Study Guide for the Ultrasonic Evaluation of Beef Cattle for Carcass Merit

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What is Ultrasound?

Ultrasound is sound waves that have a frequency beyond the audible range for human ears. Humans can hear at frequencies between 20 and 20,000 hertz. Ultrasound is sound waves above 20,000 hertz. Tissue imaging or live animal evaluation frequencies range from 1 to 10 MHz (Amin, 1995). Wilson (1994) cites that the range for biological tissues is from 2 to 20 megahertz (MHz). The frequency used is determined by the type of tissue or organ being evaluated. If deep tissue penetration is necessary then a low frequency is used. A higher frequency gives greater resolution, but less tissue penetration. Carcass evaluation most commonly uses a frequency of 3.5 MHz and reproductive evaluation uses 5.0-7.5 MHz.

Useful examples of ultrasound occur in nature. Bats 'see' or navigate by using ultrasound at a frequency of 25,000-500,000 MHz (Widmer, 1993). Bats also use ultrasonic waves to locate their prey. This process is called echo-location. Moths detect the presence of predators by sensing ultrasonic waves.

Biological applications of ultrasound usually require an ultrasound console with a transducer and perhaps an external video monitor. A computer with a frame grabber and appropriate analytical software are also required when analyzing carcass composition in livestock. The software and frame grabber are necessary to capture digital images for the evaluation of carcass traits such as fat thickness, ribeye area, rump fat thickness and percent intramuscular fat. Ultrasonic waves are generated by the ultrasound transducer. Piezoelectric crystals in the transducer convert electrical energy into ultrasound. The ultrasound is emitted from the transducer in short pulses. These short pulses of ultrasound are reflected and scattered by tissues and tissue interfaces (Nyborg and Zisken, 1985). Some of the sound waves penetrate the tissue and others are reflected back to the transducer. The echoes that return to the sound source (transducer) are detected and displayed on the ultrasound unit screen in a cross-sectional anatomical format. The characteristics of the image can be analyzed and conclusions drawn regarding anatomy, health status, fat thickness, etc. (Widmer, 1993).

Ultrasound can travel through liquids, tissues and solids. Thus it can penetrate through the human and animal body and allow one to see the muscles, bones and organs. It is used for medical and veterinary diagnostics and for carcass and reproductive evaluation. Carcass composition can be determined on all species of livestock using ultrasound technology. The most common carcass traits evaluated with ultrasound include fat thickness and *longissimus* muscle area, rump fat thickness and intramuscular fat.

History

The history of ultrasound technology began with the development of piezoelectric effects in the year 1880. This technology was first utilized in World War II (1940's) in the form of SONAR (**SO**und **NA**vigation and **R**anging). However, ultrasound has been used for diagnostic imaging of soft tissues in the livestock industry since the mid 1950's (Wild, 1950). Wild stated that the ultrasound technique is non-destructive, humane and provides a means of quantitative identification of muscle and fatty tissue of the live animal.

The first display mode was called **A-mode** and refers to amplitude modulation. A-mode is one-dimensional display ultrasonic imaging (Temple et al., 1956). Echoes from the transducer appear as spikes on the display. The distance between each spike is related to the distance between successive interfaces (Wilson, 1994). The height of the spike corresponds to sound amplitude at that tissue depth (Widmer, 1993). A-mode is only capable of measuring fat depth and muscle depth in live animals. It does not allow for the measurement of the *longissimus* muscle area (Wilson, 1994).

In 1968, the A-mode display format was modified, which led to the development of **B-mode,** brightness modulation. B-mode is an image display created by integrating multiple A-mode signals (Amin, 1995). B-mode is displayed as two-dimensional and consists of dots or pixels. The brightness of each dot or pixel is determined by the amplitude of the echo. The time it takes the echo to reflect back to the transducer determines the location or position of the dot or pixel on the screen (Wilson, 1994). These echoes are reproduced as varying shades of grey in the resulting ultrasound image. B-mode uses 64 shades of grey whereas; A-mode used 16 shades of grey. Grey scale in the image is created in the following way: The echoes are changed to electrical signals and then into radiofrequency waves by the transducer. The radiofrequency waves are then converted into digital random access memory in the computer. This allows for the assignment of grey scale numbers ranging from 1 to 64 shades. Thus the final display of the image is in shades of grey. Grey scale allows one to see the differences in tissue texture (Widmer, 1993). It does not distinguish between red muscle and fat tissue except by texture. Dense tissues give white pixels. Medium dense tissues give grey pixels.

Real-time ultrasound is a version of B-mode ultrasound. However, real-time ultrasound creates images which are seen almost instantaneously and change as the orientation of the transducer to the tissue being evaluated changes. The result is a live, dynamic ultrasound imaging process. Real time linear array ultrasonic equipment was developed for medical applications and was adapted for live animal evaluation in 1984. Linear array refers to the side-by-side arrangements of the piezoelectric crystals along the length of the transducer (Ginther, 1986). Ultrasound pulses are produced by applying a very short electrical voltage impulse to the transducer. The sound field resulting from ultrasound pulses is called a beam. The beam is divided into two regions called the near field and the far field which are important in beam focusing. The sound beams that pass through the tissues are displayed as an echo on the ultrasound screen. The echo is represented on the ultrasound image by shades of gray, extending from black to white. Real-time units produce live, instantaneous moving images by rapid electric switching from element to element in the beam. With the development of B-mode ultrasound in the late 1970's and real-time linear array technology, the *longissimus* muscle area and other body composition measures can now be obtained using ultrasound technology.

Transducer

The transducer is a vital component of the ultrasound equipment. It "lifts" a thin "slice" of the tissue being evaluated and displays it on the screen (Ginther, 1994). The transducer generates ultrasound and then transmits and receives the ultrasonic waves. Sound waves are transmitted 1/1000 of the time and received 999/1000 of the time during imaging (Widmer, 1993). The transducer uses piezoelectric material to convert electrical energy to ultrasound. Piezein is a Greek word which means to press or pressure. Thus, piezoelectric crystals mean pressure-electric crystals. The piezoelectric material or crystals are commonly made of crystalline quartz, tourmalene or man-made ceramics (Widmer, 1993). These crystals are cut in the shape of a disc in which thickness determines the operating thickness and diameter determines the characteristics of the ultrasound beam. The configuration or thickness and composition of the crystals has a unique resonant frequency, thus transducers are available at differing frequencies (3.5, 5.0, 7.5) (Widmer, 1993).

