BEEF FACTS
Product Enhancement

Beef Grading

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The grade of a beef cut sold at retail can be an important selection factor for many consumers. Likewise, the grade of a beef carcass is critical to the beef producer, since the dollar value received is directly dependent upon the grade. Yet consumers and producers alike often are confused as to what grades mean, and how they are determined.

Purpose of Beef Grading

The U.S. Department of Agriculture (USDA) has established *Standards for Grades of Slaughter Cattle and Standards for Grades of Carcass Beef* (USDA, 1996), which are designed to facilitate beef marketing by separating a highly variable population of live cattle and/or beef carcasses into groups which are more uniform in quality and composition. Beef carcass grading is a voluntary service of the USDA, and the user (the packer) is charged a fee for the service. Grades are determined by an employee of the USDA, working independently of both the producer and packer. The USDA Standards include two separate grade designations – *Quality Grades* and *Yield Grades* – and are designated by the stamps shown in Figure 1. A carcass may be either Quality graded, or Yield graded, or both Quality and Yield graded at the same time.

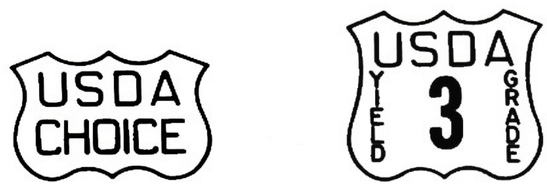

Figure 1: Qualily and Yield Grade Stamps for Beef Carcasses

Quality Grading

Beef quality refers to the expected eating characteristics (tenderness, juiciness and flavor) of the cooked product. USDA Quality Grades are used to reflect differences in *expected* eating quality among slaughter cattle and their carcasses. There are eight USDA Quality Grades for beef:

USDA Prime	USDA Commercial
USDA Choice	USDA Utility
USDA Select	USDA Cutter
USDA Standard	USDA Canner

Eating quality generally is most desirable for "Prime beef" and least desirable for "Canner beef". The Quality Grade of a beef carcass is determined by evaluating carcass indicators of *physiological maturity* and *marbling*, as reflected in the Official USDA Grading Chart (Figure 2).

Maturity. The age of a beef animal has a direct effect on tenderness of the meat it produces. As cattle mature, their meat becomes progressively tougher. To account for the effects of the maturing process on beef tenderness, evaluations of carcass maturity are used in determining USDA Quality Grades. There are five maturity groupings, designated as A through E. Approximate ages corresponding to each maturity classification are:

A — 9 to 30 months
B — 30 to 42 months
C — 42 to 72 months
D — 72 to 96 months
E — more than 96 months

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Relationship Between Marbling, Maturity and Carcass Quality Grade[1]

Degrees of Marbling	Maturity[2]				
	A[3]	B	C	D	E
Slightly Abundant	PRIME				
Moderate			COMMERCIAL	COMMERCIAL	
Modest	CHOICE				
Small					
Slight	SELECT		UTILITY	UTILITY	
Traces					
Practically Devoid	STANDARD			CUTTER	

[1]Assumes that firmness of lean is comparably developed with the degrees of marbling and that the carcass is not a “dark cutter.”
[2]Maturity increases from left to right (A through E).
[3]The A maturity portion of the Figure is the only portion applicable to bullock carcasses.

Figure 2: USDA Beef Grading Chart

Beef carcass maturity is determined by evaluating (a) the size, shape and ossification of the bones and cartilages in the carcass, and (b) the color and texture of the ribeye muscle. In youthful animals, there is a “button” of cartilage on the top of each bone in the vertebral column (backbone). During maturation, these regions of cartilage gradually change to bone (ossify). This ossification process normally occurs in a definite pattern. The sacral vertebrae (rump portion of the carcass) show first signs of ossification. Ossification gradually progresses toward the head through the lumbar (loin) and, finally, the thoracic (rib and shoulder) regions of the backbone (Figure 3).

Changes in skeletal characteristics with advancing age also include a gradual change in shape and appearance of the rib bones. A very young animal has narrow, oval-shaped ribs that are red in color. As the animal matures the ribs become wider and flatter, and become grey in color.

Appearance of the lean tissue also changes during maturation. In youthful animals, the lean tissue is fine-textured and light pinkish-red in color. As an animal matures, the texture of the lean becomes progressively coarser and the muscle color becomes darker.

Marbling. Within a maturity group, marbling (the amount and distribution of intramuscular fat) within the ribeye is the primary determinant of USDA Quality Grade. Visual evaluations of marbling in the ribeye (at the 12th rib cross-section) are related to differences in eating quality of beef. Beef cuts with high levels of marbling are more likely to be tender, juicy and flavorful than cuts with low levels of marbling. Studies suggest that beef from carcasses grading at least USDA Select is likely to be acceptable in eating qaulity for most consumers.

Ten marbling scores are used to determine USDA quality grades for beef, seven of which are shown in Figure 2. Color photographic standards for USDA marbling scores are available from the National Cattlemen’s Beef Association.

Determining USDA Quality Grade. After maturity and marbling are determined, these two factors are combined to determine USDA Quality Grade. The relationships between marbling and maturity used to determine the Quality Grade of a carcass are presented in Figure 2. For example, a carcass in the *A maturity group* with a *Small degree of marbling* would be graded *USDA Choice*.

As a general rule, the Prime, Choice, Select and Standard grades are restricted to beef from young cattle (A or B maturity; however, B maturity cattle are not eligible for the Select grade). Likewise, the Commercial, Utility, Cutter and Canner grades normally are comprised of carcasses produced by cat tle of advanced maturity (C, D and E maturity). Carcasses produced by bullocks (A maturity bulls) are eligible only for the Prime, Choice, Select, Standard and Utility Grades, while mature bulls are ineligible for Quality Grading.

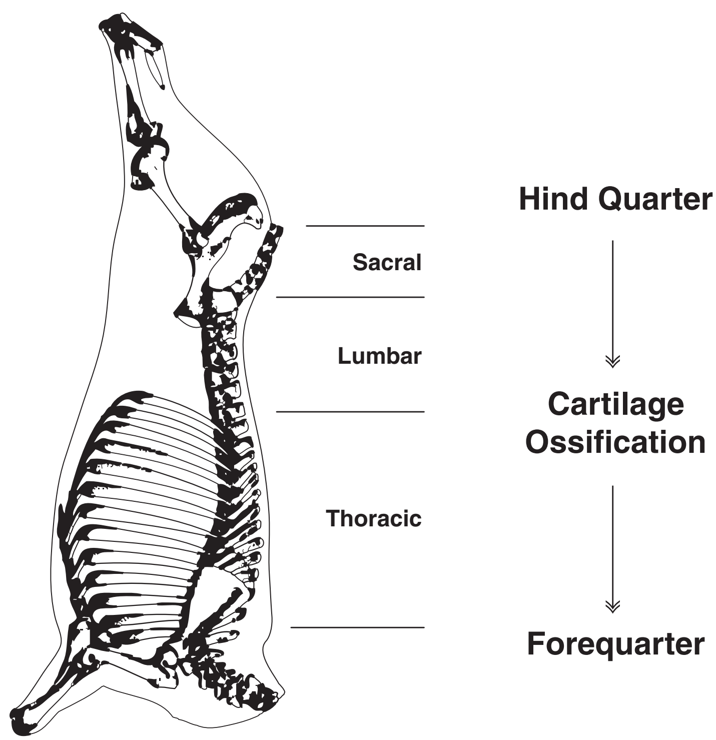

Figure 3
Skeletal Structure of Beef Carcass Showing Progression of Cartilage Ossification in Backbone

Yield Grading

USDA Yield Grades estimate beef carcass cutability, which is defined as the *combined yield of closely trimmed, boneless retail cuts (%CTBRC) from the round, loin, rib and chuck.* This is an estimate of the relative amount of lean, edible meat from a carcass. The five Yield Grades for slaughter cattle and beef carcasses are:

USDA Yield Grade 1
USDA Yield Grade 2
USDA Yield Grade 3
USDA Yield Grade 4
USDA Yield Grade 5

The lower the numerical value of the USDA Yield Grade, the higher the yield of closely trimmed, boneless retail cuts (Table 1).

