

Beef Producers' Handbook

"From Gate to Plate"



About HCC

Hybu Cig Cymru/Meat Promotion Wales (HCC) was established in April 2003 and is the strategic body for the promotion and development of red meat in Wales and the development of the Welsh red meat industry. Its mission is to develop profitable and sustainable markets for red meat in Wales and Welsh red meat outside Wales for the benefit of all stakeholders in the supply chain.

HCC's five strategic goals are:

- Effective promotion of Welsh Lamb and Welsh Beef and red meat products in Wales
- Build strong differentiated products
- Improve quality and cost-effectiveness of primary production
- Strengthen the red meat supply chain
- Effective communication of HCC activities and industry issues

This booklet forms part of a series of publications produced by HCC's Industry Development team.

The Industry Development team deal with a range of issues that include:

- Technology Transfer
- Research and Development
- Market Intelligence
- Training
- Demonstration farms
- Benchmarking

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Introduction

The environment in which cattle are bred plays an extremely important part when it comes to selecting stock for slaughter through to the quality of the end product. In this booklet, we have set out a series of guidelines on the selection of stock for the market that look at all aspects of the supply chain including conformation plus fat assessment guidelines, market demands and how to identify the quality of your cattle against market specifications, how to avoid carcase damage, factors that effect the eating quality and other supply chain information that should be considered when selecting beef for slaughter.

This is all underpinned by specific technical notes, which can be found at the back of the booklet.



Breed Improvement

The factors that influence livestock performance can be divided into those that are due to an animal's breeding potential, as determined by its genes, and those due to the environment in which it is reared.



It is important to get both of these aspects of production right. This makes the selection of breeding stock extremely important.

It is not possible to select superior breeding stock by eye alone. Performance records and genetic markers provide an essential tool in assessing breeding potential.

Estimated Breeding Values (EBVs), which help to identify breeding stock with superior genetic potential, are now widely available.

EBVs are calculated for the following characteristics:

- Gestation Length
- Calving Ease
- 200 Day Milk
- Birth Weight
- 200 and 400 Day Growth
- Muscle Score
- Muscle Depth
- Fat Depth

Two economically important indexes, Beef Value and Calving Value, are then calculated from these EBVs. These values enable the animal's potential financial benefit to be established, making it easier for commercial producers to identify the most profitable sires.

Trials show that producers can improve the financial performance of their herd by at least £17.00 per calf through the selection of breeding stock with high indexes.

(For more information see technical notes 1.)

Carcase Classification

EU Classification Legislation

Abattoirs slaughtering over 75 cattle a week are required to classify carcasses to the EUROP grid. The application of the carcass classification is monitored and enforced by the Rural Payments Agency (RPA) on behalf of Defra.

MLC offers an independent beef classification service to abattoirs, which is taken up on a voluntary basis – around 54% of carcasses in Great Britain are currently handled by the MLC's service – details of service users can be found at

www.mlcclassification.org.uk

EU Classification Legislation

Conformation

The conformation class is determined by a visual appraisal of shape, taking into account carcass blockiness and development of muscle in the hind quarters. No adjustment is made for the influence of fatness on overall shape. There are five main classes: E, U, R, O, P. (where E=excellent and P=poor) In Great Britain classes P, O, and U are sub-divided into – and +.

Fatness

The fat class is determined by a visual appraisal of external fat development. There are five main classes ranging from 1 (very lean) to 5 (very fat). In Great Britain, classes 4 and 5 are sub-divided into L (leaner) and H (fatter).

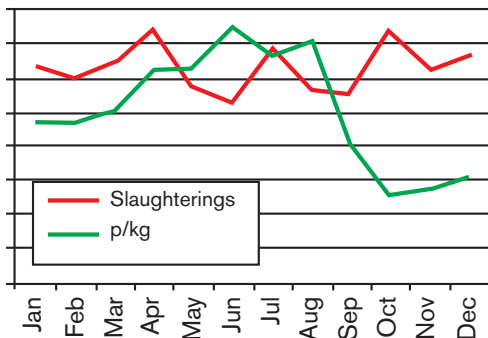
(For more information see technical notes 2.)

Target your Markets

Seasonal variation

The beef market is affected by seasonal demand. Returns improve when producers match production to market demand. This may require adjustments to breeding and feeding policies.

Seasonal variation in cattle slaughtering and prices in Wales



Market information is vital and can be accessed in a range of ways - HCC can offer this information by post, phone, fax, text and online at www.hccmpw.org.uk.

Selecting for the market

The ability to assess cattle both visually and by handling is an essential skill for a beef producer. It provides vital feedback to monitor the progress of animals, spot ailments and adjust feed regimes. By regularly weighing and recording, in order to monitor how animals are progressing towards finish, it is possible to adjust feeding regimes to bring stock to market at the best time.

Increasing fatness →

	1	2	3	4L	4H	5L	5H
E	+5	+10	+10	+5	-15	-50	-50
U+	Base	+5	+5	Base	-15	-50	-50
-U	Base	+5	+5	Base	-15	-50	-50
R	-5	Base	Base	-5	-15	-50	-50
O+	-10	-5	-5	-10	-20	-60	-60
-O	-20	-15	-15	-25	-40	-70	-70
P+	-30	-25	-25	-35	-40	-80	-80
-P	-30	-25	-25	-35	-40	-80	-80

Improving conformation ↑

This classification grid shows price differentials for each conformation/fat class.