When an electrical current stimulates the crystals, they are deformed and produce a sound wave. The deformed crystals vibrate at a specific frequency causing pulses of sound waves (Widmer, 1993). When the transducer is placed on a tissue surface, these pulses are transmitted until they reach a tissue interface, such as between fat and lean tissue. When the pulse reaches an interface, a portion of the soundwave is reflected back to the transducer while some pulses continue to penetrate the tissue. The reflected waves produce mechanical energy as they strike and deform the crystals. This energy is then converted into electrical energy, processed and displayed in different formats (Wilson, 1994). Linear array transducers have 60 to 120 crystals.

The earlier transducers were 12.5 cm long. This meant that for evaluating larger areas of interest such as the *longissimus dorsi* muscle, split screen imaging was necessary. Split screen imaging required the overlap of two ultrasonic images to produce one complete image of the *longissimus* muscle. This was accomplished by placing the transducer on the animal and freezing an image from the upper half of the *longissimus dorsi* muscle on one half of the screen and then sliding the transducer downward until a matching image of the lower half of the muscle was obtained. This was a laborious and tedious process. With the development of the 17.2 cm transducer, split screen imaging was no longer necessary. The entire *longissimus* muscle area appears on the screen at one time. The accuracy for split-screen imaging ($r = .60$) is lower than the accuracy for non split-screen imaging ($r = .80$).

Different frequencies are more applicable and produce better images for certain applications. Each transducer is also a different size to better fit the application. A 7.5 MHz transducer has a short wavelength, low penetration, and high resolution. It is used mainly for reproduction measures. This transducer is very small (5.6 cm long) and is well suited for transrectal imaging. A 3.5 MHz transducer has a long wavelength, deep penetration, and poorer resolution. It is recommended for use in the collection of ultrasonic images for estimation of carcass composition. Transducers of this frequency, used for live beef cattle carcass imaging, are usually 17.2 cm long.

Transducers are fragile and can be ruined or broken easily. They should be handled with extreme care. Not only are they fragile, they are also extremely expensive. Transducers are rigid and flat thus they do not fit the shape of the animal. To compensate for this, standoff pads (also called super flab guides) have been produced. Standoffs also act as acoustic couplers. The standoff pad is made of PVC plastic which has desirable acoustic properties (Critical Vision, 1995) and fits the curvature of the animal's back. There are different size standoff pads for each species of livestock.

Velocity

Velocity or speed is measured by the equation:

$$\text{Distance} = \frac{\text{time x velocity}}{}$$

Changes in density or velocity will cause reflection or scattering of the ultrasound waves by the tissues (Amin, 1995). The characteristics of various soft tissues and soft tissue interfaces ultimately determine what proportion of the sound waves will be reflected and received by the transducer. The velocity of the ultrasound waves increases with increasing tissue density. The more dense tissues (such as bone) reflect more of the sound waves. Differences in reflection by soft tissues are due to differences in the speed or velocity required for a soundwave to pass to a given point. In soft biological tissue, speed averages approximately 1540 meters per second.

Table 1. Velocity of propagation (meter/sec)

Source	Velocity
Air	330
Water	1500
Skin	1700
Fat	1430
Muscle	1620
Soft tissues (avg.)	1540
Bone	3500

Adapted from Amin, 1995 & Stouffer, 1988.

B-mode systems are calibrated for average velocity in soft tissues or water. This is done by adjusting for average bias and measurements from phantoms (Amin, 1995). The velocity of sound will vary with the type and temperature of tissue. Most real-time ultrasound scanners are calibrated with a velocity of water at body temperature.

Gain

Overall gain adjusts for the overall brightness of the image. There are two other gain settings, near and far. Near gain sets the brightness in the near field of image. Far gain sets the brightness in the far field of image. Gain controls provide the optimal balance of the grey tone. They are internal controls of the scanner. At different depths of tissue, the intensity on the viewing screen will be different. The gain controls adjust the scanner so the intensity will be similar at each depth of tissue (Ginther, 1994). Gain settings should be consistent from image to image when predicting percent intramuscular fat. If the gain is too high then noise and artifactual echoes will be seen (Corometrics, 1989 and Ginther, 1994).

Couplant

A coupling agent must be applied between the face of the transducer and the tissue to be imaged order to obtain high quality ultrasound images for both carcass and reproduction evaluation. Without a couplant, the ultrasound waves must travel through air which is not an efficient transmitter of sound waves. The couplant provides a more efficient medium for the transmission of sound waves. Vegetable oil (carcass evaluation) and ultrasonic gel (reproduction evaluation) are the best coupling agents. Mineral oil or purple oil can be used but tend to be more abrasive to the face of the transducer.

Preparation of Animal

A common cause of poor quality ultrasonic images is failure to establish suitable acoustic coupling of the transducer face to the curvature of the animals back. Acoustic impedance, the resistance exerted by tissue to the sound propagation, is equal to density times velocity. Echoes are generated at interfaces where there is an impedance mismatch or difference between the two media. The larger the mismatch, the greater the echo will be created (Amin, 1995). Thus a couplant must be used to obtain good echoes and a good image. There are several different types of couplants which can be used for ultrasonic work and they were discussed previously. Air provides a poor coupling since the air and soft-tissue interface will reflect more than 99% of the ultrasound energy. However, a liquid (eg. water, oil or gel) and soft-tissue interface will reflect less than 1% of the ultrasound energy. This is due to the impedance differences (Amin, 1995). The hide must be completely clean of dirt, debris and other foreign material that would trap air bubbles or interfere with the proper acoustic coupling of the sound waves entering and returning from the animal. It is important to clip cattle with more than ½ inch of hair. The couplant (oil) must be placed on the transducer face and on the animal's clean and/or clipped hide at the 12-13th rib junction for optimum image translation between the two interfaces. An ultrasonic wave-guide will also aid in the proper contact between the rigid transducer and the curvature of the animals back (very important in heavily muscled animals). Wet and/or dirty cattle can be blown dry prior to application of a couplant for better image collection. It has been suggested that temperature of the couplant can affect the quality of image captured as well. The couplant should be the same temperature as the animal's external body temperature (about 60-80^{o}F). Additionally, the ultrasound machine should also be kept above 45 degrees F.

Federal Meat Grading Systems

The U.S.D.A. meat grading service places grades on carcasses of red meat animals based on criteria related to palatability of meat when cooked and on estimations of relative cutability. This service was instituted as a system for setting and reporting prices of commodities in the wholesale meat trade. It has become the basis for the trading of live animals and merchandising of retail cuts.