Table 1: Expected Yields of Closely Trimmed, Boneless Retail Cuts (% CTBRC) and Total Retail Cuts (% Total Yield) for Each USDA Yield Grade

Yield Grade	%CTBRC[a]	%Total Yield[b]
1	>52.3	≥80
2	50.0 to 52.3	75 to 79
3	47.7 to 50.0	70 to 74
4	45.4 to 47.7	65 to 69
5	<45.4	<65

[a] Includes cuts only from the round, loin, rib, and chuck.
[b] Includes steaks, roasts, and ground beef from the entire carcass.

The Yield Grade of a beef carcass is determined by evaluating the following factors: (1) external fat thickness over the ribeye, (2) ribeye area, (3) estimated percentage of kidney, pelvic and heart fat (%KPH), and (4) hot carcass weight.

Fat Thickness. Fat thickness is measured at a point three-fourths of the distance of the length of the ribeye from its chine bone side (Figure 4). This single measurement is a reasonably accurate predictor of overall carcass fatness; however, to improve the accuracy of the predictions of overall carcass fatness, the fat thickness measurement usually is adjusted up or down by the grader to account for visible differences in the distribution of external fat in other areas of the carcass.

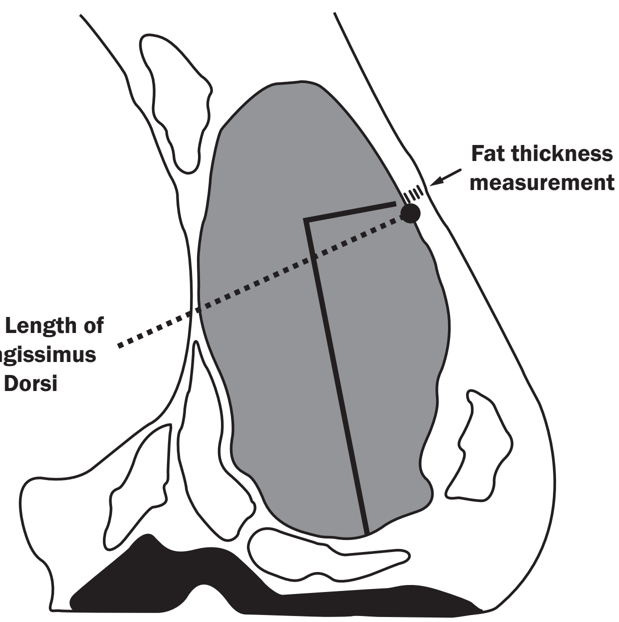

Figure 4
The Location Where Fat Thickness Over the Ribeye is Measured

Ribeye Area and Carcass Weight. The relationship between ribeye area and carcass weight is used in Yield Grading beef carcasses to reflect differences in cutability stemming from carcass muscularity. Ribeye area normally ranges from about 9 to 17 square inches among carcasses of common weights and can be measured using a plastic grid (Figure 5).

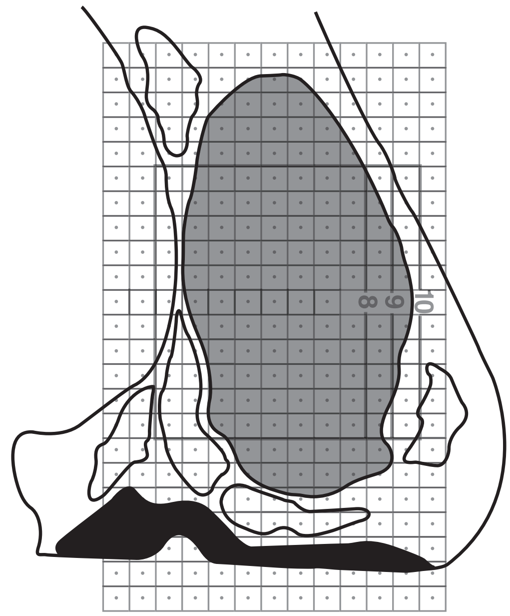

Figure 5: Method of Measuring Ribeye Area
In using the grid to measure a ribeye, place it on the cut surface of the ribeye and count all squares in which lean surrounds a dot. Divide the number of squares counted by 10. The resulting number is the area of the ribeye in square inches.

Kidney, Pelvic and Heart Fat Percentage (%KPH). Fat deposits around the kidney and heart, and in the pelvic cavity, typically are left in the carcass during the slaughter process and affect carcass cutability. Most carcasses have 1% to 4% of the carcass weight represented as kidney, pelvic and heart fat.

Determining USDA Yield Grades. The formula for calculating Yield Grade is:

YG = 2.5 + (2.5 x adjusted fat thickness, in.)
+ (.20 x KPH%)
– (.32 x ribeye area, sq. in.)
+ (.0038 x hot carcass weight, lbs.)

While the USDA Grader may use this equation occasionally, most determinations are based upon the Grader's experience and training, checking occasionally with the formula when requested to do so. The same holds true for the Grader's determination of the USDA Quality Grade.

Summary

Consumers and producers often do not have a clear understanding of beef grading. Beef grades are of two types, Quality Grades and Yield Grades. Most consumers are familiar with the names of several Quality Grades and may use them as a selection criterion when purchasing at retail. However, Yield Grades have less direct impact on consumer selection decisions. Producers, on the other hand, depend greatly on both Quality and Yield Grades as a marketing tool for beef cattle and carcasses.

USDA Quality Grades are used to predict the palatability of meat from a beef animal or carcass, using carcass physiological maturity and marbling to determine the USDA grade. USDA Yield Grades are used to estimate the expected edible lean meat, with a USDA YG 1 being the leanest and a USDA YG 5 being the fattest.

References

Boggs, D.L. and Merkel, R.A. *Live Animal, Carcass Evaluation and Selection Manual.* Dubuque, IA: Kendall/Hunt Publishing Company, 1990.

United States Department of Agriculture: Standards for Grades of Slaughter Cattle and Standards for Grades of Carcass Beef. Agricultural Marketing Services, USDA. Washington, D.C., Government Printing Office, 1996.

This fact sheet was authored and reviewed by members of the American Meat Science Association.

For more information contact:

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BEEF FACTS
Product Enhancement

Ranking of Beef Muscles for Tenderness

By Chris R. Calkins, Ph.D. and Gary Sullivan, University of Nebraska

The Significance of Tenderness

Tenderness and flavor are the most important palatability characteristics relating to consumer satisfaction with beef. Research has repeatedly shown consumers are willing to pay a premium for beef that can be guaranteed tender. Considerable resources have been expended to understand factors influencing tenderness and to develop technology capable of predicting tender cuts.