The grids below helps you to:

- Understand how best to target your markets
- Understand market specifications
- Identify the quality of your cattle against market specifications
- Select your cattle to meet market specifications

The preferred classification for different markets is highlighted in red. For example, an R4L carcass would attract the supermarket base price and would be acceptable for all three markets illustrated.

A carcass of classification R4H however, would only be targeted by the traditional/ catering butcher. The supermarkets do not require this type of carcass. as they would be penalised by 15p per kg. Carcasses which are not well suited to any of the target markets attract the most severe price penalties. For example fat class 5L or 5H.

Supermarket

Conf: E,U+,-U,R

Fat: 3,4L

→

	1	2	3	4L	4H	5L	5H
E	+5	+10	+10	+5	-15	-50	-50
U+	Base	+5	+5	Base	-15	-50	-50
-U	Base	+5	+5	Base	-15	-50	-50
R	-5	Base	Base	-5	-15	-50	-50
O+	-10	-5	-5	-10	-20	-60	-60
-O	-20	-15	-15	-25	-40	-70	-70
P+	-30	-25	-25	-35	-40	-80	-80
-P	-30	-25	-25	-35	-40	-80	-80

Improving conformation ↑

Traditional Butcher

Conf: E,U+,-U,R,O+

Fat: 4L,4H

→

	1	2	3	4L	4H	5L	5H
E							
U+							
-U							
R							
O+							
-O							
P+							
-P							

Improving conformation ↑

Catering Butcher

Conf: E,U+,-U,R,O+

Fat: 3,4L,4H

→

	1	2	3	4L	4H	5L	5H
E							
U+							
-U							
R							
O+							
-O							
P+							
-P							

Improving conformation ↑

Selecting Stock for Slaughter

Visual appraisal

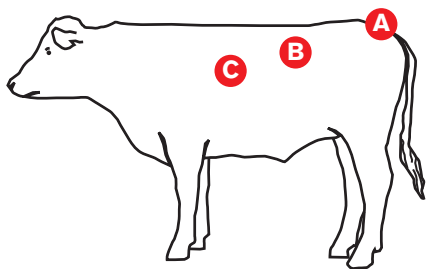
General appearance gives some guide to an animal's fatness. As lean cattle walk, muscles visibly ripple. These muscles are less visible with higher levels of fat cover, making cattle appear smoother.

Traditionally, butchers preferred cattle which were well-finished down to the hock and full in the flank. In fact, both characteristics indicate excessive fatness by modern standards.

A wide, deep brisket projected well forward also indicates fatness.

Today, most of the trade requires lean, muscular cattle with rounds which curve well into the hock and are 'cut up' in the flank. Weight and visual appraisal are general guides to market condition, but to ensure accurate selection, handling is essential.

Three key points give the best indication of fat class. The handling points for fat assessment (see below) combine reliability and ease of access. Other handling points, eg flank, cod and brisket, may be used, but they tend to be less reliable, or less accessible.



Key handling points to assess fatness for beef cattle:

A: Over the pin bones and on either side of the tail head

B: The transverse processes of the loin

C: Over the last three ribs

FATNESS ASSESSMENT

Handle animals on the left side as seen from behind. Kidney fat which is attached to the underside of the loin on the right hand side can mislead the handler when assessing fat cover. Use just the tips of fingers, to feel fat depth over the underlying muscle and bone at each of the handling points

As animals get fatter, the ends of the transverse processes over the loin and the pin bones, as well as shoulder blade ridge, become more rounded. The hollows between ribs and shoulders fill up completely at the highest fat levels

Hide thickness varies with breed. Consider this when assessing fatness, particularly over the tail head, loin and ribs. Use the descriptions below to predict carcass fat class with reasonable accuracy, in the live animal. Further information and practical training on how to assess live animals are available through HCC.

RIBS – HANDLING POINT C

Fat Class

- | | |
|-------|--|
| 1 & 2 | Ribs are prominent, clearly visible and are felt as deep corrugations. |
| 3 | Some fat cover is detectable over the bones but individual ribs are felt easily as corrugations. |
| 4L | Thin layer of fat is felt over the bones. Individual ribs felt with light pressure. |
| 4H | Distinct layer of soft fat is felt over the bones. Individual ribs are felt only with moderate pressure. |
| 5L | Thick soft fat covers ribs. Individual ribs are felt only with firm pressure. |
| 5H | Rib cage is smooth to the touch with a tendency to patchiness. Individual ribs cannot be felt. |

TAIL HEAD – HANDLING POINT A

Fat Class

- | | |
|-------|--|
| 1 & 2 | Skin is tight. Area around root of tail and over the pin bones is firm and unyielding. |
| 3 | Indicated by a very thin fat cover which yields slightly to moderate pressure. |
| 4L | Thin layer of fat felt when skin on either side of tail head is pinched between fingers and thumb. Thin soft layer is felt over the pin bones. |
| 4H | Looks slightly puffy; soft layer of fat felt using light pressure. Surface area around pin bones is soft and the fat tends to spread back towards the tail head. |
| 5L | Looks puffy and feels spongy. Moderate fat cover over pin bones is felt as distinct soft layer. |
| 5H | Looks very puffy and feels very spongy. Thick and sometimes patchy layer of soft fat over the bones |

