INTERNATIONAL STUDY GUIDE

REAL-TIME ULTRASOUND
BEEF CATTLE APPLICATIONS

U. S. SEEDSTOCK AND COMMERCIAL APPLICATIONS

INTERNATIONAL SEEDSTOCK AND COMMERCIAL APPLICATIONS

RIB FAT THICKNESS
RUMP FAT THICKNESS
EYE MUSCLE AREA
INTRAMUSCULAR FAT

OPERATOR TRAINING MANUAL

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UNDERSTANDING ULTRASOUND

To some, ultrasound may sound like a new science just introduced into the field of live animal evaluation with all the pitfalls and shortcomings of a new technology. However, early records include the development of the piezoelectric crystal as early as 1880. Realistically, most first remember either hearing or reading about ultrasound in the form of SONAR (SOund NAvigation and Ranging) used in military applications in the 1940's. In the early 1950's, researchers (Wild, 1950) began reporting using A-mode (amplitude modulation) for ultrasonic imaging of biological tissues. The technology continued to progress until today B-mode (brightness modulation) is a widely used technology for imaging tissue. While A-mode is one-dimensional and is limited to measuring depth of tissue, B-mode allows characterization of tissue with different densities.

Ultrasound is really a high-frequency sound wave. While audible sound waves are of the order 20-20,000 hertz (Hz) (cycles per second), ultrasound waves are in the 1-10 megahertz (MHz) range (Goddard, 1995). An ultrasound image is generated when an electrical current is applied to the piezoelectric crystal located in the transducer generating sound waves that are then directed into the tissue. The sound wave travels through the biological tissue until it strikes a tissue of a different density and an echo is returned to the transducer. This echo is converted back to an electrical signal and interpreted by the instrument as variations in brightness displayed on the cathode ray tube of a B-mode system as a dot. The brightness of the dot depends on the amplitude, or intensity, 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. The B-mode units use grey scale numbers ranging from 1 to 64, and the final image is generated by differences in shades of gray generated from the tissue field. Dense tissues give a bright, white echo (pixel) while lesser density tissues are seen as grey pixels.

Animal tissues have different densities, characterized by differing velocity of propagation through the tissues. Therefore these differences allow the use of ultrasonics to characterize these tissues for different purposes. Velocity for common food animal tissues (Powis, 1996) are:

TISSUE	**VELOCITY (m/s)**
Blood	1,549-1565
Fat	1,476
Connective tissue	1,545
Skeletal muscle	
Longitudinal	1,592
Cross-sectional	1,545
Bone	3,406-4,030
Scanner calibration	***1,540***

Distance can be calculated as:

$$\text{Distance} = \frac{\text{time x velocity}}{2}$$

Real-time ultrasound is a specialized version of B-mode ultrasound producing images almost instantaneously thereby creating "live", moving objects. By using a liner transducer with multiple crystals emitting a continuous beam of ultrasound pulses, a picture of the scanned area can be recorded and interpreted.

UNDERSTANDING THE TERMINOLOGY

Competent operators should have a basic understanding of the terminology associated with ultrasound and food animal scanning. The following terms are commonly used in the industry:

AAACUP – American Angus Association Centralized Ultrasound Processing, an organization that process images sent by certified operators in a central location.

AUP – Association of Ultrasound Practitioners, an organization that certifies proficiency of operators based on pre-established standards.

Absorption - Loss of energy (principally due to molecular friction forces and the production of heat). As frequency increases, absorption increases.

Acoustic coupling - Since ultrasound is poorly transmitted through air it is necessary to exclude air and link the transducer to the surface of the subject with a suitable coupling gel.

Acoustic enhancement - Tissues distal to an anechoic structure may display enhanced echogenicity.

Acoustic interface - Junction of two tissues with different acoustic impedance. This leads to the reflection of a proportion of the incident beam and possible diffraction of much of the remainder of the beam. The greater the difference in acoustic impedance, the stronger the reflection.

A-mode - Amplitude modulation. A one-element (one dimensional) display with time (distance) on the horizontal axis. The relative strength of the echo is registered as amplitude on the vertical axis.

Amplitude - Height of the ultrasound waveform.

Anechoic (sonolucent) - A tissue failing to reflect the ultrasound beam produces no echoes (e.g. a fluid-filled viscus).

Anterior - Toward the head, may also use *cranial*.

Array - Distribution of crystals along the length of a linear scan head.

Artifact - An on-screen representation of a structure which does not exist or is incorrectly located.

Attenuation - Decrease in power of the ultrasound beam, caused principally by absorption, scatter and reflection.

AutoQuip – method of estimating intramuscular fat (marbling) in beef cattle without need of off-line (computer) processing.

Axial resolution - Measure of the ability of the system to differentiate two structures lying closely together along the path of the ultrasound beam.