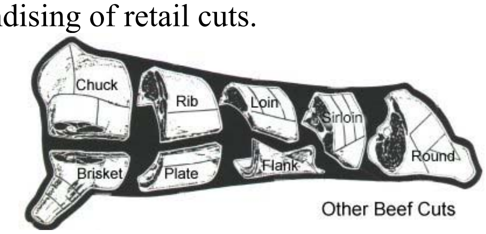


Figure 1. Retail cuts of a beef

<u>Yield Grade</u>

The method of estimating carcass composition most widely used in industry is the determination of saleable and edible product. Murphey et al. (1960) developed a system for estimating the yield of closely trimmed, boneless retail cuts that was established in 1965. The yield grading system for beef carcasses is based on evaluations of hot carcass weight, area of the *longissimus* muscle at the 12th and 13th rib interface, 12-13th rib interface subcutaneous fat thickness and estimated percentage kidney, pelvic and heart fat. USDA yield grade 1 would have the highest yield of closely trimmed wholesale and retail cuts as a percentage of carcass weight and yield grade 5 would have the lowest cutability.

The use of mechanized hide-pullers, which may disfigure the subcutaneous fat layers of the carcass, must be accounted for when collecting carcass data. Therefore, an adjusted fat thickness level is generally estimated from the hanging carcass.

Quality Grade

USDA. quality grades for beef carcasses are based on estimation of physiological age of the animal at the time of slaughter (maturity), color and texture of *longissimus* muscle area at the 12-13th rib interface, ossification of cartilage in the skeletal system and by the estimated amount and distribution of marbling in the exposed *longissimus* muscle.

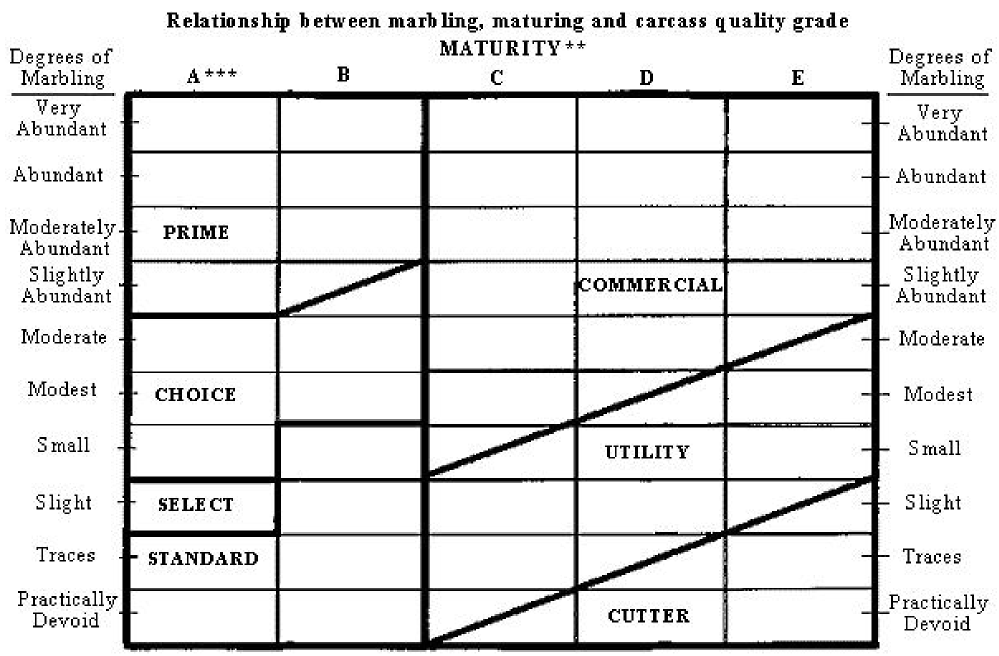


Figure 2. Relationship between marbling, maturity and carcass quality

On March 4, 1987, the U.S.D.A. issued a formal proposal in the Federal Register to rename the U.S. Good grade as U.S. Select as suggested by Cross et al. (1986) in the 1985 National Consumer Retail Beef Study. Although the U.S.D.A. quality and yield grade systems may contradict one another in most cattle (i.e. quality grade encourages fatness and yield grade penalizes fatness), one must understand the manner in which different fat depots contribute to total carcass fat content as cattle mature. However, current knowledge of fat distribution patterns is limited. Swatland (1984) stated that fat is deposited in the following order: mesenteric regions, thoracic-abdominal-pelvic cavities, subcutaneous regions, intermuscular seam areas and finally in intramuscular sites. Deposition of marbling in most red meat animals, occurs later in an animal’s life than other fat depots. Generally, by the time an animal has deposited enough intramuscular fat to qualify for the highest U.S.D.A. grade, it has deposited too much fat elsewhere and its yield grade suffers because of excess trimmable fat. The USDA.quality grading system may be antagonistic to increasing leanness of beef cattle and their carcasses because it encourages over fattening. However, there are animals within various breeds of cattle that can be lean enough to be a Yield Grade 1 and still deposit enough intramuscular fat to grade Choice or better. The use of ultrasound body composition measurements in the genetic evaluation of beef cattle should identify cattle capable of overcoming these antagonisms.

Ultrasound Technician versus the Grading System

Evaluation of the live beef animal currently involves the measurement of fat thickness and *longissimus* muscle area between the 12-13th ribs. These measurements have been emphasized because of their importance in the U.S.D.A. yield grade equation and ease of location by physical palpation of the ribs. The accuracy and proficiency of technicians are determined primarily by their live animal estimates of 12-13th rib fat thickness and *longissimus* muscle area as compared to the actual carcass measures of these same traits. Thus technicians must have a thorough knowledge of the anatomical tissue interfaces of the animal at the 12-13th rib and how these structures will be ultrasonically imaged in the live animal. Technicians often study a large number of ultrasonic images of animals that are followed through the slaughter process in order to become more comfortable and accurate in interpreting ultrasonic fat thickness and *longissimus* muscle area images