LOIN – HANDLING POINT B

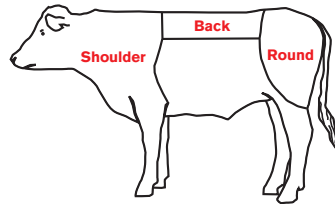
Fat Class

- | | |
|-------|---|
| 1 & 2 | Ends of transverse processes of vertebrae very prominent; individual bones felt as deep corrugations. |
| 3 | Ends of transverse processes prominent. Individual bones are felt as corrugations. |
| 4L | Ends of transverse processes slightly rounded by fat, felt with light pressure. |
| 4H | Ends of individual transverse processes are felt only with moderate pressure. |
| 5L | Transverse processes are felt only with firm pressure. |
| 5H | Individual transverse processes cannot be felt. |

CONFORMATION ASSESSMENT

Assessing conformation takes account of depth and thickness of the round, fullness of loin and chine (the back) and thickness of fleshing over shoulders.

Remember, carcass classification is an assessment of three areas: round, back and shoulder. When the three parts differ, the classification for two of the three is applied.



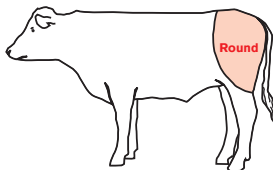
Cattle of good conformation have a full outline. Lean cattle of good conformation have thickly fleshed, well-rounded contours. Viewed from the rear, they stand wide with a convex round - wider than the back. From the front they are wide between the legs and thick through the shoulder.

Cattle of poor conformation have a relatively straight or, at some points, hollow appearance. They are often bony and angular, although excess fat may disguise this to some extent.

If an animal lacks muscle thickness, its overall appearance may be improved by additional feeding, but much of the extra gain will be fat. So, it is important to handle for fatness before assessing the extent to which conformation indicates a lean or fat beast.

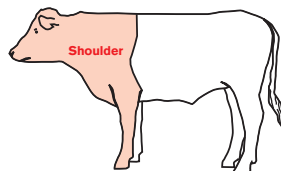
ROUND

E	Very rounded
U	Rounded
R	Well developed
O	Average to lacking development
P	Poorly developed



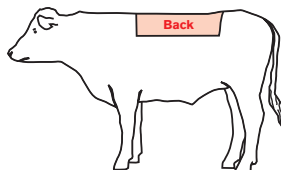
SHOULDER

E	Wide and very thick up to the shoulder
U	Wide and thick up to the shoulder
R	Still thick but less width at the shoulder
O	Average to lacking thickness
P	Narrow with bones visible



BACK

E	Very rounded
U	Rounded
R	Fairly well developed
O	Average development to almost flat
P	Flat with bones visible



Handling Live Animals

Good handling is vital for animal welfare and avoids:

- carcass damage and wasteful trimming,
- stress and the risk of dark cutting meat,

Damage to carcasses always reduces value so careful handling of live cattle is important

Carcass damage

Bruising and abscesses lead to wasteful trimming, even partial condemnation of carcasses.

Bruising is best avoided by:

- Handling cattle in layouts with smooth walls and no sharp corners, nonslip floors and gradual ramps.
- Avoiding use of sticks and goads.
- Using vehicles that avoid overcrowding with internal partitions to restrict movement.
- Using clean injection needles to avoid infection.



Carcass showing bruising

Pre slaughter handling/transport

Careful handling of livestock prior to slaughter reduces the risk of stress. Stressed cattle use up their muscle energy reserves prior to slaughter. As a consequence of this the meat can be very dark, making it unattractive, of poor flavour and more prone to bacterial growth, thus reducing shelf life.

A similar problem can arise if cattle are underfed prior to slaughter.

To avoid stress;

- always handle cattle quietly,
- avoid mixing cattle from different groups,
- provide clean, dry bedding and plentiful drinking water in the lairage
- take special care with bulls, as they are more susceptible to stress than steers or heifers.

Killing Out Percentages and Carcase Weight

Dressing Specifications

By industry agreement, abattoirs may choose from four recognised dressing specifications;

The table below illustrates the parts of the carcase which are subject to trim depending on the specification used.

