0.01 index units	Low
Sex	0.3	With low ossification values, females have a higher index value than steers by around 0.3 index units	Low

The values presented in Table 1 are the average effect calculated for 2.8 million carcases across all states of Australia.

* Relative importance indicates the size of effect changing that trait will have on the MSA Index within a herd, if all other traits remained the same. Some traits may have a large impact but are difficult for a producer to alter.

** Hump height can be used in conjunction with carcase weight as the determinant or verification of TBC during MSA grading.

Using the size of effects from Table 1, producers can estimate how much their MSA Index will change as a result of changes in genetic or management interventions.

Using the MSA Index to generate change

The MSA Index will allow processors to benchmark their suppliers by evaluating the eating quality of the carcases that they purchase. Producers can change the MSA Index of their carcases to ensure they supply carcases of the desired eating quality for a processor.

Table 2 provides an example of changes made by a producer to supply cattle to a new market, which required cattle to be heavier at the same age with more marbling.

Table 2: The impact of livestock production changes on the MSA Index.

Trait	Carcase 1	Carcase 2	Change in MSA Index
Carcase weight (kg)	260	280	+ 0.12
MSA marbling	280	300	+ 0.33
Ossification score	150	150	0
TBC (%)	0	0	0
Hump height (mm)	50	50	0
Rib Fat (mm)	10	12	+ 0.18
Sex	M	M	0
HGP	No	No	0
Milk-fed vealer	No	No	0
Saleyard	No	No	0
MSA Index	**59.67**	**60.30**	**+ 0.63**

Increase marbling – To increase marbling through genetic management, producers can purchase sires with higher Estimated Breeding Values (EBVs) for Intramuscular Fat (IMF%) to increase marbling in their progeny. Ensuring animals are finished on a high plane of nutrition prior to slaughter will also aid in ensuring marbling is developed.
An increase in MSA marbling of 20 points equates to an actual IMF % increase of around 0.4%. The sire of carcase 2 would need an IMF% EBV of around 0.8% higher than the sire of carcase 1 to see an increase of 20 MSA marbling points in their progeny.

Increased carcase weight and rib fat depth – To achieve heavier carcases at the same maturity (ossification), producers could use sires with higher 400 or 600-day growth EBVs and/or increase the nutritional value of feed to enhance the growth rate of the animals. If positive genetic selection pressure was placed on IMF and on rib and rump fat EBVs, then heavier carcases will also be fatter at the rib site. Improving nutrition to increase growth may also increase carcase fatness.

How to access the MSA Index

Producers can access MSA Index values for carcases in the online feedback system, myMSA at **www.mymsa.com.au.** Producers can also use the MSA Index calculator at this website to guide decision making by predicting the impact of production changes on the MSA Index.

Scan to use the MSA Index mobile calculator

Or go to www.mymsa.com.au/msamobile on your mobile device.

For more information

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

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To access MSA grading data and the MSA index, visit **www.mymsa.com.au**

Enquiries: **mymsa@mla.com.au** or 1800 111 672.

MSA Index tracker

Kill date	Number of cattle graded	MSA Index range	Average MSA Index	Notes
13 Dec 2017	50 Example	54.65 - 64.72	59.69	HGP free steers. Processed at ABC abattoir

MSA Index tracker

Kill date	Number of cattle graded	MSA Index range	Average MSA Index	Notes

On farm management and marketing

	Recommended practice	Why?	How?	✓ or ✗
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.	

	Recommended practice	Why?	How?	✓ or ✗
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 ✗
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 ✗
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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