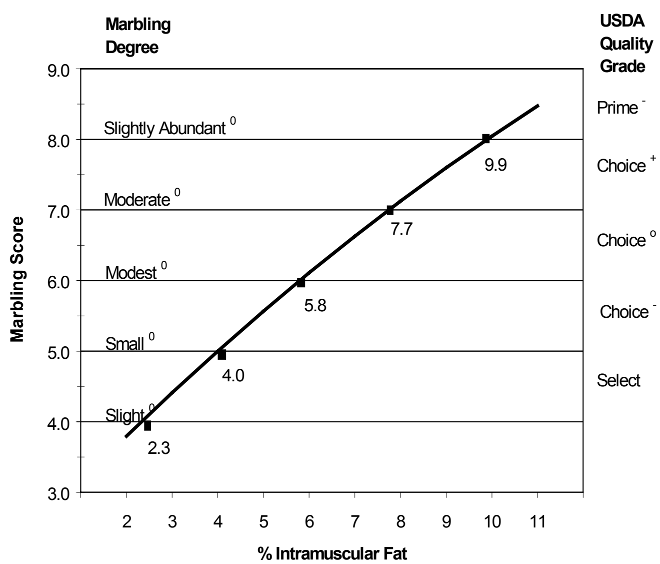
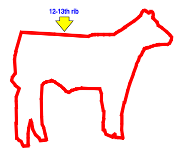
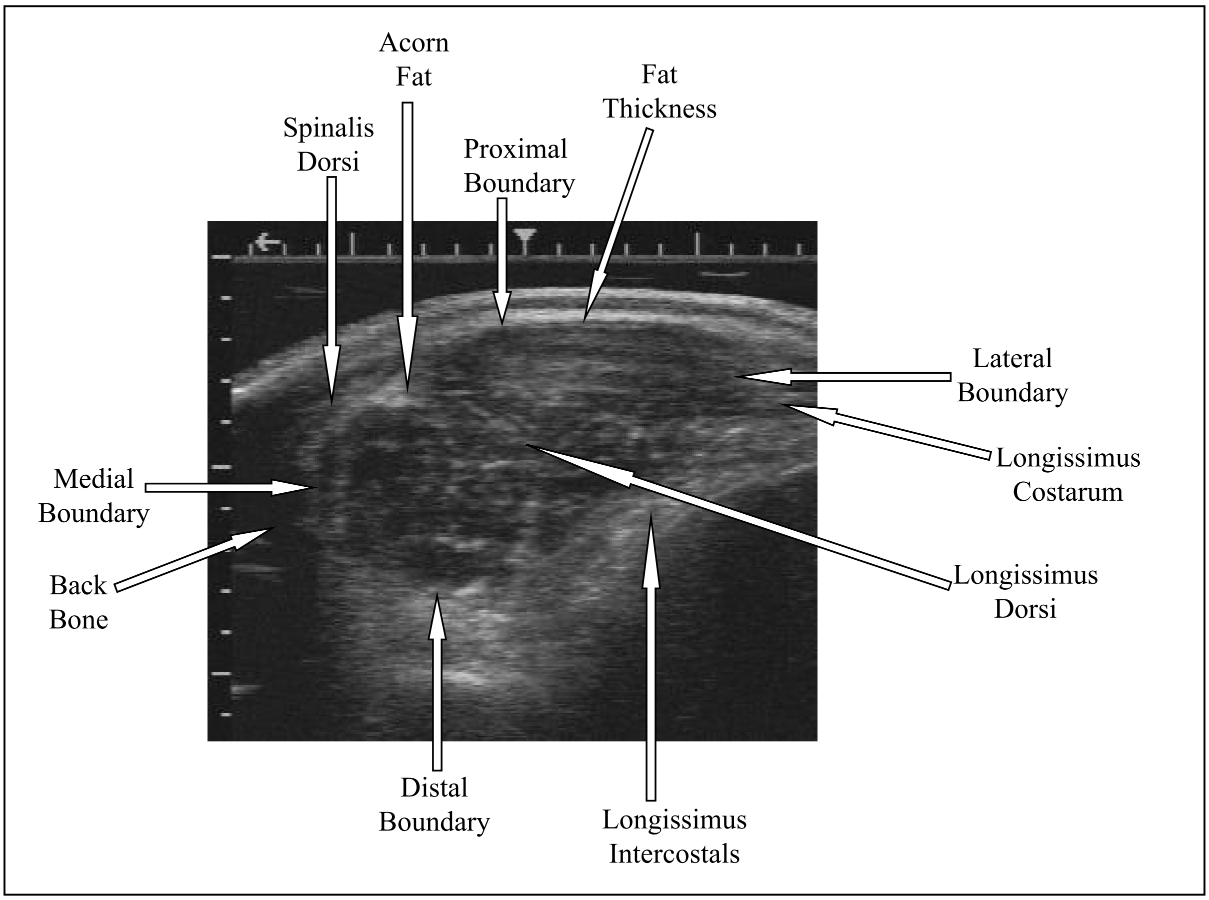


Figure 3. Percent Intramuscular Fat (%IMF) to USDA Marbling Score Conversion.

Anatomy of Ultrasound Area

The image below shows a ribeye cross section taken between the 12-13th ribs showing various important anatomical structures. The spine is located medially with the subcutaneous fat layer being located on the dorsal surface of the *longissimus* dorsi muscle. Backfat depth is measured ¾ of the distance from the medial to the lateral edge of the *longissimus dorsi* muscle. The *longissimus costarum* muscle will be located on the lateral side of the *longissimus dorsi.* Intercostal muscles should appear as two parallel lines immediately ventral to the *longissimus* dorsi and *longissimus costarum* muscles. The *spinalis dorsi* muscle is located dorsomedially to the *longissimus dorsi*. Each of these anatomical features is a very important landmark for accurate measurement of fat thickness and determination of the boundaries of the *longissimus* dorsi muscle.





Placement of Transducer

In order to place the transducer, you must find the last rib (13th) by physical palpation. After the last rib has been located, the transducer can be placed in between it and the second to last rib (12th rib). The transducer should be placed close to the spine and parallel to the ribs. If the transducer is not placed parallel to the ribs, a “v”-shaped reflection will appear at the bottom of the image at the location where the transducer crosses the rib face. If the transducer is placed too close to a rib, the intercostal muscles may appear to converge or may not appear distinctly at all on the image. Proper placement is essential for an accurate measurement of fat thickness and *longissimus* muscle area.

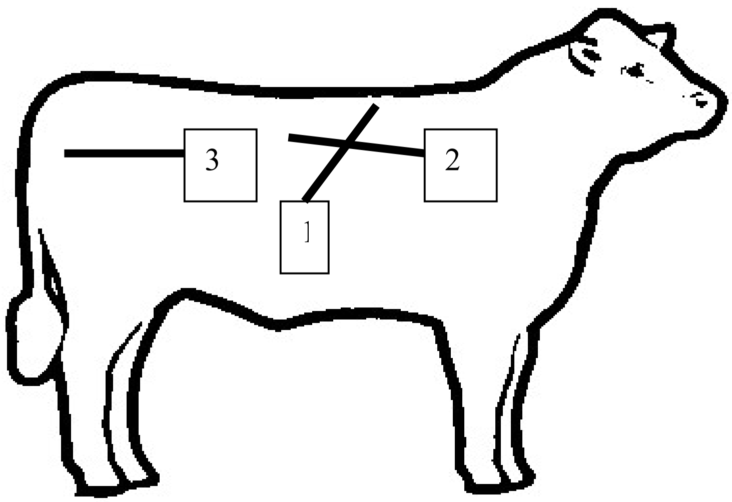


Figure 4. Location of reference points for ultrasound transducer placement (1 = ribeye area, 2 = marbling, and 3 = rumpfat).