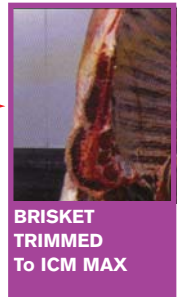
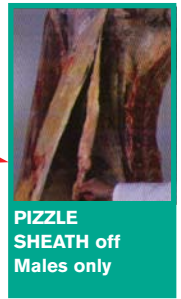
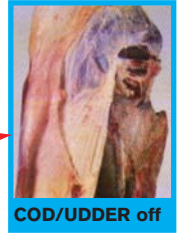
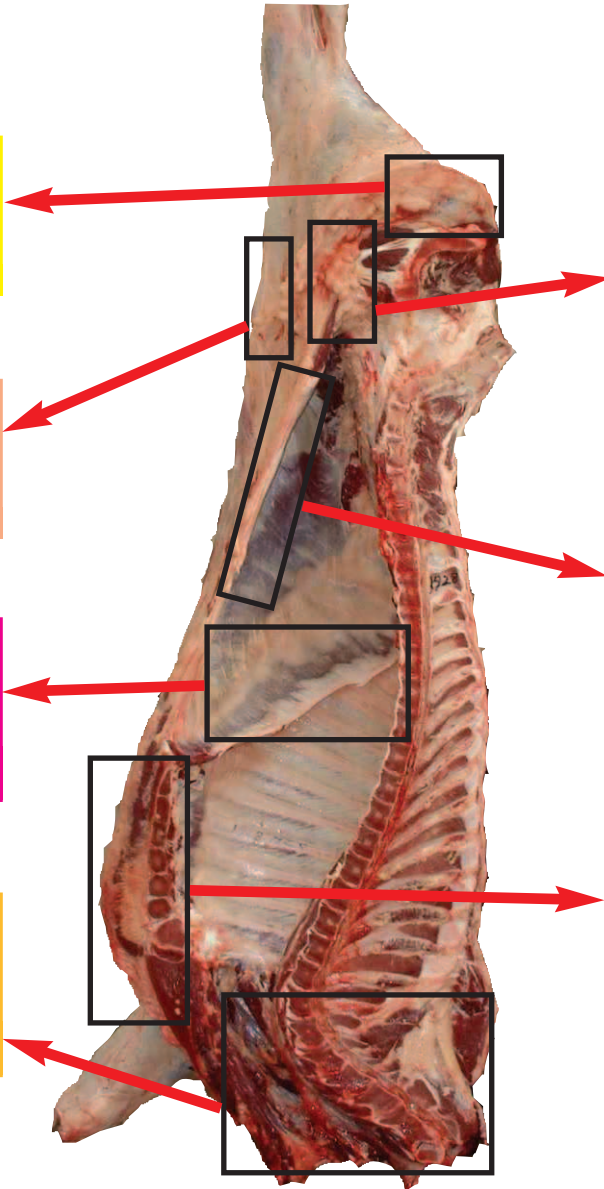
	COD/ UDDER	CROWN FAT	THIN SKIRT	JUGULAR VEIN AND ADJACENT FAT	PIZZLE SHEATH	BED FAT	BRISKET FAT TO 1cm MAX
1. The MLC Standard Conditions Specification	ON	ON	ON	OFF	ON	ON	ON
2. The New National Specification	ON	OFF	OFF	OFF	ON	ON	ON
3. The Old EC Specification	OFF	OFF	OFF	OFF	ON	ON	ON
4. The New EC Specification	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Note - The term "Company Specification" identifies carcasses which have not been dressed to a recognised specification.

As a guide, MLC trials indicate that on average, carcase weight reduces by 1% between each of the specifications, using the MLC Standard Conditions Specification as the reference.

A very small percentage of carcasses are now dressed with the kidney knob and channel fat (KKCF) attached.

For an average carcase of 320kg, the payable weight can differ by over 9kg depending on the dressing specification applied.



Dirty Hides

- Cattle in a dirty condition will not be accepted for slaughter. A dirty hide is worth less than a clean one and it can contaminate the carcase. Cattle in yards require frequent bedding with dry straw. Handling yards should always be kept clean.
- Dirty cattle cannot be slaughtered under the Meat Hygiene Service enforced clean livestock policy which uses scores in categories 1-5 (where 1 is very clean and 5 is extremely dirty). Animals with scores of 3, 4, or 5 will not be accepted for slaughter.



MHS Category 1



MHS Category 3



MHS Category 5

Factors which Affect Carcase Weight

Hot Weight Rebates

Following industry consultations in 2002, all abattoirs slaughtering prime cattle were recommended to adopt a change to reducing hot carcase weights by 2% by early 2003.

In practice, the larger abattoirs in Great Britain (those slaughtering more than 20,000 cattle a year) adopted the change and reduce the hot carcase weight by 2% to establish the cold weight (payment weight) to the supplier.

However, whilst some lower throughput abattoirs have adopted the 2% hot weight reduction, others continue to use the historical reductions based on the following table;

Side weights	Rebate per side
Up to 125kg	2.0kg
125.5 . 150kg	2.5kg
150.5 . 200kg	3.0kg
200.5kg and over	3.5kg

Suppliers should therefore enquire which hot weight rebate method is used at the abattoir to which cattle are sent.

Rounding of Carcase Weights

Abattoirs which apply the 2% hot weight reduction must record the actual hot weight shown on the scale (scales may be calibrated to 0.1, 0.2 or 0.5kg but no rounding must be applied to the indicator weight).

Abattoirs continuing to use the historical table of rebates are likely to still round hot weights down to the nearest 0.5kg.

Other factors influencing killing out percentage

- Breed – different breeds carry varying hide weights i.e, Limousins have a thin, light hide; Herefords have a thicker, heavier hide
- Production systems/seasonal variation – forage fed cattle tend to develop a proportionately larger gut than cereal fed cattle – resulting in, on average, a lower KO%
- Fatness level – cattle of a higher fatness level will, on average, produce a higher KO% than leaner cattle
- Cows, because of age, proportion of gut and udder development (which is removed before weighing at slaughter) generally produce a lower KO% than 'clean' cattle.