B-mode - Brightness modulation. A compound A-mode scan with amplitude translated into a brightness scale. Location on the display is related to position and depth.

Beef Improvement Federation - Established in 1968 to standardize programs and methodology and to create greater awareness, acceptance and usage of beef cattle performance concepts. This organization originally established standards of proficiency for certification evaluation.

Bias - Average deviation of an operator's estimates from the carcass measurements. Bias is used to standardize measurements between different technicians.

CPEC – Cattle Performance Enhancement Company, technology used to sort U.S. feedlot cattle into uniform outcome groups.

Calipers - A system for measurement of distance and area is provided on most instruments.

Caudal - Toward the tail, may also use *posterior*.

Certification - A proficiency-testing program generally offered at least twice per year. The certification program for beef operators is intended to evaluate operator proficiency against standards established by AAACUP, AUP or other certifying organizations. Most breed associations will only accept data or images from <u>certified</u> operators.

Cranial - Toward the head, may also use anterior.

Diffuse reflection - An echo from a target(s) less than one wavelength in size.

Distal - Away from the body in a limb of the animal.

Doppler ultrasound - When an ultrasound beam meets a moving object the reflected ultrasound is either of increased or decreased frequency, depending on whether the motion is towards or away from the transducer. Either continuous or pulsed Doppler can be used and some systems can display compound information.

Dorsal - Toward the upper part or back of the standing animal.

Echogenic - A structure causing a marked reflection of the ultrasound beam. A change in echogenicity in a homogenous structure may indicate a pathological change.

Ether extractable fat - Chemical fat determination to estimate *intramuscular fat* or *marbling* in meat.

Focal area - Region of the scanned field where resolution is greatest. Focusing can be achieved by electronic or physical means.

Frame rate - The frequency with which images are updated on the screen. Altering the frame rate may improve image quality in some applications.

Frequency - Number of ultrasound waves emitted per second. One (1) cycle per second = 1 hertz (Hz).
Gain - The amplification level of a returned signal. On some instruments different depths of the field are handled separately. Incorrect setting of gain controls will lose detail from fine structures.
Grey scale - Range of intensities displayed on the cathode ray tube.
Hyperechoic - Showing increased echogenicity.
Hypoechoic - Showing decreased echogenicity.
Intramuscular fat - Fat that is deposited within muscles and appears a delicate pattern of wavy lines in the meat, also known as *marbling*.
Lateral - Toward the sides of the standing animal.
Lateral resolution - Measure of the ability of the system to differentiate two structures lying side-by-side at the same distance from the transducer.
Linear array - Distribution of piezoelectric crystals along the length of a scan
Longitudinal - Plane running lengthwise, parallel to the mid-line of the animal.
M-mode - Motion mode. Essentially a rapidly updated one-dimensional B-mode display with time on the second axis to allow study of moving structures. Used principally in cardiology.
ManQuip – Multiple measurement technique for intramuscular fat estimation in beef cattle using off-line computer program with QUIP index.
Marbling - Common term for intramuscular fat.
Medial - Toward the midline, plane that separates right and left sides of the body.
Piezoelectric crystals - Crystals of materials such as lead zirconate-titanate, capable of converting applied electrical energy to mechanical deformation and vice-versa.
Posterior -Toward the tail, may also use *caudal*.
Power - Energy of the ultrasound beam. It is generally expressed in watts (or as intensity in watts cm^{-2}). The minimum power consistent with good image quality should be employed.
Probe - The transducer array and its housing.
Proximal - Toward the body in a limb of the animal.
QUIP – Quality Ultrasound Index Program, Pie Medical's proprietary tissue analysis system to characterize areas of loin eye muscle for aid in estimation of intramuscular fat (marbling) in beef animals.
Real-time - Images generated from reflected ultrasound following sequential activation of the transducer array are displayed on the screen at sufficient speed to give the appearance of a live image.
Reverberation echo - An artifact created by the retransmission of a strongly reflected ultrasound signal. The display may show several images of a single structure, which appear at increasing distances from the transducer.
Scan converter - A component of the processing system that converts the electrical output of the transducer to the cathode ray tube image, essentially by aggregating sequential arrays across the screen. A scan

converter allows for subsequent analysis beyond the screen display (post-processing) and the use of standard TV accessories.

Scatter - When the ultrasound beam encounters a small object in its path the beam energy is spread in all directions.

Sector scan - A pieslice/sector-shaped image is produced on the screen. The initial signal is produced by a single vibrating piezoelectric crystal or a small number of rotating crystals (although an electronic phased linear array can produce a sector image). The scan head only needs a limited contact area (small footprint).

Shadowing - Caused by severe attenuation of the ultrasound beam such that it fails to penetrate sufficiently deeply.