Recently, the Muscle Profiling research conducted by the University of Nebraska and the University of Florida, funded by The Beef Checkoff, brought attention to the potential use of under-utilized muscles for value-added products. That study evaluated 39 different muscles from the beef chuck and round for many traits, including Warner-Bratzler shear (WBS) force and sensory characteristics, such as tenderness and juiciness. One of the most successful results has been the Flat Iron steak. Muscle Profiling research demonstrated the exceptional tenderness of the *infraspinatus*, which is the muscle of the Flat Iron steak. In 2006, more than 92 million pounds of Flat Iron steaks were sold in the U.S. indicating there is great value in knowing which muscles produce tender steaks.

Features of Muscle Structure Influencing Tenderness

Beef tenderness is a complex trait. Structural elements of muscle have profound effects on the perception of tenderness. Savell and Cross (1988) reiterated the commonly used categorization of factors influencing meat tenderness - an actomyosin effect, a background effect, and a bulk density or lubrication effect.

Actomyosin effect

This term refers to aspects of meat tenderness influenced by the condition of the sarcomeres in the muscle fibers. Sarcomeres are the smallest unit of muscle contraction and they make up the bulk of muscle fibers (cells). The proteins actin and myosin are the main elements of the sarcomere. These proteins combine during contraction and also during rigor mortis to form actomyosin.

Sarcomeres that are contracted (shorter) are less tender than those which are not. Sarcomere length is affected by muscle position during rigor mortis (stretched muscles have longer sarcomeres) and the temperature at which rigor mortis occurs (cold pre-rigor muscle temperature results in short sarcomeres).

A second feature of the sarcomere is the ease with which it may be fragmented after cooking. This fragility is most often caused by proteolytic degradation of key proteins in the muscle fiber through conditions that contribute to proteolysis such as warmer temperatures during storage and an extended period of time under refrigeration. In fact, cooler aging is recognized as one of the easiest and most effective ways to improve meat tenderness.

Background effect

The term background effect relates to connective tissue located throughout a muscle. This connective tissue retains considerable strength throughout extended periods of cooler aging. Thus, even when the actomyosin effect is very low, background toughness will be caused by this connective tissue.
Two aspects of connective tissue come into play relative to tenderness. First is the amount. The more connective tissue (comprised primarily of the protein collagen) the less tender the meat. Typically, muscles of locomotion (those found in the thoracic and pelvic limbs of animals) have more connective tissue and are less tender.

The second feature of connective tissue is its heat-induced solubility. Upon cooking, especially slow cooking under moist heat conditions, the collagen in connective tissue softens and solubilizes. Naturally, this reduces the contribution of connective tissue to beef tenderness. It is important to note that older animals have more cross-links within collagen than younger animals, meaning the collagen of older

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animals is less soluble when heated. Therefore, older animals provide meat that is less tender.

Bulk density or lubrication effect

Smith and Carpenter (1974) explained this effect caused by intramuscular fat within the muscle. They proposed that fat might dilute the protein in a given, bite-sized portion of meat, thereby lowering the bulk density and resulting in an increase in tenderness. These authors also suggested that fat contained between the cells of a muscle, or within the connective tissue, could thin the connective tissue to a sufficient extent to reduce the amount of force required to cut the meat. In addition, fat provides lubrication between the fibers of a muscle and could increase the perception of tenderness. Fat may also provide some protection against overcooking.

Perceptions of Meat Tenderness

The most common objective method used to quantify the degree of meat tenderness is called Warner-Bratzler shear force analysis. This device records the amount of force required to shear a core of cooked meat. Over the years, core size has ranged from ½ inch to 1 inch in diameter; however, the ½ inch core has become the most commonly used size.

Cover et al. (1962) helped to define at least six features of meat tenderness that can be perceived by highly-trained sensory panels. This includes softness to tongue and cheek, softness to tooth pressure, ease of fragmentation, mealiness of muscle fibers, adhesion between muscle fibers, and tenderness of connective tissue. With tenderness being such a complex and multidimensional trait, it should come as no surprise that there is not always complete agreement between tenderness determined from a Warner-Bratzler shear force analysis and that determined from a trained sensory panel.

Muscle Ranking

Consumers, producers, and product development experts often ask about the tenderness ranking of various beef muscles. Through the years, scientists have completed studies that included many muscles and few animals as well as few muscles over many animals. Not surprisingly, the relative tenderness of specific muscles has not always been in agreement.

On the surface, ranking seems like an easy task. Quickly, however, one encounters a number of questions that must be addressed. What kind of animals should be included? What about breeds and gender classes? How should the muscles have been cooked? Is it more appropriate to use trained sensory panels or untrained consumers? To what degree of doneness should the beef have been cooked?

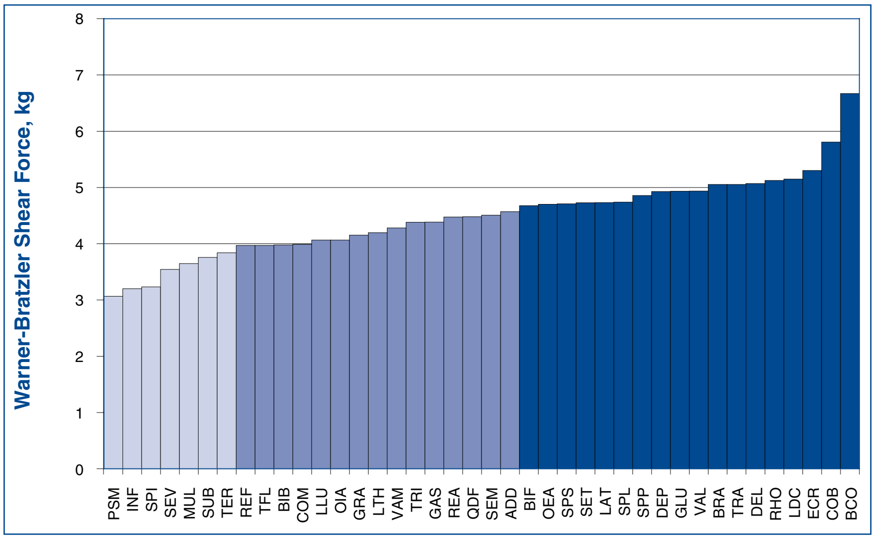
Published literature was collected for papers that ranked at least 3 muscles from at least 3 animals. Fewer muscles would not give the perspective necessary to balance out differences among studies. Data from fewer animals were not considered highly reliable.

Initially, 58 papers were identified spanning 6 decades and many institutions. However, these studies included a wide variety of

Table 1. Abbreviations and common names for the muscles ranked

Abbr.	Muscle	Common Name
ADD	Adductor	Top (inside) round
BIB	Biceps brachii	
BIF	Biceps femoris	Bottom (outside) round
BRA	Brachialis	
BCO	Brachiocephalicus omotransversarius	
COM	Complexus	
COB	Cutaneous-omo brachialis	Shoulder rose
DEP	Deep pectoral (pectoralis profundus)	Brisket
DEL	Deltoideus	Outside chuck (chuck)
ECR	Extensor capri radialis	
GAS	Gastrocnemius	Round heel
GLU	Gluteus medius	Top sirloin
GRA	Gracilis	Inside round cap
INF	Infraspinatus	Top blade; Flat Iron; Triangle
LAT	Latissimus dorsi	
LNG	Longissimus dorsi	Ribeye; Loin eye
LDC	Longissimus dorsi (chuck)	Chuck eye
LLU	Longissimus lumborum	Loin eye
LTH	Longissimus thoracis	Ribeye
MUL	Multifidus dorsi	Sub-eye
OEA	Obliquus externus abdominis	
OIA	Obliquus internus abdominus	Sirloin butt flap
PSM	Psoas major	Tenderloin
QDF	Quadriceps femoris	Knuckle; Sirloin tip
REA	Rectus abdominis	Flank
REF	Rectus femoris	Knuckle center
RHO	Rhomboideus	Hump meat
SEM	Semimembranosus	Top (inside) round
SET	Semitendinosus	Eye of round
SEV	Serratus ventralis	Boneless short ribs; Inside chuck
SPI	Spinalis dorsi	Rib cap
SPL	Splenius	
SUB	Subscapularis	
SPP	Superficial pectoral	Brisket
SPS	Supraspinatus	Mock tender; Chuck tender; Scotch tender
TFL	Tensor fascia latae	Tri-tip
TER	Teres major	Shoulder Tender; Petite Tender
TRA	Trapezius	Outside chuck
TRI	Triceps brachii	Clod heart; Shoulder center; Shoulder top; Ranch Cut
VAL	Vastus lateralis	Knuckle side
VAM	Vastus medialis	