Making Marketing Decisions

In order to maximise returns, the following needs to be considered:

- The quality of cattle being produced
- The target market e.g. export, domestic (supermarket or local butcher)
- Market signals e.g. weekly, regional, deadweight/liveweight price reports

Carcase Quality

Carcase classification provides a nationally recognised description of carcase quality, which can be used to help target market requirements.

Target Markets

Most outlets, whether export or domestic (supermarkets or local butchers), produce weekly payment schedules using carcase classification to define the quality of product required.

Market Signals

HCC provides extensive marketing information on a daily, weekly and annual basis. Information can be obtained from the following sources:

- Website www.hccmpw.org.uk
- Ceefax : BBC2 Page 249
- Printed info e.g market bulletins direct from HCC

Summary

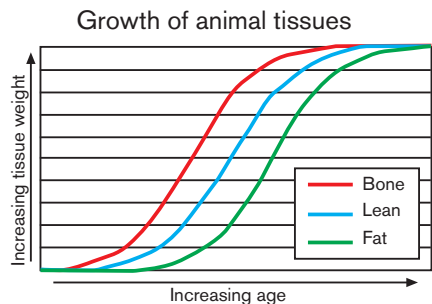
armed with the knowledge of the quality of stock they produce, market requirements and pricing schedules, producers can develop market strategies which maximise their returns.

Growth/Muscle Development

Growth

The main purpose of rearing animals is the production of meat for human food. Meat comprises lean muscle with associated bone and fat.

As an animal grows the tissues grow and mature at different rates. Of the important components of the carcass, bone grows first, followed by muscle and then fat.

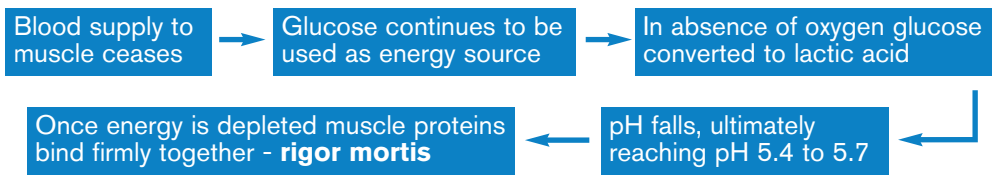


This means that the energy intake of an animal is first directed to bone growth and then to lean growth. Once the demands of these two tissues are met, excess energy is stored as fat.

Fat is energy dense and the energy cost is about six times that of depositing lean. It is important for cost effective animal production to match dietary supply with the needs for lean tissue growth to produce lean meat required by the market.

The conversion of muscle to meat

Following slaughter, muscle undergoes a number of changes that are important in determining visual appeal and ultimate meat quality. These changes are illustrated in the diagram on the next page.



The rate at which a muscle goes into rigor mortis is influenced by a number of factors:

- energy stores within muscle when the animal leaves the farm
- the depletion of energy stores during transport and lairage
- stimulation of the metabolic processes via pre-slaughter stress
- stimulation of muscular activity during slaughtering
- the rate at which the muscle is cooled

(For more information see technical notes 3.)

Eating Quality

Why is eating quality important? – The Consumer View

Consumers' initial purchasing decisions are based on price and visual appeal. Repeat purchases, and hence the profitability of individual businesses, are reliant on the product giving a satisfactory eating experience.

Consumer research on beef eating quality has shown that the most important attribute in determining acceptability is tenderness. Flavour is also important and where tenderness is less variable, flavour increases in relative importance.

Pre-slaughter factors influencing eating quality

Breed

Research has demonstrated that breed effects on eating quality are small. Although not all breeds have been evaluated, where clear differences have been identified they are mainly in purebred animals.

Sex

- There is no eating quality difference between steers and heifers.
- Young bull beef is generally tougher than that from steers and heifers and therefore requires particular attention to post slaughter handling to enhance tenderness.

Diet

- Diet can influence beef flavour with the stronger flavour of grass fed beef being generally preferred by British consumers.
- Vitamin E in the diet (at 1000IU per day for 100 days) can extend shelf life and protect flavour in beef fed on conserved forage or concentrate diets low in antioxidants.

Age/seasonality

Older animals produce tougher meat. An upper age limit for prime beef production of 30 months is likely to be sufficient to give protection against potential eating quality problems from older and, perhaps, slower growing heifers and steers. For bulls, a cut off of 15 months is more appropriate

Fatness and conformation

At very low levels of intramuscular (or marbling) fat, the eating quality of beef is less satisfactory. A minimum fat level of fat class 3 provides protection against very low intramuscular fat levels.

In terms of conformation, O+ is widely accepted as a minimum.

(For more information see technical notes 4.)

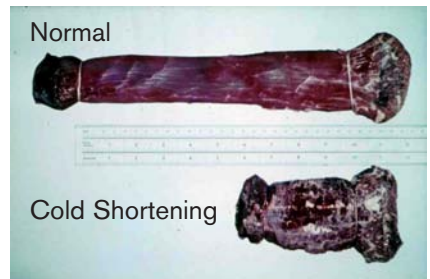
Post-slaughter factors influencing eating quality

Stunning and slaughter

Cattle are usually stunned by the use of a captive bolt pistol that fires a bolt into the brain. Alternative methods include electrical stunning (head to back) and percussion stunning. Stunning method does not have an important influence on meat quality.