Specular reflection - A strong echo created by a highly reflective tissue interface representing an area significantly larger than one wavelength.

Standard error of prediction (SEP) - Standard deviation of the differences between real-time ultrasound and carcass measurements for a given operator. SEP measures the ability of the technician to rank or predict differences between animals correctly.

Time-gain compensation (TGC) - Since the ultrasound beam is increasingly attenuated as it travels deeper into tissue, by applying TGC tissues of similar reflectivity are represented with similar brightness, regardless of distance from the transducer.

Transducer - The piezoelectric crystal or element which converts electrical to mechanical energy.

Ultrasound - Sound of a frequency above that perceived by the human ear. Diagnostic ultrasound lies in the 1-10 MHz region.

Velocity - Speed of travel of the ultrasound wave. In tissue this is usually density dependent and ranges from 1500 to 1600 m/s^{-1}. An average of 1540 m/s^{-1} is usually adopted.

Ventral - Toward the lower part or belly of the standing animal.

UNDERSTANDING THE EQUIPMENT

While there may be various brands or models of equipment on the market, all possess the same basic components.

Scanner

The basic function of the scanner is to process the image acquired by the transducer and to display this image on the screen. Units used for live food animal work are portable and can be used for both reproduction and composition work. The Pie Medical 200 SLC Scanner can be used for a multitude of scanning purposes, depending on the selection of transducer. The unit is equipped with a keyboard for annotations, provisions for measuring, freezing and storing images, and easy to use pull-down menus. Data and images can be transferred to a computer for storage and retrieval via Optical Data Transfer (ODT) software available from Pie Medical, or the built-in image transfer function (v2.7 software).

Transducer

The transducer (probe) is the "eye" of the scanner. At the heart of the transducer are the piezoelectric crystals generating ultrasound pulses across its axis, sending the generated beams into the tissue and receiving the echoes to be processed by the scanner. The recommended transducer for most food animal scanning applications is the Animal Science Probe (ASP-18). This probe contains a total of 128 piezoelectric crystals arranged in a linear array. The probe is a full 18 centimeters in length, allowing for single scan imaging for all food animals (beef, sheep, and swine).

Standoff Pad

A standoff pad (wave-guide) is used to "fit" the straight, linear array transducer to the curved back of the animal for image acquisition. The standoff pad is essential for measuring cross-sectional loin eye muscle area. The pad is not required for longitudinal scanning common for rib fat, rump fat, muscle depth or intramuscular fat estimation.

SPECIALIZED FOOD ANIMAL SCANNING

During the last 35 years, a considerable amount of research effort has been directed at developing non-invasive, non-destructive techniques for assessing composition and quality of live beef animals and beef carcasses. Real-time ultrasound (RTU) has emerged as a cost effective and reliable method of estimating composition and quality of live beef animals (Houghton and Turlington, 1994). Several approaches identified by various researchers to develop RTU technology range from simple prediction of carcass fat and loineye area (Stouffer, 1961) to using RTU to estimate intramuscular fat (Wilson et al., 1995). Most of these technologies have used an off-line computer image interpreting system for composition (Hamlin et al., 1995a; Hamlin et al., 1995b) and muscle quality (Whittaker et al., 1992; Brethour, 1994; Wilson et al., 1995). However, recent advances in RTU technology have made this technology more user-friendly and available to the practicing veterinarian and producer.

During the last five years, Pie Medical has become the worldwide leader in ultrasound technology for food animal scanning. This is primarily due to the introduction

Figure 1. Pie 200 SLC Scanner and ASP-18 Probe.

of the Pie 200 SLC Scanner System (Figure 1) and the 18 cm, 3.5 MHz linear array animal science probe (Model ASP-18).

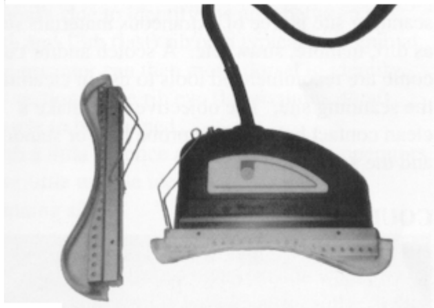


Figure 2. ASP-18 probe with beef and swine contact pads.

While the 200 Scanner has a multitude of uses in the veterinary and animal science fields, the ASP-18 probe (Fig. 2) is unique for food animal scanning. Pie Medical's leadership is further enhanced by introduction of the first, and only, on-line system for muscle quality evaluation known as the Quality Ultrasound Index Program (QUIP). This program provides the opportunity for chute-side estimation of intramuscular fat (IMF) as well as backfat, rump fat and loineye area currently used in most countries to assess live animal composition. These estimates can be made "chute-side" without need of any "off-line" computer processing. Besides the scanner the only other accessories required are a contour-fitting standoff or contact pad (Fig 2) necessary for use in loin eye muscle area determinations and the calibration phantom (Fig 3) for machine standardization for muscle quality assessment with the QUIP system.