Figure 1. Rank of muscles based on Warner-Bratzler shear force values



Muscles presented as light grey are tender, as light blue are intermediate and as dark blue are tough.

protocols. Age of animals varied from 10 months to over 11 years of age. Heifers, steers, and bulls from *Bos indicus* to dairy-type breeds were used. USDA yield grades ranged from 1 to 5 and quality grades included nearly all possible grades for both young and mature beef. Aging periods varied from 1 to 28 days. Both steaks and roasts were cooked to an end-point temperature ranging from 57-85°C using a wide variety of cooking methods with samples evaluated for WBS using 1.2 to 2.54 cm cores. Sensory panel rating scales offered 5 to 10 classifications.

Due to these differences, constraints were placed on papers used to determine the overall rankings. Selection was based around traits typical of the U.S. market beef population. Acceptable studies included those utilizing steers, heifers, or both that were under 30 months of age or were A and B maturity carcasses from any quality grade. Purebred *Bos indicus* cattle were excluded, but crossbreds were allowed. Additional constraints were added to handling and testing techniques. Steaks included were those cooked or frozen from 5 to 14 days post-harvest. Moist cooking methods were excluded for consistency and products included were cooked to an end point temperature range of 70-77°C. Papers were narrowed to those that used 1.2-1.3 cm cores for WBS and only trained sensory panels were chosen, though no selection was placed on rating scale. Ultimately, 22 papers were used for ranking muscles on the basis of WBS. There were 11 papers for ranking on tenderness ratings, 11 for ranking by juiciness, and 6 for beef flavor.

Muscles were weighted by number of observations to create a rank. Sensory panel ratings were analyzed in the same method after being standardized to a 100 point scale. A correlation coefficient was obtained to compare the ranks on the basis of shear force values and sensory tenderness.

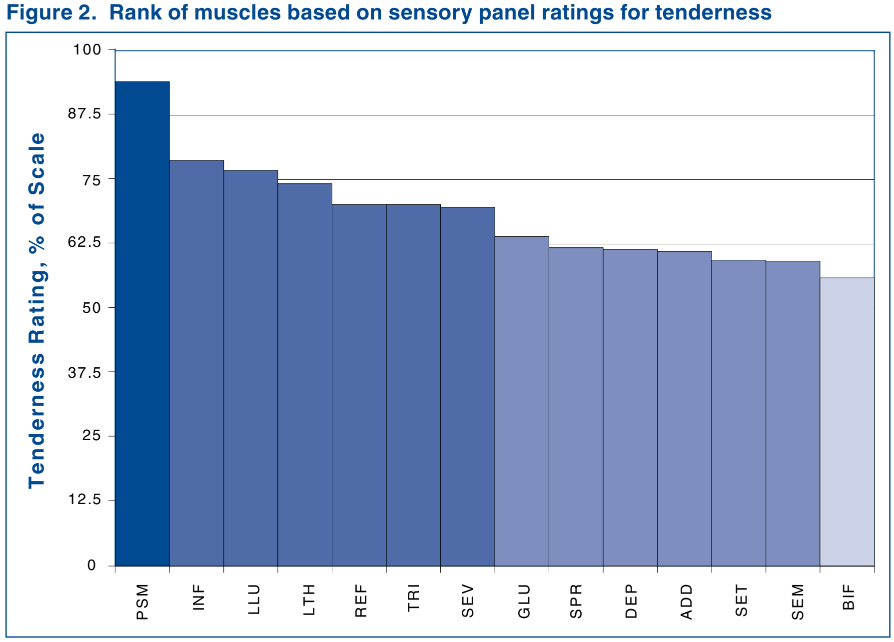
Muscles were placed in 3 tenderness groups on the basis of WBS: tender (<3.9 kg), intermediate (3.9 kg<x< 4.6 kg), and tough (>4.6 kg). The sensory panel results were placed in eight groups: <18.75% of the rating scale, and in increments of 12.5% beyond that for tenderness, juiciness, and beef flavor.

Ranking results

Table 1 lists the muscles that were ranked, along with abbreviations used in the figures and common names applied to those muscles. A detailed description of most of the muscles may be found at the Bovine Myology Web site at *www.bovine.unl.edu*. In some cases, a single muscle has been described broadly (like the *longissimus dorsi*) or more specifically (*longissimus lumborum* and *longissimus thoracis*). Because it was not possible to know where the *longissimus dorsi* was measured, all three references from the literature were included. As a result, all three were ranked, recognizing some overlap necessarily occurs.

Of the 40 muscles ranked for WBS (Figure1; Table 2), the *psoas major, infraspinatus, spinalis dorsi, serratus ventralis, multifidus dorsi, subscapularis,* and *teres major* were classified as tender (<3.9 kg). The *psoas major* has long been utilized for its tenderness and is the muscle of the beef tenderloin. The *multifidus dorsi* and *spinalis dorsi* are found in ribeye steaks and chuck eye rolls. The *infraspinatus* and *teres major* have been increasingly utilized as 'value cut' steaks. However, the *serratus ventralis* and *subscapularis* are under-utilized muscles in relationship to their inherent shear values. The major muscles that were classified in the tough group (>4.6 kg) were the *biceps femoris, supraspinatus, semitendinosus, deep pectoral, gluteus medius, vastus lateralis, rhomboideus,* and the

Figure 2. Rank of muscles based on sensory panel ratings for tenderness

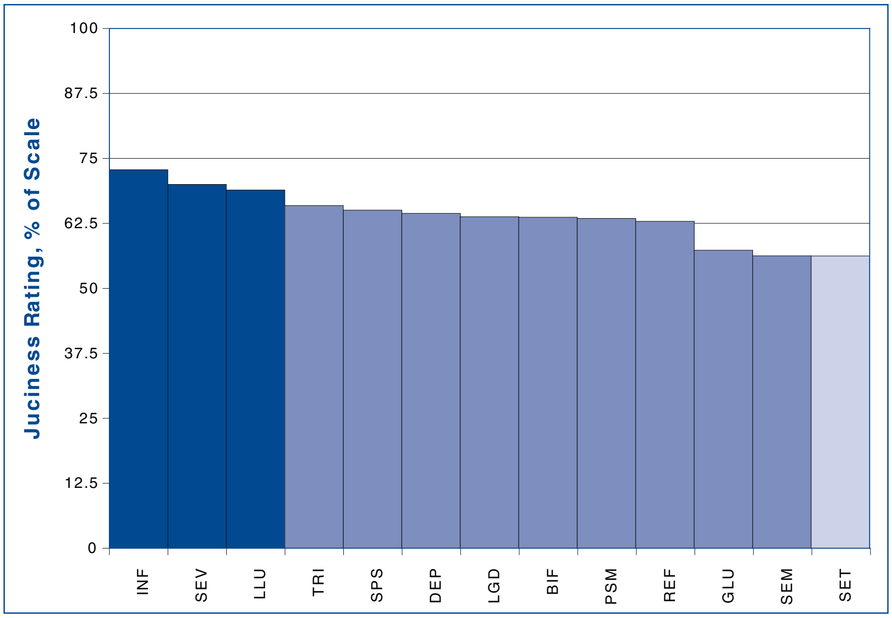


Muscles presented as dark blue are very tender, as medium blue are tender, as light blue are intermediate, and as light grey are tough.