Chilling regimes

Contraction of the muscle prior to rigor mortis (“shortening”) results in increased meat toughness. As a general rule, chilling to avoid a temperature below 10°C in any muscle within 10 hours of slaughter will avoid cold shortening.



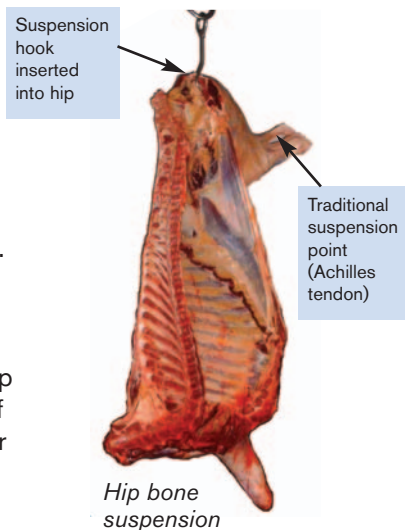
Example of cold shortening

Electrical stimulation

Electrical stimulation is used in some meat plants to improve eating quality. An electrical current is applied to the carcass after slaughter. This stimulates the muscles to contract and hence use up energy. This accelerates the onset of rigor mortis enabling chilling to take place earlier. High voltage electrical stimulation increases tenderness more than low voltage but is not as effective in improving tenderness as hip suspension (see right).

Carcass suspension method

The tenderness of the leg and loin muscles are increased by suspension of the carcass from the hip rather than the Achilles tendon. This is the result of the stretching of muscles, avoiding contraction prior to rigor mortis.



Maturation (ageing)

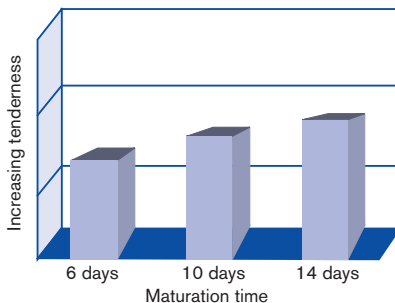
Extended storage of beef increases tenderness. Ageing tenderisation occurs as enzymes naturally present within the meat break down the protein. Beef grilling and roasting cuts benefits from ageing for up to 21 days.

(For more information see technical notes 5.)

Cooking

It is important to cook meat with a suitable method. Cuts higher in connective tissue benefit from moist cooking methods. When using dry methods (grilling, frying and roasting) overcooking can result in drying out and toughening of meat.

Effect of ageing on tenderness of beef loin



Butchery/ Meat Yield

Whether selling live or dead weight, producer returns are ultimately reliant on the value of the carcase. Value is directly related to the yield and the distribution of saleable meat.

- Fat content has a significant impact on carcase meat yield.
- In order to meet consumer requirements, over-fat carcasses need to be trimmed. Trimming of excess fat reduces meat yield and increases processing costs.
- A typical beef carcase (R4L) produces approximately 71% saleable meat. Reducing the fat to class 3 increases the meat yield by approximately 1.5%. Increasing the fat to class 4H decreases the meat yield by approximately 1.5%.



- It may not always be possible to remove all excess fat from individual cuts.
- Even after trimming, cuts from fatter carcasses may still have a higher than desirable fat content and as a consequence, be visually less appealing to the consumer.
- Conformation has less impact on meat yield compared to fatness, due to the need to trim excess fat from over-fat carcasses.
- The main influence of conformation is the distribution of meat within a carcass. Better conformation carcasses will have more of their meat in the higher value hindquarter cuts.

(For more information see technical notes 6.)

Technical Notes

1. Breed Improvement

Whether you are a commercial beef producer or a pedigree breeder, Estimated Breeding Values (EBVs) are an essential decision making tool when developing a breeding policy.

The objective of EBVs are to produce animals which have shorter gestation length, easier calving, higher growth rates or carcase weights, better carcase shape and less fat.

The following chart provides an example of EBVs on the performance of two different bulls:

		BULL A	BULL B
Gestation length	Days	+1.7	+2.1
Calving ease		+0.8	-2.6
Birth weight	Kg	+1.5	+3.2
Calving value		3	-6
200 day milk	Kg	+4	+1
200 day growth rate	Kg	+20	+32
400 day growth rate	Kg	+45	+61
Muscling score	Pts	+0.3	+0.7
Muscle depth	mm	+0.1	+0.2
Fat depth	mm	+0.2	-0.8
Beef value		24	30

Conclusion

Bull B has the best overall carcase EBVs and this is reflected in the Beef Value (30). It has significantly higher growth and muscle EBVs and is leaner than Bull A.

In contrast, Bull B's offspring will be more difficult to calve than Bull A due to the heavier birthweight. This is reflected in the longer gestation length and negative ease of calving, whereas Bull A will lead to a more unassisted calving.

EBVs are decision making tools and it is important to check the animals' overall characteristics as well as setting breeding objectives prior to selecting breeding stock.

2. Beef Carcase Classification

How production systems affect classification

Conformation and fatness are affected by the production system used. Animals with the same genetic background put through different systems may have different characteristics, but some characteristics are more controllable than others.