Fat thickness (FT) is an assessment of external fat on the carcass and is measured over the *longissimus dorsi* at a point ¾ of the distance from the medial (spine) side to the lateral side of the muscle. FT, along with *longissimus* muscle area, is highly correlated to the retail product yield of a beef carcass. Greater fat thickness depth results in lower percent retail product in the carcass. The yield grade also increases numerically toward 5. FT accounts for the majority of the variation found in beef carcass yield grades. FT is moderate to highly heritable (Wilson, 1994).

Ribeye Area

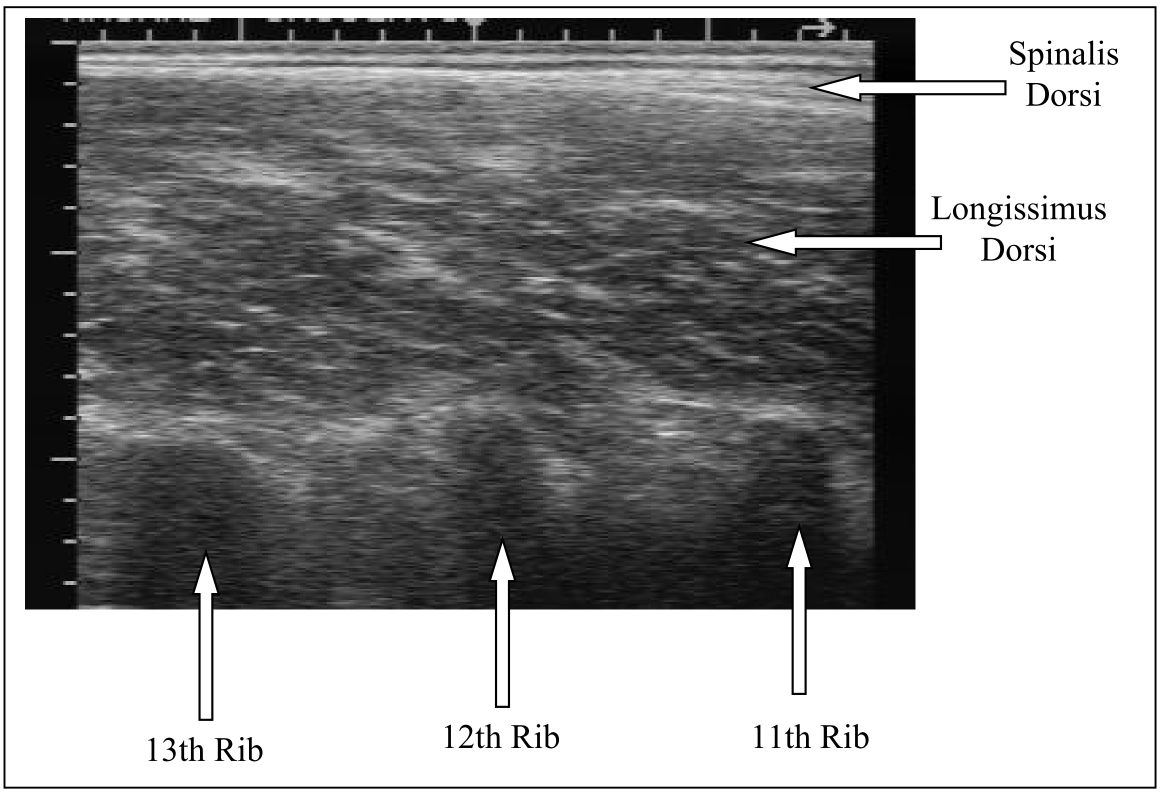
Ribeye area (REA) is the area of the *longissimus* dorsi ~~muscle~~ or ribeye muscle and is measured by including only the area of the *longissimus dorsi* muscle. You should not include any other muscles (e.g. *spinalis dorsi* or *longissimus costarum*) in the interpretation. It is measured in square inches or square centimeters between the 12th and 13th ribs. The normal REA ranges from approximately 8.0 to 16.0 in^2 in yearling cattle. The guideline for estimating REA on live beef animals is 1.10 in^2 / 100 pounds of body weight up to 1000 pounds and 1.0 in^2 / 100 pounds of body weight over 1000 pounds. On average, a 1000 lb. steer should have an 11.0 in^2 REA and a 1100 pound steer would have a 12.0 in^2 REA. REA is positively correlated with pounds of retail product. Within a specific carcass weight range, REA may have a significant impact on the variation in beef carcass yield grades. REA is moderate to highly heritable (Wilson, 1994).

Rump Fat Thickness

Rump fat (RFU) measures the depth of subcutaneous fat at the juncture of the *gluteus medius* and *biceps femoris* muscles. Rump fat is an additional fat measurement collected because animals deposit fat at different rates in different locations. Rump fat measurements are the most highly repeatable.

Marbling (Intramuscular Fat)

According to Wilson (1994), marbling may be objectively measured in live cattle using real-time ultrasound and is reported as percent fat in the ribeye muscle. Percent fat correlates with a USDA grader's subjective visual evaluation of marbling in a beef carcass and is the primary component for carcass quality pricing. Heritability of marbling is moderate. There is a relatively high correlation (r = .75) between ultrasound prediction of percent fat in the live animal and the actual percent fat in the carcass ribeye according to research studies at Iowa State University (ISU). Although marbling can be assessed with somewhat less accuracy than fat thickness and LMA in live cattle, ultrasound gives us the opportunity to objectively measure this economically important trait. With the current available technology, bulls within a breed can be sorted into low, average, and high groups for percent intramuscular fat. Bulls will have a lower percent intramuscular fat than steers or heifers of equivalent age, management and genetic potential. Research studies have shown that the genetic correlation between marbling and fat thickness are very low, suggesting that selection for improved quality grades can be obtained without an increase in external fat and associated lower cutability (Wilson, 1994).



Applications

REA, FT and percent intramuscular fat adjusted to a common endpoint may be used by breeders and buyers to make decisions relative to the carcass merit of particular animals (Wilson, 1994). Ultrasound data can be used to identify sires and dams or bloodlines that are superior or inferior for the trait(s) of interest. Seedstock breeders and commercial producers alike can utilize ultrasound body composition measurements to improve the genetics in their herds for end-product merit.