Figure 3. Calibration phantom used to calibrate machine for intramuscular fat estimation.

Those producers and researchers involved with the food animal industry are well aware of the applications of RTU for food animals. However, most veterinarians have normally thought of RTU in terms of injury diagnosis and reproductive physiology applications only. Some additional uses of RTU in the beef industry include:

Reproductive Physiology

1. **Pregnancy detection**
2. **Fetal sexing**

There are several uses of RTU in reproductive physiology (Beal et al., 1992). One specific use is to monitor ovarian activity to increase the number of cyclic cows and heifers to aid conception. This might include evaluation prior to the breeding season or toward the end of the artificial insemination (AI) breeding season. This can then be followed by pregnancy detection as early as 9 days (Boyd et al., 1988). Fetal sexing is also possible as early as 48 days (Muller and Wittkowski, 1986; Wideman et al., 1989). This is of particular importance to the purebred beef producer in that male calves are generally of greater economic value than female calves.

Carcass Composition and Quality

1. **Backfat (subcutaneous fat) determination**
2. **Rump fat determination**
3. **Loin eye muscle area**
4. **Muscle quality by intramuscular fat estimation**

Composition and quality of beef carcasses are the driving forces behind interest in a value-based marketing system. The feedlot operator and packer are both interested in the ability to produce carcasses of consistent composition and quality. RTU offers the ability to accurately assess subcutaneous fat that is a prime contributor to variation in lean composition of animals of similar weights (Faulkner, et al., 1989). The Australian P8 site fat measurement may also be used to estimate composition in the live animal, especially for leaner cattle (Rouse et al., 1995). Loin eye muscle area (LEA) is of particular importance to seedstock producers selecting for muscling in breeding animals (Wilson et al., 1995) as well as to estimate composition in market animals. Intramuscular fat is highly related to market quality (Savell et al., 1986).

Performance Evaluation

1. **Sort feeder cattle into uniform production groups**
2. **Estimate quality potential of young cattle**
3. **Estimate days on full feed required for quality endpoints**

Feedlot operators are continually seeking ways to increase the efficiency of production of beef. RTU can be used to sort cattle into uniform groups based on subcutaneous fat and muscling so that these cattle will finish at a uniform weight with consistent composition (Houghton, 1988). Houghton et al. (1990) reported that ultrasonic measurement of backfat measurements for feeder cattle are more highly correlated to carcass fat than visual estimates.

While this publication is devoted to applications in the beef industry, operators should also realize the same type of image analysis may be performed on other species of food animals, especially swine (see Swine Study Guide) and sheep with minor adjustments.

SCANNING LIVE BEEF CATTLE

Animal restraint and scanning site preparation

A great advantage in using RTU is that it is non-invasive and relatively free of stress to the animal. The scanning operation requires no special handling equipment for the animal other than those items of equipment normally found on farms or ranches and in clinics. To reduce animal stress and reduce chance of injury to the animal and operator, most find that the best location for the scanning operation is in a livestock squeeze chute or crush (Fig. 4).

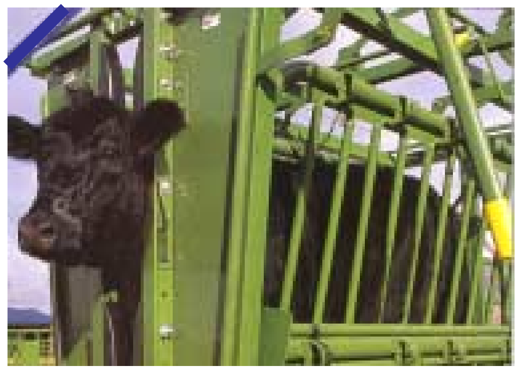


Figure 4. Typical animal squeeze chute (crush) that should be used for animal restrain while scanning.

The animals should be moved to the chute or crush with as little emotion or stress as possible. The head should be safely secured in the head gate and checked to insure that there is sufficient freedom to not cause choking or any other type of injury to the animal. When the operator has safely secured the animal, any of the previously described scanning operations may be performed including backfat, rump fat, loineye area and muscle quality characterization. The two sites most commonly used in beef cattle scanning are the region of the 12th and 13th rib and the rump, or Australian P8 site. Site preparation is similar for all scanning operations. To obtain good acoustical contact, some operators prefer to ***clip the hair*** from the site before scanning. While this might be the ideal situation for scanning purposes, this may not always be practical (i.e., time restraints, show or exposition cattle, sorting feedlot cattle). If the scanning site has not been clipped, the operator may improve image quality by insuring the removal of loose hair and dirt by use of a brush or metal comb (Fig. 5).