Table 2. Warner-Bratzler shear force rank and tenderness categories of beef muscles

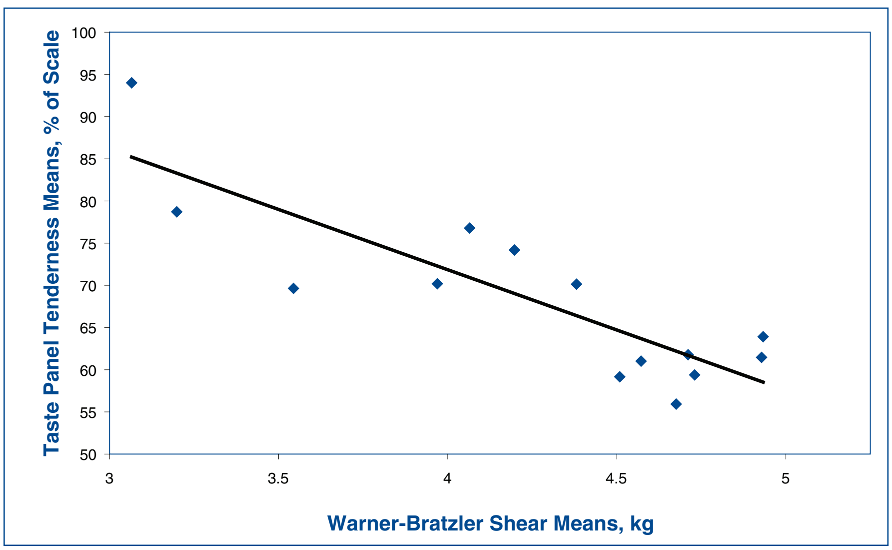
Muscle	Shear force, kg	Shear force, lbs	Tenderness Category
Psoas major	3.07	6.75	Tender
Infraspinatus	3.20	7.05	Tender
Spinalis dorsi	3.23	7.12	Tender
Serratus ventralis	3.54	7.81	Tender
Multifidus dorsi	3.65	8.03	Tender
Subscapularis	3.76	8.27	Tender
Teres major	3.83	8.46	Tender
Rectus femoris	3.97	8.74	Intermediate
Tensor fascia latae	3.97	8.74	Intermediate
Biceps brachii	3.98	8.76	Intermediate
Complexus	3.99	8.79	Intermediate
Longissimus lumborum	4.07	8.95	Intermediate
Obliquus internus abdominus	4.07	8.96	Intermediate
Gracilis	4.15	9.15	Intermediate
Longissimus thoracis	4.20	9.25	Intermediate
Vastus medialis	4.28	9.43	Intermediate
Triceps brachii	4.38	9.65	Intermediate
Gastrocnemius	4.39	9.66	Intermediate
Rectus abdominis	4.48	9.59	Intermediate
Quadriceps femoris	4.48	9.87	Intermediate
Semimembranosus	4.51	9.93	Intermediate
Adductor	4.57	10.07	Intermediate
Biceps femoris	4.68	10.30	Tough
Obliquus externus abdominis	4.70	10.35	Tough
Supraspinatus	4.71	10.38	Tough
Semitendinosus	4.73	10.42	Tough
Latissimus dorsi	4.73	10.42	Tough
Splenius	4.74	10.44	Tough
Superficial pectoral	4.86	10.70	Tough
Deep pectoral (pectoralis profundus)	4.92	10.86	Tough
Gluteus medius	4.93	10.87	Tough
Vastus lateralis	4.94	10.87	Tough
Brachialis	5.05	11.13	Tough
Trapezius	5.05	11.13	Tough
Deltoideus	5.07	11.17	Tough
Rhomboideus	5.12	11.29	Tough
Longissimus dorsi (chuck)	5.15	11.34	Tough
Extensor capri radialis	5.30	11.68	Tough
Cutaneous-omo brachialis	5.81	12.79	Tough
Brachiocephalicus omotransversarius	6.67	14.69	Tough

Figure 3. Rank of muscles based on sensory panel ratings for juiciness



Muscles presented as dark blue are juicy, as light blue are intermediate, and as light grey are dry.

Figure 4. Pearson's correlation of means for shear force and tenderness rating (r = -0.85; P = 0.001)



longissimus dorsi from the chuck region. Although the *gluteus medius* (sirloin) is often used in steak applications, it only ranked 31 of 40 for WBS values.

For muscles analyzed by sensory panel, all steaks (n=14) that had a tenderness rating greater than or equal to a six point equivalent on an eight point scale also had a WBS less than 4.5 kg (Figure 2). However, there were differences in muscle ranking. For example, the *serratus ventralis* ranked fourth using WBS but ranked seventh in the taste panel. In contrast, the *triceps brachii* ranked 17th using WBS but was ranked sixth by the panel. Although not all muscles were included in both comparisons, differences clearly exist between WBS and sensory evaluation.

It is established that muscles vary in tenderness from one end to the other. Unfortunately, authors rarely describe the precise anatomical location from which samples are derived. In addition, differences exist in the relative contribution of connective tissue and muscle fiber tenderness to WBS values versus sensory tenderness ratings. These two situations likely account for some of the differences. Shackelford et al. (1995) reinforced this point and described a method to relate WBS values to sensory ratings for different muscles from the beef carcass.

In addition, muscles differ in the characteristics that influence tenderness. McKeith et al. (1985) studied 13 major muscles of beef carcasses and reported differences in composition, sarcomere length, and collagen content, in conjunction with sensory panel ratings and Warner-Bratzler shear force values. Rhee et al. (2004) studied 11 beef muscles in greater detail, including a measure of proteolysis. These later authors also related the various traits among all muscles as well as within muscles. Their results reinforce differences within a muscle, meaning one portion of a muscle is often different from another portion of the same muscle for the various traits studied.

The correlation between sensory panel tenderness ratings and WBS values for 14 muscles was evaluated. Mean tenderness ratings had a correlation to mean shear force value, by muscle, of -0.85 (p=0.001) (Figure 4) indicating good, but not complete, agreement.

For juiciness (n=13), the *infraspinatus, serratus ventralis*, and *longissimus lumborum* were among the highest rated and the *gluteus medius, semimembranosus*, and *semitendinosus* were among the least juicy (Figure 3).

Conclusion

This fact sheet compiles the data from 60 years of tenderness and sensory research to create a definitive ranking of beef muscles on the basis of Warner-Bratzler shear force and trained sensory panel evaluations of tenderness, juiciness, and beef flavor. These data can be used to identify raw materials for specialized uses and value-added products.

References:

Cover, S., R.L. Hostetler, and S.J. Ritchey. 1962. Tenderness of beef. IV. Relations of shear force and fiber extensibility to juiciness and six components of tenderness. J. Food Sci. 27:527-536.