It has been suggested that ultrasound be used to collect field data for development of carcass merit EPD's in beef cattle. Since ultrasonic data collection does not require the slaughter of progeny, it will be more efficient and cheaper than traditional structured sire evaluation programs for carcass merit (Wilson, 1994). However, only limited studies evaluating genetic parameter estimates of ultrasonic live animal measures of carcass merit in breeding cattle exist. Turner et al. (1990) reported heritabilities for ultrasonic measures of .04 for fat thickness and .12 for ribeye area in yearling Hereford bulls. These estimates seem low compared to those reported by other authors. Are they representative of the reported values prevalent in the literature? Heritability estimates of .24 were reported for ultrasonic fat thickness measurements by Lamb et al. (1990) from 824 Hereford bulls represented by 95 sires. Shephard et al. (1993) indicated heritability values of .50 and .12 for FT and LMA; respectively, in 1,556 Angus bulls and heifers representing over 30 sires. These moderate heritability levels, along with high levels of accuracy and repeatability for ultrasonic FT and REA measurements, indicate a potential for favorable response to selection. Wilson (1994) states that "As the industry moves toward value-based marketing and carcass merit programs, ultrasound body composition data will be increasingly useful in selection decisions and in making genetic improvement."

Contemporary Groups

The development of body composition EPD requires that scanned animals be associated with a well-defined contemporary group. Animals born of the same sex, reared and managed together up until the time of scanning form a contemporary group. Additionally, it is suggested that breeders define only calves that are within a 60-day age window as a contemporary group. Scanning contemporary group definition includes the following: herd code, weaning date or weaning lot date, weaning management group (pasture, creep, non-creep, etc.), scanning date or scanning lot date, and post-weaning management group designation. The lot date is used in lieu of actual measurement date when weaning or scanning must occur over more than one consecutive day within a contemporary group.

For animals scanned at a central test, the contemporary group definition for an animal must include its herd of origin and other birth and weaning contemporary group information.

Reference Animals. National cattle evaluation requires that performance records be tied across contemporary groups or herds. The pedigree relationship matrix used in the prediction methodology allows for many indirect ties to be established, however, the best ties are made when sires have progeny represented across contemporary groups, herds and years. It is recommended that all scanning contemporary groups have at least two sires represented, and that at least one of these sires has been or is being used in another herd that is also participating in scanning for national cattle evaluation.

Factors Affecting Accuracy

Several factors have been identified which affect accuracy and precision of ultrasonic estimates of body composition in livestock. Some of these factors include technological limitations (e.g. intramuscular fat prediction models, cattle restraint facilities), scanning technique, degree of fatness and muscling, sex of animal, age of animal, changes in tissue character postmortem, removal of hide and effects of hanging carcass versus standing animals. Standardization of scanning protocols and education of breeders regarding proper facilities, cattle ages, and nutritional management of cattle to be scanned will help to minimize these potential problems. Further development and refinement of hardware and software used in image capture and interpretation will also lead to advances in precision and accuracy.

Acceptable Image - ALOKA

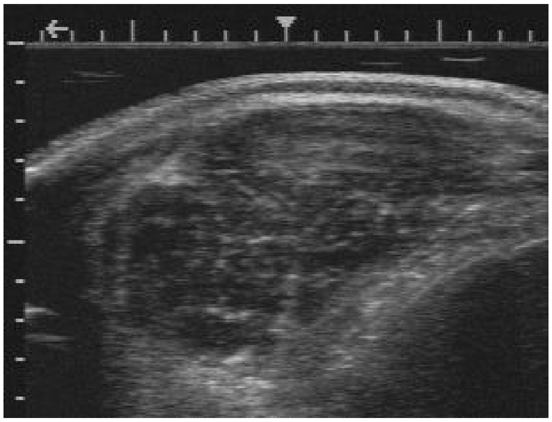


Image 1. Excessive spinalis muscle.

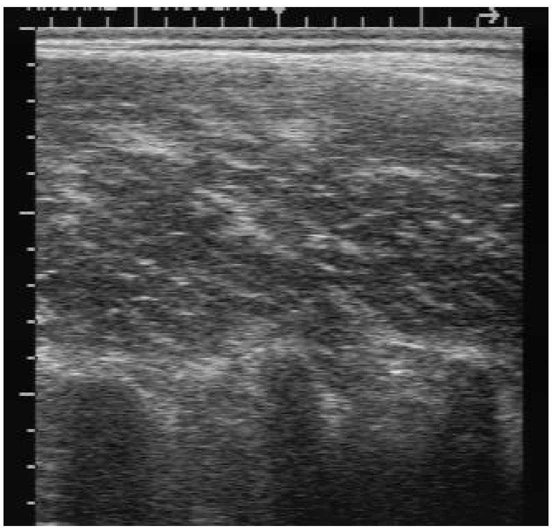


Image 2. Excessive spinalis muscle.

Image 3. Excessive spinalis muscle.

Marginal Images – ALOKA

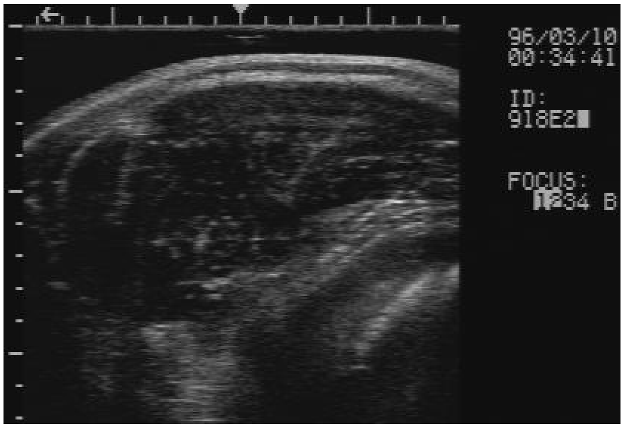


Image 4. Dark Medial.

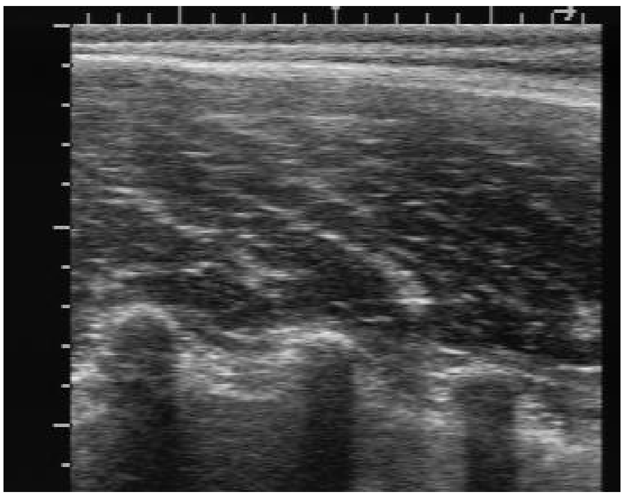


Image 5. Excessive spinalis muscle.