Figure 5. Illustration of operator cleaning scanning site with curry comb(may also use brush, other styles of combs or blower).

Figure 6. Palpation of scanning site and application of acoustical couplant (vegetable oil).

RTU technicians/operators are well aware of the need for good acoustical contact between the probe and skin surface since sound waves will not travel through air. Human applications use a scanning gel for acoustical contact, however, the use of gel for beef cattle scanning may be expensive and impractical since it will be difficult to get gel into the hair coat without air pockets. Therefore, food animal scanning requires the use of ***vegetable oil*** for this purpose (Fig 6). This couplant is readily available, inexpensive and is not harmful to the animal, operator or probe. **(MINERAL OIL SHOULD *NEVER* BE USED SINCE IT IS HARMFUL TO THE PROBE SURFACE AND CABLES).** Since most scanning operations are done outdoors under less than ideal environmental conditions, oil temperature may have an influence on image quality. Best results are obtained when oil temperature is near 80° F (27° C). This keeps the oil free flowing and allows better penetration into the hair coat. Operators are encouraged to acquire a portable, insulated heater (Fig. 7) to maintain the scanning couplant at the suggested temperature.

Figure 7. Insulated electric container for warming and storing vegetable oil.

It is apparent from observing the straight ASP-18 linear array probe that some type of adaptation would be necessary for cross-sectional scanning of loin eye muscle area. Therefore, an acoustical contact (Fig 2) is available as an accessory to the Pie 200 scanning system. Contacts of varying curvature are available for either beef or swine scanning. The contact is easily attached to the probe with a small amount of scanning gel (AQUASONIC 100™) used to assure complete acoustical contact between probe and the curved pad. The quantity of gel used may depend on animal conditions and operator preference. However, temperature of contact pad and gel may again play a role in image quality, especially in colder climates. Best results are obtained when the contact pad and acoustical gel are also maintained near oil temperature. Pads should be cleaned with warm soap and water after each use and stored in a container to prevent damage and drying out of the flexible material. Pads should last indefinitely if cared and stored as recommended.

Selection of scanning sites

A cross-section scan at the 12th and 13th rib is necessary to detect loin eye muscle area (LEA) and subcutaneous fat depth (BF). A simple recollection of animal anatomy will insure the proper selection of the scanning site. The easiest method of site selection will be for the operator to palpate for the separation of the 12th and 13th rib (Fig. 8).

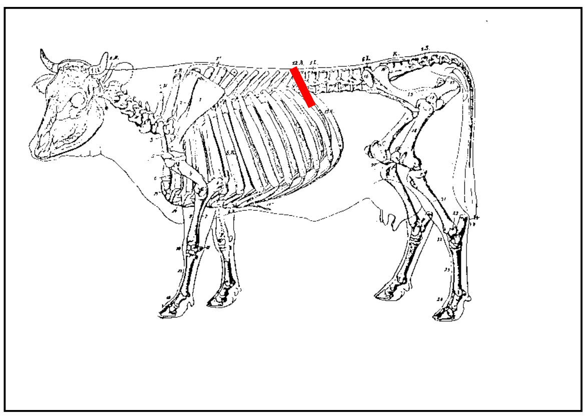


Figure 8. Skeletal illustration of selected 12th/13th rib scanning site. (Illustration adapted from Sisson and Grossman).

Figure 9. Palpation of scanning site and probe placement for cross-sectional scanning at 12th/13th rib.

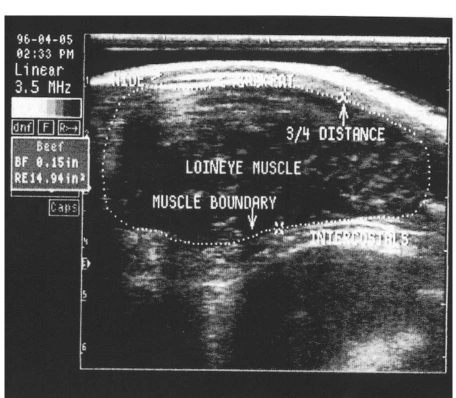


Figure 10. Typical cross-sectional image with identification of critical features.

The operator can now simply follow the separation of the ribs vertically and locate the proper scanning site. This site can now be prepared as previously described. The probe (equipped with contact pad) is now placed along a plane that will be parallel to the area between the 12th and 13th rib (Fig 9). An image similar to that illustrated in Figure 10 should now be visible on the monitor screen.