- **Fatter animals tend to have better conformation**

In a given system the more finish an animal carries the better the conformation classification. However the difference is not that dramatic. Data from a large sample of bulls, steers and heifers shows that for every increase in fat class there is only a small increase in conformation class. For native breeds this is about one quarter of a conformation class for each increase in fat class and for Continental breeds this is around one-sixth.

- **Older cattle tend to be of poorer conformation**

Older cattle tend to be of lower conformation than younger ones. This can be seen at its most extreme when you consider the likely conformation class of a 2- year old finished heifer compared with an animal of the same breeding that is slaughtered as a 5-year-old cow. Examining the typical slaughter ages for steers and heifers shows that a steer or heifer slaughtered at 30 months is likely to be about 1 conformation class poorer than one slaughtered at 18 months old.

- **Fat classification is independent of age**

There is no relationship between age and fat classification. This is good news because it means producers do a good job of managing finishing condition.

- **Sex and fatness**

Classification for fatness uses subcutaneous fat and the same system applies for bulls, steers and heifers. There is evidence to show that fat inside muscles does differ between the sexes. This means that heifer and steer beef at a given classification has a higher proportion of fat than bull beef.

- **Sex and conformation**

The sex of a finishing animal has a significant effect on conformation score. The table below is an example of how the outcomes differ for the same continental sire used across similar suckler cows.

	Bulls	Steers	Heifers
Class			
E			
U+	46		
U-	51	27	12
R	3	53	41
O+		20	44
-O			3

3. The conversion of muscle to meat

Before slaughter the muscles of the animal are generating energy through biochemical pathways that use oxygen. Following bleeding out there is no longer a blood supply to the muscles. This has two effects:

- There is no longer any oxygen
- The products of metabolism cannot be removed via the bloodstream and therefore accumulate in the muscle.

In the absence of oxygen, the muscle attempts to maintain energy (in the form of Adenosine triphosphate (ATP) levels. Muscle is capable of producing ATP from glucose without the need for oxygen. This anaerobic metabolism produces lactic acid. The acid accumulates and gradually reduces the pH of the muscle from about 7.2 in a normal resting live muscle to an ultimate pH (pHu) of about 5.4 to 5.7 in normal meat. Muscle can generate energy from glucose until all the glucose is used up or until the accumulation of acid in the muscle destroys the metabolic processes.

This ability to generate energy even after slaughter means that muscle can continue to contract for a considerable time after the animal's central nervous system is dead. Different muscles, or even different muscle fibre cells within a muscle, can continue to function for varying lengths of time.

The main bulk of the muscle is made up of the proteins myosin and actin. When all of the available energy is exhausted, the myosin and actin molecules bind firmly together and the muscle loses its extensibility and flexibility. This is rigor mortis.

4. Pre-slaughter factors influencing eating quality

▪ **Breed**

Within *Bos taurus* (European) breeds, it appears that if there is a breed effect it may arise from associated factors like fatness or rate of maturity, although there is some evidence for an effect mediated by differences in muscle fibre composition.

The USDA Meat Animal Research Center at Clay Center has been conducting large scale evaluations of cattle breeds since the late 1970s. A wide range of breeds have been used as sires with common dams (either Hereford, Angus or the 'MARC III' composite). Each 'cycle' of the programme increases the number of breeds evaluated. The results have consistently shown that *Bos indicus* breeds result in tougher meat. Among the *Bos taurus* breeds results have not been consistent between cycles of the programme. Breed effects have also generally been small.

Research conducted in the late 1990s looked at the effect of sire genotype and fatness on eating quality of progeny from dairy dams. In steaks there was no difference across the six sire breeds (Hereford, Aberdeen Angus, Charolais, Limousin, Belgian Blue and Piedmontese) for eating quality. In roast topside, the Belgian Blue produced higher tenderness scores than the other five sire types. Overall it was concluded that breed effects were unimportant.

Work in pure bred steers, aimed at studying the effect of growth rate on eating quality, showed a small tenderness advantage for the Aberdeen Angus when compared with the Holstein. Charolais was intermediate. The Aberdeen Angus also gave higher flavour, juiciness and overall acceptability scores than both the other breeds.

It can therefore be concluded that breed effects are small and only of clear benefit in purebred animals

- **Diet**

The composition of the diet influences the products of digestion and hence meat odour, flavour and fat characteristics. Generally, stronger beef flavour is imparted by grass based diets and this is preferred by British consumers.

- **Pre slaughter handling/transport**

If the energy reserves of the muscle are depleted prior to slaughter, the degree of glycolysis which can occur is diminished and the ultimate pH (pHu) will not be as low as in normal muscle with higher energy reserves. If the pHu is greater than 6.0, the muscle will have a dark and dry appearance with a firm texture. This condition is termed Dark Firm Dry meat (DFD) or sometimes 'dark-cutting' meat.

A combination of reduced oxygen penetration into the meat and lower light reflectance results in less visible red oxymyoglobin pigment and hence the dark appearance. The dryness is thought to be a consequence of the higher pH leading to a higher water holding capacity of the myofibrillar proteins. DFD meat is normally found to be more tender, but the higher pH also leads to a better environment for the growth of spoilage bacteria and consequently a poorer shelf-life.