Rejected Images - ALOKA

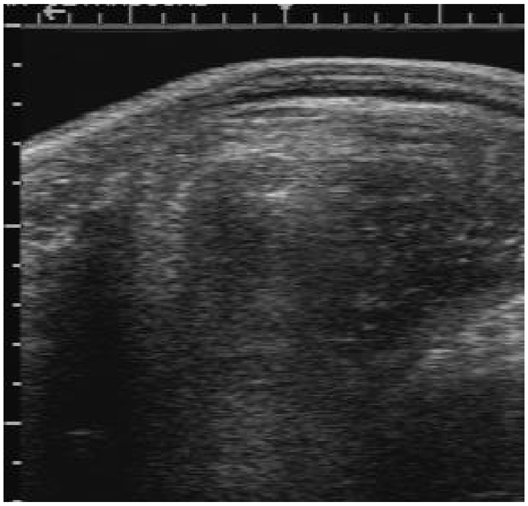


Image 6. Missing Lateral

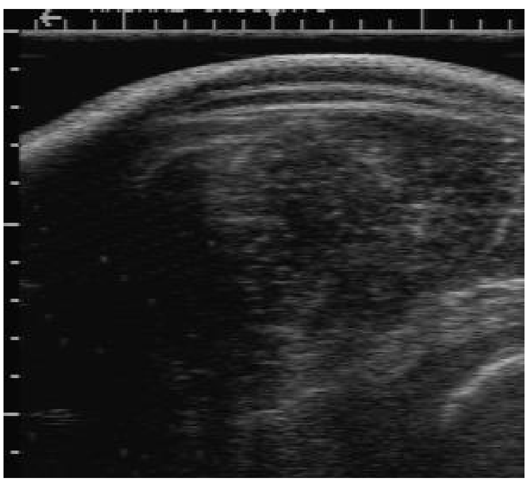


Image 7. Missing medial (very dark medial)

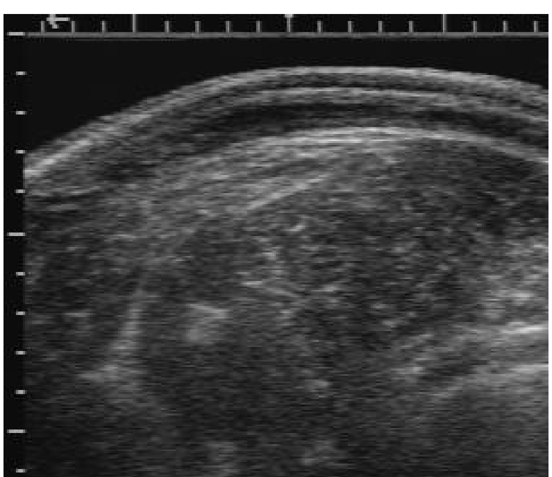


Image 8. 11-12th scan (too far forward)

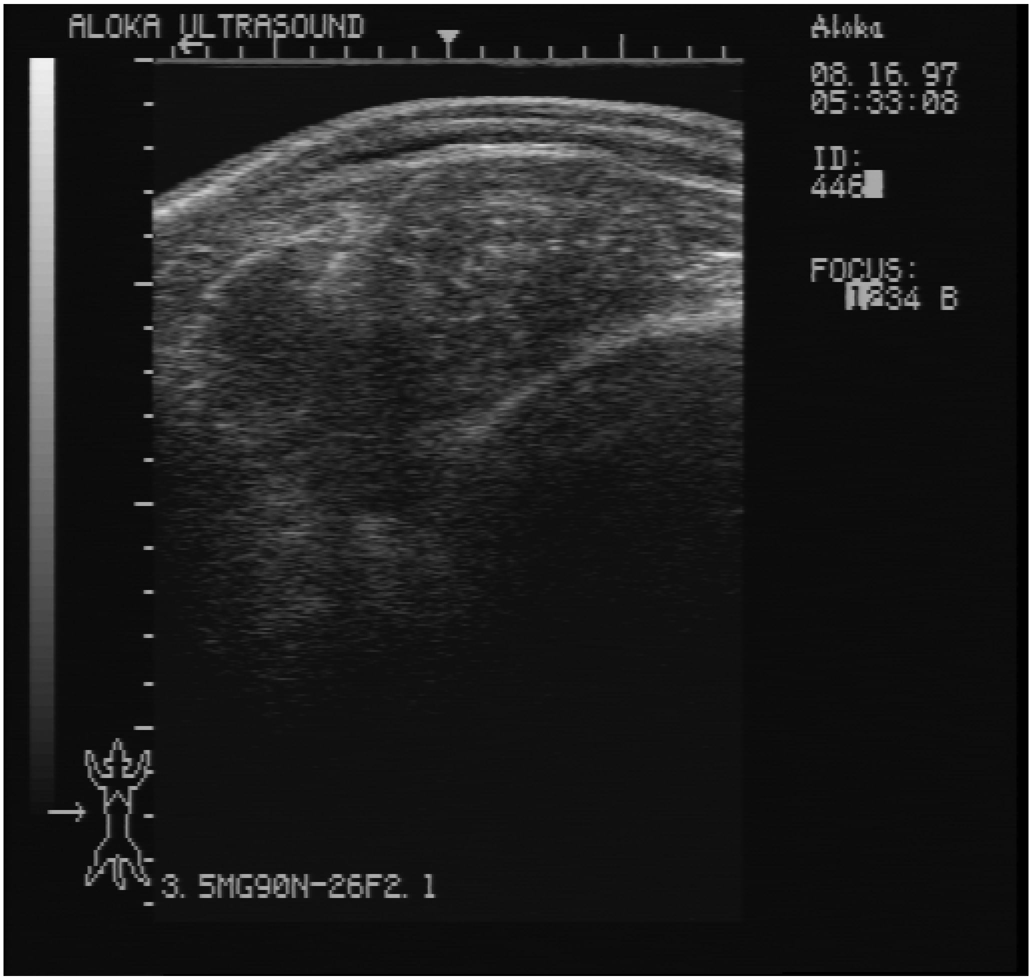


Image 9. Ribbed (on top of a rib).