For best results, it is recommended that a scanning depth of 6 in. or 15 cm. (5 Fps) should be used for beef cattle scanning. Unusually large animals may require a greater scanning depth. Focal points may be adjusted for maximum image quality and brightness according to individual operator preference. Certain reference points should be readily visible that will identify a high quality image (Fig 10). Operators should see three distinct outer, parallel curved lines. The outermost line will be the outer surface of the skin or animal hide. The middle line will be the interface of hide and top surface of the fat layer. The innermost line of the three will be the reflection of the interface of the bottom surface of the fat layer and the top surface of the *longissimus dorsi* (loin eye) muscle. The loin eye muscle should be very visible to include both lateral and medial surfaces with the intercostals visible at the bottom of the loin eye muscle. When a good, high quality image is visible, the operator should depress the **FREEZE** button by using the remote button on the probe, scanner keyboard or the optional footswitch. Once the image has been frozen, chute (crush)-side interpretation may be performed (Gresham, 1995; Gresham, 1996). Backfat is measured by selecting a site to approximate ¾ of the length of the loineye muscle (Fig 10). **[IT IS RECOMMENDED THAT OPERATORS PREPROGRAM BACKFAT, LOINEYE AREA AND QUIP INDEX AS MACRO FUNCTIONS ACCORDING TO DIRECTIONS OUTLINED IN OPERATORS MANUAL].** Backfat is measured by selecting the **ANIMAL SCIENCE** function from the pop-up menu, depressing **SELECT**, select **BEEF** and then select **BACK FAT**. A "Beef" box will appear on the monitor screen. Move the cross-hair to the selected site to be measured and depress **SET**. Move the tracking ball to the outer edge of the fat layer and again depress **SET**. The actual backfat for the animal to the nearest 0.01 in. or 0.01 cm will appear in the box (Fig. 10). To measure loin eye muscle area (REA) you may use the same image as for backfat . Depress **SELECT**, move the tracking ball to highlight **ANIMAL SCIENCE** and depress **SELECT**. Select **BEEF** and then **RIB EYE**. Place cross-hair cursor at any site on the surface of the visible muscle, depress **SET** and trace the outer edge of the muscle back to the original starting point. Muscle area in square inches, or square centimeters, will appear in the data box (Fig. 10).

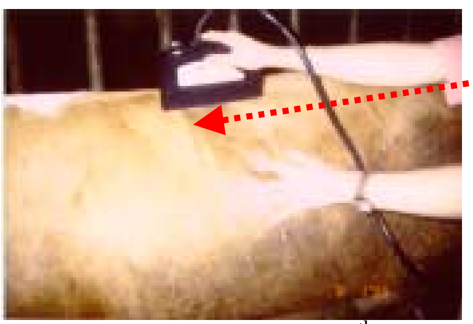
Another area of interest is the determination of rump fat, also known as the P8 measurement in Australia. The rump site can be approximated as equidistant between the hooks (tuber coxae) and pins (tuber ischii) of the animal (Fig. 11). Site preparation would be the same as described for cross-sectional scanning. However, it may not be necessary to

use the acoustical contact curved pad. An image similar to Figure 12 should be obtained. Distance measurement would utilize the same technique as described for backfat scanning. The common anatomical point of reference is the intersection of the tissue line at the bottom of the *gluteus medius* muscle and the bottom of the subcutaneous fat layer. This measurement is especially useful in estimating fat in very young cattle (less than one year of age).

ESTIMATING INTRAMUSCULAR FAT

AutoQuip technique

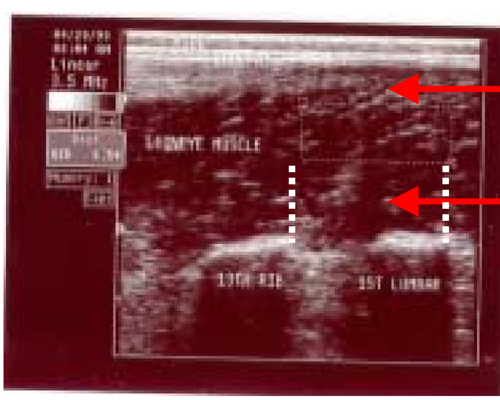
The most recent capability added to the Pie 200 Scanner System is the Automatic Quality Ultrasound Index Program (***AutoQuip***). This function enables operators to estimate muscle quality by determining the amount of ether extractable (intramuscular) fat present in the loin eye muscle. This information can then be correlated to quality grading systems used in several countries that are based on intramuscular fat content (Gresham, 1996). Animal preparation and acoustical couplant is the same for this analysis as previously described. The major difference is that quality indexing will use a



Place metal safety ring immediately over 12th /13th rib separation.

Figure 13. Proper probe placement on live animal for intramuscular fat determination.

longitudinal plane scan at the 13th rib and 1st lumbar vertebrae as opposed to the cross-sectional scan. Site identification, palpation and site preparation are the same except that the probe is placed in a plane parallel to the mid-line of the animal at a point to approximate the midpoint of the loin eye muscle lateral of the spinal column (Fig. 13). An image similar to that illustrated in Figure 14 should be visible.