Rhee, M.S., T.L. Wheeler, S.D. Shackelford, and M. Koohmaraie. 2004. Variation in palatability and biochemical traits within and among eleven beef muscles. J. Anim. Sci. 82:534-550.

Savell, J.W. and H.R. Cross. 1988. The role of fat in the palatability of beef, pork, and lamb. In Designing Foods: Animal Product Options in the Marketplace. National Academy Press, Washington D.C.

Shackelford, S.D., T.L. Wheeler, and M. Koohmaraie. 1995. Relationship between shear force and trained sensory panel tenderness ratings of 10 major muscles from bos-indicus and bos-taurus cattle. J. Anim. Sci. 73:3333-3340.

Smith, G.C. and Z.L. Carpenter. 1974. Eating quality of animal products and their fat content. Proceedings of the Symposium on Changing the Fat Content and Composition of Animal Products. Washington D. C. National Academy of Science.

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National Cattlemen's
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MARBLING DESCRIPTIONS & ILLUSTRATIONS

Quality Grade Description

At right appear the six most commonly found marbling degrees available to foodservice purchasers.

The descriptions apply to beef carcasses from animals of approximately 9 to 30 months of age. The U.S. Department of Agriculture designates this age animal to be "A" maturity in its official grading standards.

95 percent or more of the officially graded beef that is made available to foodservice purchasers is of "A" maturity.

Marbling Descriptions

- The degree of marbling illustrates the minimum amount of marbling necessary to qualify for the following U.S. quality grades.
- Though not officially graded except as U.S. Prime or U.S. Choice, the degree-of-marbling photographs do identify the points within each grade level.

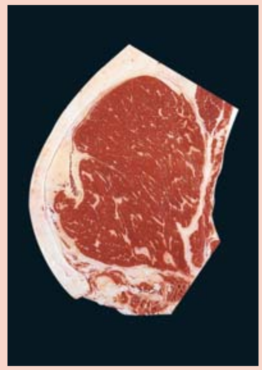
Further explanations as to the meaning of the quality grading photographs or the criteria may be obtained from the US. Department of Agriculture, Agricultural Marketing Service, Livestock & Seed Program, either the Standardization Branch, or the Meat Grading and Certification Branch, or from a member of the North American Meat Processors Association.

Since marbling is such an important factor in grading beef quality, the following pictures illustrate the lower limits of six marbling degrees: Moderately Abundant, Slightly Abundant, Moderate, Modest, Small, and Slight.

It should be noted that there are ten degrees of marbling referred to in the Official United States Standards for Grades of Carcass Beef. These color photographs have been developed to assist government, industry, and academia in the proper application of official grade standards.

MODERATELY ABUNDANT

- The minimum marbling degree necessary for average U.S. Prime.



SLIGHTLY ABUNDANT

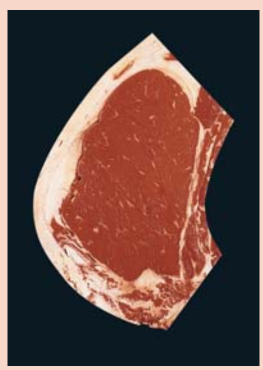
- U.S. PRIME must, at the minimum level, be representative of Slightly Abundant.
- The minimum marbling necessary to qualify for U.S. Prime grade.

MODERATE

- The minimum marbling degree necessary for high U.S. Choice.

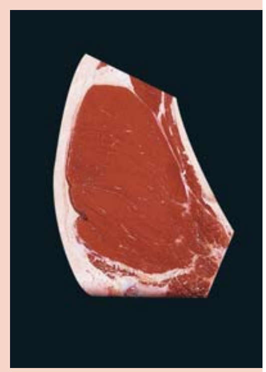
MODEST

- The minimum marbling degree necessary for average U.S. Choice.



SMALL

- U.S. CHOICE must, at the minimum level, be representative of Small.
- The minimum marbling necessary to qualify for U.S. Choice grade.



SLIGHT

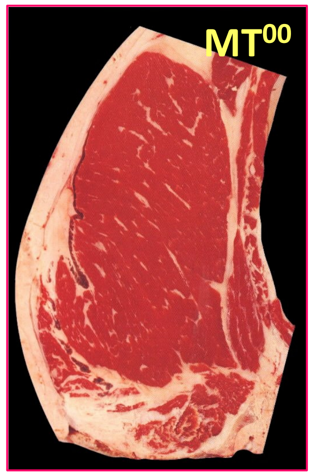
- U.S. SELECT must, at the minimum level, be representative of Slight.

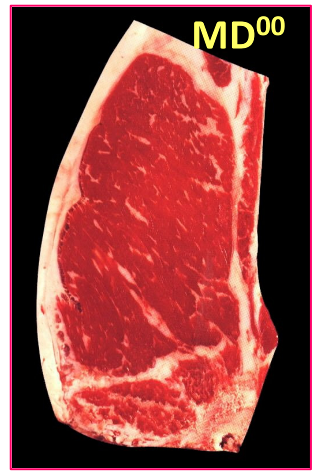
The above illustrations are reduced reproductions of the Official USDA Marbling Photographs prepared for the U.S. Department of Agriculture by and available from the National Cattlemen's Beef Association.