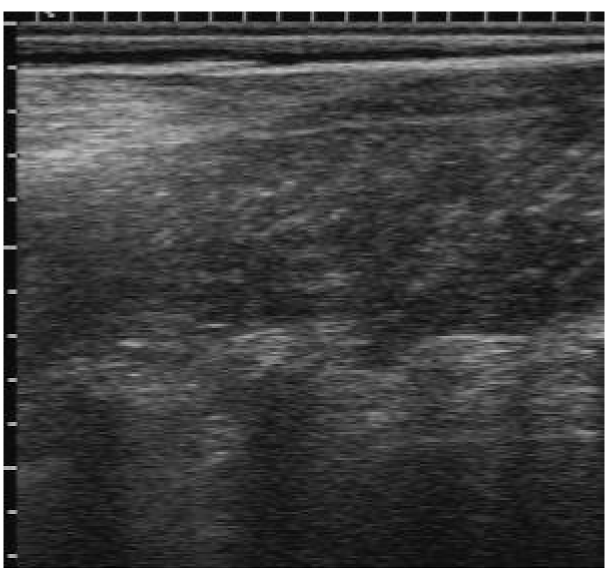


Image 10. Excessive spinalis muscle.

Acceptable Images - Classic

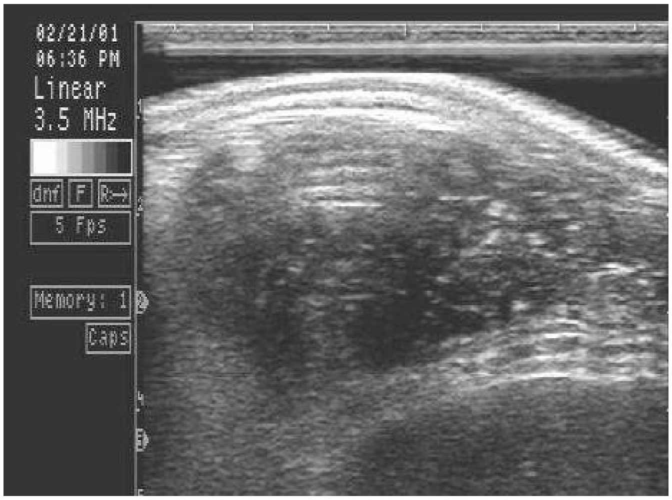


Image 11. Ribeye.

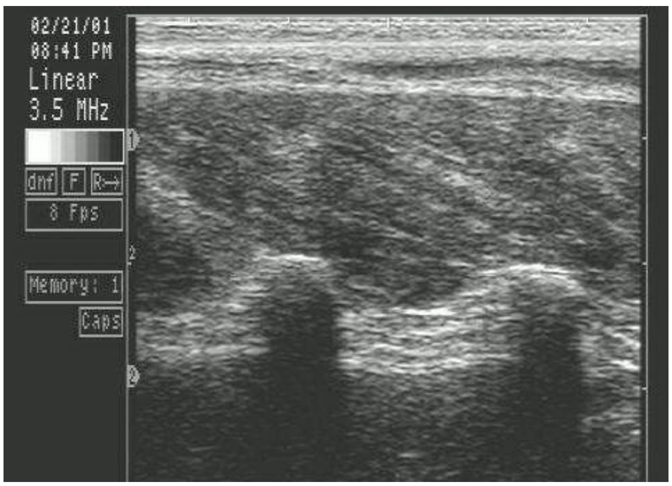


Image 12. Marbling.

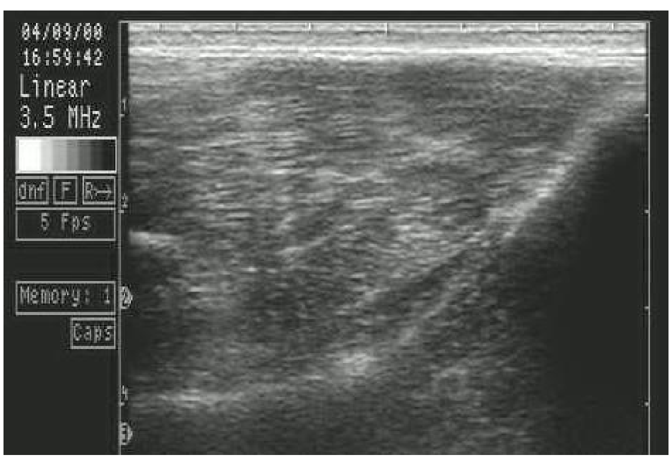


Image 13. Rumpfat.

Marginal Images – Classic

Rejected Images - Classic

Glossary

A-mode - refers to amplitude modulation. A-mode is one-dimensional display ultrasonic imaging.

B-mode – refers to brightness modulation. B-mode is an image display from multiple A-mode signals. It is displayed as two-dimensional and consists of dots or pixels.

longissimus dorsi – the muscle known as the ribeye muscle that is exposed when a carcass is ribbed between the 12-13th for carcass grading. Used in the calculation of yield grade.

Quality Grade – a USDA measurement for beef carcasses based on estimation of physiological age of the animal at the time of harvest (maturity), color and texture of ribeye muscle area at the 12-13th rib interface, ossification of cartilage in the skeletal system and by the estimated amount and distribution of marbling in the exposed ribeye muscle.

Real-time ultrasound – high frequency sound waves. A sound emitting probe held snugly on an animal bounces sound waves off tissues of different densities, such as fat and muscle. An image is created by the reflected sound and appears on the video screen instantly. It creates images which are seen instantaneously and are live, moving objects.

SONAR – Sound navigation and ranging.

Stand Off – instrument made up of a pliable rubber product that is used to hold the transducer when collecting a ribeye image. It fits the curvature of the animals back. Also known as a wave guide.

Transducer – instrument attached to the ultrasound equipment that captures a thin slice of the sample and displays it on the screen. The transducer generates ultrasound and then it sends and receives the ultrasonic waves.

Ultrasound - sound waves that have a frequency beyond the audible range for human ears. Humans can hear at frequencies between 20 to 20,000 hertz. Ultrasound is sound waves above 20,000 hertz.

Yield Grade (YG) – a USDA measurement for cutability in a beef carcass. It predicts saleable % of boneless, closely-trimmed retail cuts in the carcass and is calculated as follows: YG = 2.5 + 2.5 (fat thickness, inches) + 0.2 (percent kidney, pelvic, heart fat) + 0.0038 (hot carcass weight, pounds) – 0.32 (ribeye area, square inches). The lower numerically the YG, the higher the cutability and/or percent of retail product.

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