Initial box placement should be 0.5 in. (1.25 cm.) below fat layer.

Analysis box placement should be area above region between 13th rib and 1st lumbar vertebrae and over 1st lumbar vertebrae.

Figure 14. Typical image used for intramuscular fat estimation with reference points identified.

Operators can again identify the hide, backfat, loin muscle, 13th rib and 1st lumbar vertebrae (Fib. 14). **The initial box placement should be approximately 0.5 in. (1.25 cm) below the backfat layer.** This placement will insure freedom from echoes generated by tissue separation of fat and the top of the loin eye muscle. The location of the analysis box should be at a site above the area between the 13th rib and 1st lumbar vertebrae plus the area above the 1st lumbar vertebrae.

If the probe has been placed properly, analysis for intramuscular fat is obtained by simply selecting the **QUIP INDEX BEEF** function from the **ANIMAL SCIENCE-BEEF** pop-up menu, and pressing **SELECT**. The preprogrammed analysis box will appear and a **QUIP INDEX BEEF** (**QIB**) value will appear. Now the operator should use the trackball and scroll down so that the box will expand. Expand the box until the bottom line of the box is about 0.25 in. (0.6 cm.) above the rib and lumbar vertebrae (Fig. 15). The estimated intramuscular fat content (%) will appear as the **QIB** Index.

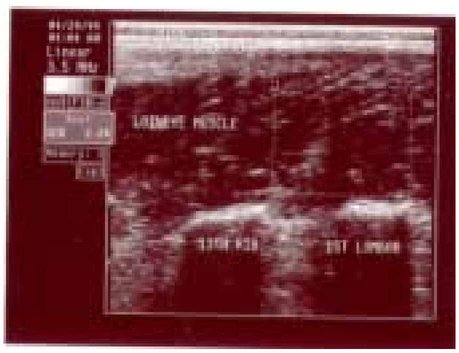


Figure 15. Illustration of intramuscular fat calculation using the AutoQuip technique. Estimated intramuscular fat is 2.86%. (Official determination is 2.77 %).

MANUAL ADJUSTMENT FOR IMAGE QUALITY

Current software applications in the Scanner 200 provides a pre-determined box location for QUIP analysis. However, for fatter feedlot cattle, a manual adjustment may be necessary. Figure 16 illustrates an image where the analysis

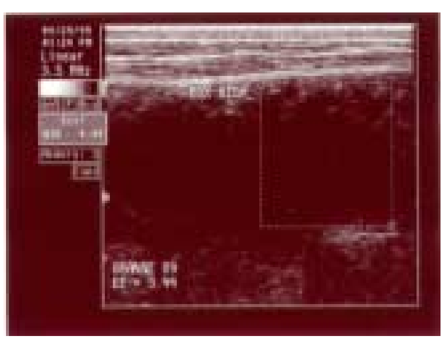


Figure 16. Illustration of automatic box placement in fatter cattle resulting in analysis area extending too near line of fat and loin muscle separation.

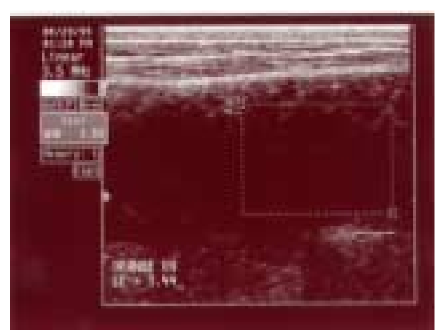


Figure 17. Manual adjustment of analysis box location so that box will be 0.5 in. (1.25 cm.) below line of fat and loin muscle separation.

box extends into the echogenic area of the tissue separation of the fat layer and top of loin eye muscle. This box placement results in an erroneous reading with the resulting calculated intramuscular fat value being too high. This image calculates a **QIB** value of 4.46 % whereas the actual laboratory ether extractable value was 3.44 %. Figure 17 reflects a manual adjustment of box location approximately 0.5 in. below the fat and muscle separation. The calculated value with the correct box placement is 3.58 %.

Multiple measurement technique

A second technique of analysis is also widely used, especially in the U.S. feedlot cattle industry. This technique is quite similar to the **AutoQuip** technique with the exception that an off-line computer program is utilized to facilitate downloading of data for records summary. Animal preparation and site selection for the multiple measurement, manual technique (**ManQuip**) is identical to that described for the AutoQuip technique.

If the probe has been placed properly, analysis for intramuscular fat is obtained by selecting the **QUIP INDEX CALIBRATION** (**QIC**) function from the **ANIMAL SCIENCE-BEEF** pop-up menu, and pressing **SELECT**. The preprogrammed analysis box will appear at the same location as described for **AutoQuip** measurement (Fig. 14).