U.S. Marbling Scores

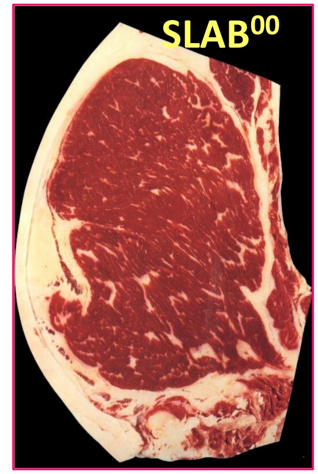
SELECT

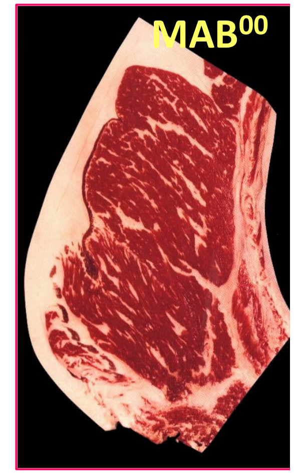
LOWER 1/3 CHOICE





UPPER 2/3 CHOICE

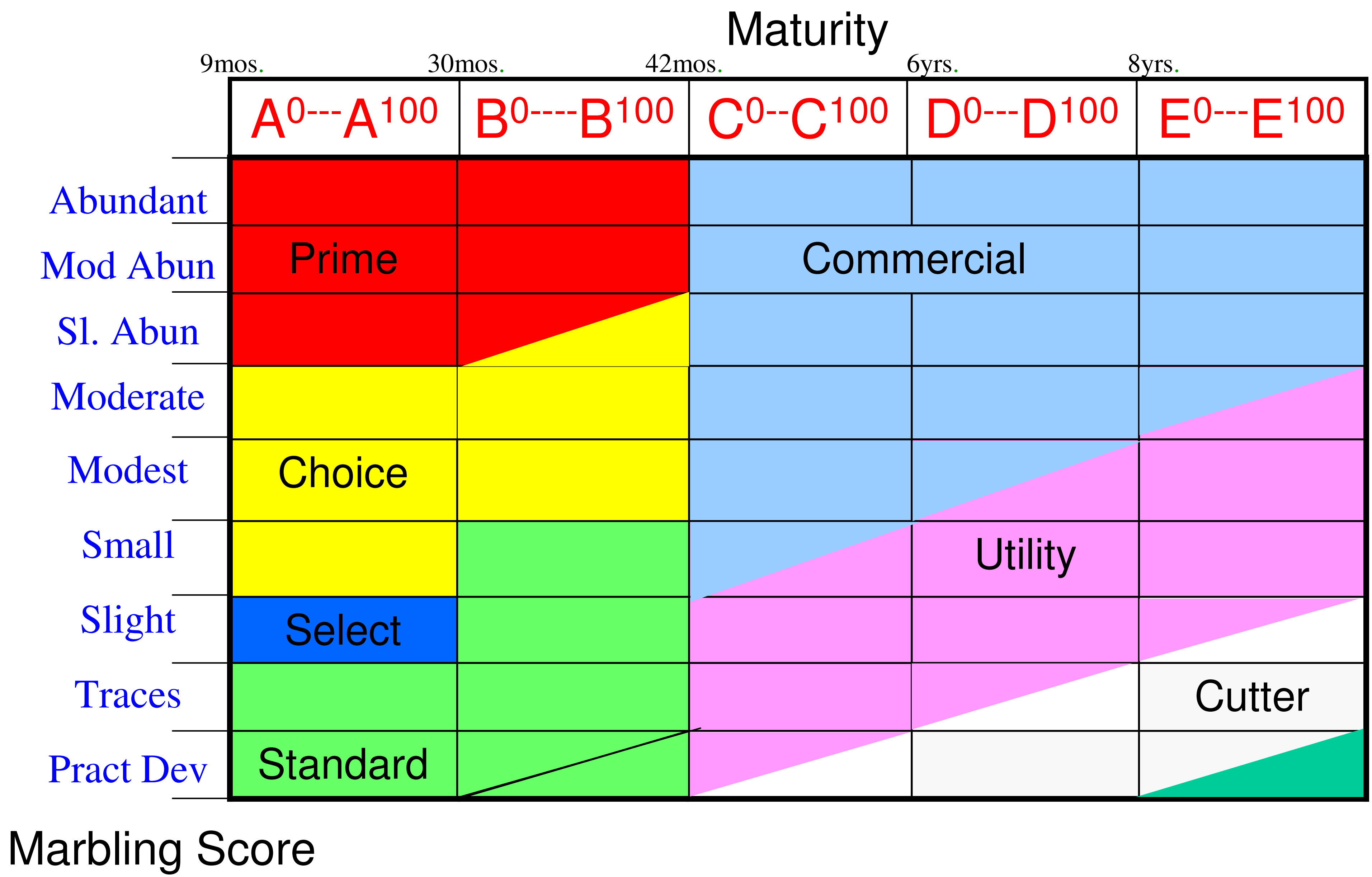




PRIME

PREMIUM BEEF PROGRAMS

USDA Beef Grades



BEEF FACTS: Meat Science

Aging of Beef

By **F.C. Parrish, Jr.**, Ph.D.
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Introduction

Postmortem aging, sometimes called *"conditioning"* or *"ripening,"* is a natural process which improves the palatability attributes of meat, especially cuts from the rib and loin. Commercially, postmortem aging is accomplished by subjecting carcasses, primal or subprimal cuts to controlled, refrigerated (above freezing) storage conditions. Of the palatability attributes of beef steaks, tenderness is the attribute most demanded by consumers, and the improvement in tenderness is the primary reason for postmortem aging. Postmortem aging, however, also improves the palatability attribute of flavor.

Primal or subprimal beef cuts from the loin and rib (middle meats) are specifically aged postmortem, since these serve as the source of the most desirable steaks (rib, T-bone, Porterhouse, top loin, sirloin and filet mignon steaks).

(While carcasses or cuts from any species could be aged, postmortem aging is generally limited to beef, due to the relative youth of pork, lamb and veal. Consequently, this discussion concentrates on the postmortem aging of beef.)

What is Postmortem Aging?

Postmortem aging is a process that occurs naturally in all muscle tissues, whether vacuum packaged or in the form of carcasses or wholesale cuts. In the conversion of muscle to meat, natural enzymes (*proteases*) found in muscles, break down specific proteins in muscle fibers (a process called *proteolysis*). This breaking (or *fragmentation*) of these protein strands, called *myofibrils*, by natural enzymes results in improved tenderness of the rib and loin muscles during postmortem aging.

Tenderization occurs at a relatively rapid rate until 3 to 7 days postmortem, and then the rate of increased tenderness diminishes with time. Practically speaking, the increase in tenderness of rib and loin cuts after 7 to 10 days is relatively small, compared with the increase during the first 7 to 10 days postmortem.

Types of Aging

Two types of postmortem aging processes are practiced commercially: *"dry"* and *"wet"* aging.*

Dry aging (Figure 1) is the traditional process of placing an entire carcass or wholesale cut (without covering or packaging) in a refrigerated room for 21 to 28 days at 32-34° F and 80-85% relative humidity, with an air velocity of 0.5 to 2.5 m/sec. All three conditions, although varying widely in commercial practice, are extremely important in the proper postmortem aging of carcasses, as well as beef ribs and loins.

Figure 1: Dry aging of a beef carcass.

* A third method, *accelerated aging,* uses a higher holding temperature, with ultraviolet light used to retard microbial growth which would normally occur at higher temperatures. This method, however, has not been used commercially to a significant degree in recent years, due to the extent that vacuum packaged products are subjected to *wet aging.*

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Too much humidity will allow excessive microbial growth, whereas too little will cause excessive shrinkage. Eighty-five percent relative humidity is a happy medium in slowing microbial growth and moisture loss.

Tenderness development can be accelerated by aging at a higher temperature; however, increased microbial growth becomes a serious problem at higher temperatures.

Air velocity is essential because it acts as a medium for moisture removal from the refrigerated area. Insufficient air velocity will allow excessive moisture to condense on the product, and as a result, off-flavors and aromas, as well as spoilage, will occur. Too high an air velocity, on the other hand, will result in excessive surface drying, with resulting weight and trim losses. The main disadvantage of dry aging is the cost associated with these weight and trim losses.

Wet aging (Figure 2) is the aging of meat in vacuum bags (usually the middle meats) under refrigerated conditions of 32-34° F. Obviously, humidity and air velocity are not necessary requirements for proper wet aging. Because most beef is vacuum packaged at the site of carcass *fabrication* (cutting), wet aging is the predominant method of postmortem aging today.

The aging process continues when a primal or subprimal cut has been placed in a vacuum package. By the time the cut reaches the retail store, at least 7-10 days have normally elapsed following slaughter, due to holding at the packing plant for carcass chilling and fabrication, inventory storage, shipping to the retail warehouse, and subsequent shipping to the retail store level. Therefore, the time associated with the rapid tenderization (7-10 days) and that associated with product movement to the retail store are similar. However, additional aging time is generally beneficial.

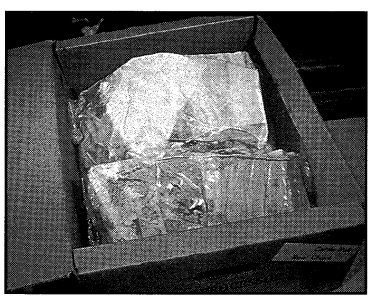

Figure 2: Wet aging of vacuum-packaged beef.

Dry and wet aging both result in a similar degree of palatability of rib and loin steaks; however, there can be distinct flavor differences. Meat from vacuum-aged cuts has a more bloody/serumy and metallic flavor, whereas, meat from dry-aging has a more brown-roasted beefy flavor.

What Factors Affect Aging?