5. Post-slaughter factors influencing eating quality

▪ **Chilling regimes**

Muscle will contract (shorten) naturally as it goes into rigor mortis if it is not restrained from doing so. Most muscles are under tension when the skeleton of the carcass is in its normal standing posture. If muscle is restrained it will develop tension as it goes into rigor but will not be able to shorten in its overall length. The extent to which muscles are able to shorten depends on the remaining energy (ATP) available, the load on the muscle and the temperature of the muscle when these events occur. Shortened muscle is usually significantly tougher because of the overlapping muscle fibres which are densely packed. The response depends on the degree of shortening.


There is an important effect of temperature on the ability to shorten during rigor. There are two types of shortening. For shortening to be minimised rigor should occur at about 15°C. This can never be achieved in practice for all muscle fibres because of the different rates of cooling in different locations of the carcass and the different rates of rigor development in different fibres. It is however a useful guideline.

Hot shortening is the shortening that occurs with rigor above 20°C. This occurs as the energy supply is being exhausted and it is generally quite weak. Hot shortening has the potential to affect meat quality but its importance is still debated.

Cold shortening is quite different. It occurs if the muscle is exposed to low temperature (<10°C) prior to the development of rigor. Under these conditions the muscle spontaneously contracts and, since it does so at higher levels of ATP and pH than rigor shortening, the degree of contraction (and toughening) can be considerable.

▪ **Electrical stimulation (ES)**

ES can be used to improve tenderness of beef. ES was developed primarily to allow rapid chilling without the risk of cold shortening. The electrical current applied stimulates the muscles to contract and hence use up energy. This accelerates the onset of rigor mortis enabling chilling to take place earlier. It also appears that High Voltage ES (HVES) has additional benefits in tenderness, perhaps through accelerating the ageing process or direct physical damage to the muscle fibre structure. In beef, however, these effects are not as great as the effect of hip suspension.



If low voltage stimulation is used it must be applied whilst the nervous system is still intact. In practice this means immediately after bleeding. Good contact (ie electrode positioning) and timing are critical for low voltage stimulation to be effective. This means that it is a less reliable approach than high voltage stimulation. There is also the risk of a toughening effect of LVES due to hot shortening. Where LVES is effective it seems to simply prevent cold shortening.

High voltage stimulation does not depend on an intact nervous system. It is applied later on the slaughterline and therefore electrode contact is easier and the high voltage makes positioning less critical. Because it is applied later the carcass has cooled to an extent where hot shortening is less likely, although this can occur in the deep muscles of a beef carcass.

- **Carcass suspension method**

It is clear from the section on chilling that the state of contraction of muscles is a significant factor in determining eating quality. Muscular contraction post mortem is moderated by the attachment of the muscles to the skeleton. The tension imposed on any individual muscle in the carcass depends on the position of the skeleton. Hip suspension stretches the muscles of the leg and loin yielding tenderness benefits.

In Britain the use of the aitch bone has largely been replaced by the ischium (an alternative position in the pelvic region) for safety reasons. In terms of the tension on the muscles, this achieves the same effect.

- **Maturation (ageing)**

The action of enzymes that damage or destroy proteins (proteolytic enzymes) in post-mortem muscle is a highly significant source of variation in the tenderness of meat. The enzymes primarily responsible for the tenderisation process are a family of calcium activated enzymes, called the calpains, and their inhibitor calpastatin.

Generally proteolytic degradation and hence tenderisation is considered to occur more quickly in white fibres, and muscles made up predominantly of these, than in red fibres/muscle. This is reflected in differences in the rate of tenderisation (and hence optimum ageing time) between muscles within a carcass and between the species.

The enzymes are more active at nearer neutral pH and at higher temperatures, therefore their greatest level of activity is around the time of rigor when sufficiently high levels of calcium may become available.

6. Butchery/Meat Yield

Most beef is sold boneless. Bone-in beef, which represents approximately 2% of sales, is mainly rib roasting joints and T-bone steak.

The removal of bones and trimming excess fat means that only 71% of an average beef carcass is sold as retail/catering cuts or products.

The basic butchery principal of removing bone and trimming fat to an acceptable level is the same whether product is being prepared in a large meat plant or a butcher's shop. In butchers' shops, where time is available between customers, the practice of traditional boning is often used. This approach often involves the removal of individual vertebrae and the careful separation of the meat from them in order to maximise yield.

In the major meat plants, where maximising efficiency is key, sheet boning is commonly used. With this approach vertebrae are removed as a block and less time is spent removing flesh from the bone.

Whether adopting traditional or sheet boning, the level of fat in the carcass has a significant impact on the proportion of saleable meat. Most consumers require a product with the minimum amount of fat. With an increasing proportion of meat being purchased from self-service multiple retailer display cabinets, consumers are able to be selective. Product with unacceptable levels of fat will often remain on the shelf.

Excess fat therefore needs to be removed during the butchery process, this adds to processing costs.

Better conformation carcasses will have a higher proportion of saleable meat in the higher value hindquarter cuts. High value cuts, which include sirloin and rump grilling steaks and topside/silverside roasting joints represent approximately 40% of the carcass.

The fillet, which is the highest value cut, only represents approximately 1.5% of the carcass.

Further information

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