Aging rate and time are postmortem variables affecting tenderness. Different rates of aging means some carcasses and/or cuts tenderize very early, while others tenderize gradually. In fact, some beef does not tenderize appreciably, regardless of the aging time. Muscles that are moderately high to high in connective tissue (e.g., muscles located in the round) generally are not very tender after adequate aging because the connective tissue is not fragmented sufficiently during aging.

Widely differing amounts of time for postmortem aging occur in commercial practice, due primarily to the time that vacuum packaged cuts are held in inventory prior to being processed into retail cuts for sale. The *National Beef Tenderness Survey*, conducted in 1991, indicated that beef was held (and, in effect, aged) from 3 to 90 days (with an average of 17 days) before retail sale. Aging beyond 28 days results in little benefit to enhanced palatability, and may even be detrimental in terms of increased and unwanted microbial growth and flavor changes.

Fortunately, most beef reaches some level of acceptable tenderness during postmortem aging; even so, the *National Beef Tenderness Survey* indicated that 15-20% of beef was undesirable in tenderness. Postmortem aging optimizes tenderness, but does not insure totally and uniformly tender beef steaks.

Specific muscles and quality grades are also considered important variables in postmortem aging. The tenderloin is the most tender muscle in the beef carcass, and interestingly requires little postmortem aging. The loin muscle, a relatively tender muscle, because of high fragmentation and small quantities of connective tissue (collagen), has a similar pattern of postmortem aging as the eye of the round, a less tender muscle of low fragmentation and more quantities of connective tissue (collagen). Steaks from different USDA quality grades, although differing in tenderness within and between grades, have a similar pattern of aging. That is, beef cuts from USDA Choice will age very similarly to beef cuts from USDA Select.

While postmortem aging can have a profound effect on improving palatability (especially tenderness), breeding, feeding, processing and preparation all play an important role in final consumer satisfaction. Indeed, cooking (preparation) often can be the most profound factor in determining beef steak tenderness. For example, beef loin steaks broiled to a rare degree of doneness will be more tender than steaks cooked medium or well done.

Summary

Postmortem aging of beef carcasses and cuts is a natural process that usually improves tenderness under refrigerated conditions. Natural enzymes act to break specific muscle protein strands into smaller pieces to result in improved beef steak tenderness of rib and loin cuts. Most tenderization occurs early in the postmortem aging process, and by 10 days postmortem, most tenderization has occurred in rib and loin cuts.

Although postmortem aging has a profound optimizing effect on tenderness, it does not insure total and uniformly tender beef steaks because several other ante- and postmortem factors impact tenderness.

References

Huff, E.J. and F.C. Parrish, Jr. 1993. Bovine longissimus muscle tenderness as affected by postmortem aging time, animal age and sex. J. Food Sci. 58:713-716.

Huff-Lonergan, E.J., T. Mitsuhashi, D.D. Beekman, F.C. Parrish, Jr., D.G. Olson and R.M. Robson. 1996. Proteolysis of specific muscle structural proteins by μ- Calpain at low pH and temperature is similar to degradation in postmortem bovine muscle. J. Anim. Sci. 74(5):993-1008.

Miller, M.F., G.W. Davis and C.B. Ramsey. 1985. Effect of subprimal fabrication and packaging methods on palatability and retail caselife of loin steaks from lean beef. J. Food Sci. 1544-1546.

Morgan, J.B., J.W. Savell, D.S. Hale, R.K. Miller, D.B. Griffin, H.R. Cross and S.D. Shackelford. 1991. National Beef Tenderness Survey. J. Anim. Sci. 69:3274-3283.

Parrish, F.C., Jr., R.B. Young, B.E. Miner and L.D. Anderson. 1973. Effect of postmortem conditions on certain chemical, morphological and organoleptic properties of bovine muscle. J. Food Sci. 38:690-695.

Parrish, F.C., Jr., J.A. Boles, R.E. Rust and D.G. Olson. 1991. Dry and wet aging effects on palatability attributes of beef loin and rib steaks from three quality grades. J. Food Sci. 56:601-603.

Warren, K.E. and C.L. Kastner. 1992. A comparison of dry aged and vacuum-aged beef strip loins. J. Muscle Foods. 3:151.

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CREATING CRAVE THE BEEF FACTOR

A Guide to Understanding Flavor and the Umami Effect

Flavor 101: A Brief Overview

Most of us use the terms taste and flavor interchangeably, but they're actually different. **Taste** refers to the five basic receptors: **sweet, salty, sour, bitter** and **umami** (the one we didn't learn about in school). **Flavor** is a combination of taste plus the other sensations that influence our perception of food, such as aroma, texture, juiciness, mouthfeel and color.

Umami:[oo-MOM-ee], known as the **fifth taste**, is described as meaty and savory or delicious *(umami is derived from umai, the Japanese word for delicious)*. It is the taste of **glutamates**–the salts of an amino acid–and other small molecules called **nucleotides**. Although umami has been known for quite a while, recently **umami receptors** have been clearly identified so this is a bona fide fifth taste. The ability to detect these five tastes has been key to our survival throughout the ages, directing us toward vital foods away from potential poisons. **Sweet** means energy-giving carbohydrates. **Salt** indicates essential minerals for life-sustaining cell functions and wound healing. **Sour** says "to proceed with caution," since many foods sour as they deteriorate. **Umami** signifies life-giving protein. And **bitter** warns "spit it out, don't touch it" because many natural toxins taste bitter.

Beef Flavor Pairings: Matches Made in Heaven

It's no accident that beef is often paired with certain ingredients *(see back for examples)*. Food trend research reveals that many of the most popular ingredients in beef dishes contain umami compounds–just as beef does. And we've now learned, when two or more umami compounds meet, **synergism** *(the whole is greater than the sum of its parts)* occurs. This explains the delicious pairings of mushrooms and steak, and wine or tomato sauces with beef.

In addition, ripening, aging and fermenting foods can dramatically increase their umami flavor compounds. That's why a truly ripe tomato, aged Parmigiano-Reggiano and fermented foods, such as wine and soy sauce, possess enticing, complex flavors–and also pair well with beef dishes.

BEEF LOVING TEXANS®
TEXAS BEEF COUNCIL

The Umami Effect

A 50-50 mixture of two umami compounds can produce **eight times** as much flavor as either one of the compounds alone!

The Flavor Equation: Beef + X = Amazing Flavor

Just what is the **"X" factor** in the above flavor equation? When it comes to unlocking beef's amazing flavor, "X" equals many different factors. So the more "X" factors you discover, the better your chances of creating the most flavorful beef dishes and products imaginable!

"X" Factor s: Top Ten Factors Influencing Beef Flavor

- **Marbling**
- **Quality Grade**
- **Cooking Method**
- **Degree of Doneness**
- **Aging**
- **Marinating**
- **Freezing/Thawing**
- **Type of Packaging**
- **Added Flavors**
- **Beef Production (feeding practices)**

Top Flavors to Pair with Beef

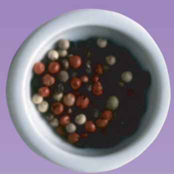
✦ Tomatoes*

✦ Mustard

✦ Bacon*

✦ Aged Cheeses*

✦ Red Wine*



✦ Peppercorns

✦ Sour Cream*

✦ Mushrooms*

✦ Soy Sauce*

✦ Garlic

✦ Barbecue Sauce*

✦ Onions

✦ Thyme

✦ Worcestershire Sauce*

✦ Bell Peppers

* Indicates umami-rich ingredients