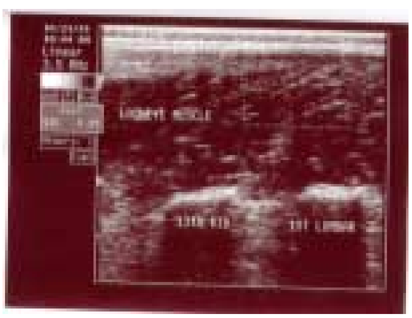


Figure 18. Image with initial (QIC1) reading. Analysis box position is automatic. Operator may be required to manually adjust down for extremely fat cattle.

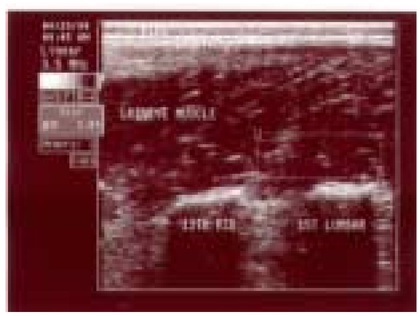


Figure 19. Image with QIC2 reading. Analysis box is scrolled Down from QIC1 site with trackball to location just above 13^{th} rib and 1^{st} lumbar vertebrae.

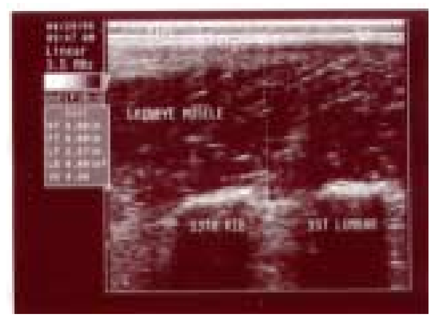


Figure 20. Illustration of image with DEPTH measurement indicated. This measurement determined as distance from mid-point of 13^{th} rib image to top of loineye muscle.

The operator should record the first **QIC** value (Fig. 18) as a QUIP1 reading (see later explanation). The operator should now scroll the preset box down to the top of the rib and lumbar vertebrae (Fig. 19) and record that **QIC** value as the QUIP2 reading. The third step is to measure the depth of the longissimus muscle as a point from the mid-point of the 13^{th} rib to the top of the muscle (Fig. 20). This value is recorded as the DEPTH reading. Operators will now have three values commonly referred to as QUIP1, QUIP2 and DEPTH. These three values are entered into the Fat Calculator software program available from Classic Ultrasound, Tequesta, FL. The resulting value for intramuscular fat percent will be printed on the screen (Appendix B). Users desiring to utilize the **ManQuip** technique may request a copy of the Fat Calculator program from:

Classic Ultrasound Equipment
19900 Mona Rd, # 105
Tequesta, FL 33469
Ph: 561-746-9527

The QUIP system of muscle quality evaluation is based on a proprietary method of tissue characterization utilizing the unique characteristics of the 128 crystal ASP-18 probe. In order to insure the accuracy of tissue characterization it is imperative that this equipment only be used according to manufacturer's recommendations. **At the present time the QUIP software is only programmed to characterize live muscle tissue in beef animals up to 24 months of age and when using the calibration phantom.**

PREPARING SCANNER FOR QUALITY INDEXING

The **QUALITY INDEX BEEF** and **QUALITY INDEX CALIBRATION** indexing systems can be found under the **ANIMAL SCIENCE-BEEF** prompt of the pop-up menu. Best results are obtained when a scanning depth of 4 in. (6 cm.) is selected with a frame speed of 8 Fps. When stored as a macro or **GOTO** function, this becomes a simple two to three step operation.

CALIBRATION OF SCANNER

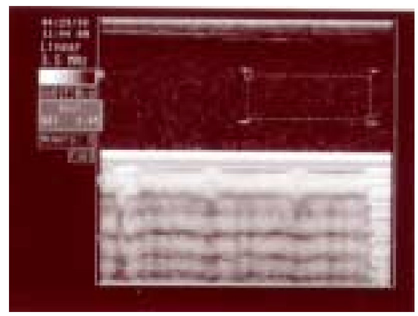
In order to calibrate the Pie 200 system for quality evaluation the operator must:

1. Set scanner to 4 in or 6 cm scanning depth using focal points 1 and 2. Scanner box will reflect a frame speed of 8 Fps at this setting.
2. Turn off all gains.
3. Place a small quantity of AQUASONIC 100 scanning gel on surface of ASP-18 probe.
4. Insert probe into calibration phantom (Fig 21). Probe should be upright and perpendicular to surface of calibration material. Do not apply additional pressure to probe while calibrating machine since pressure may compress phantom material and give an inaccurate reading.

Figure 21 Probe placement in phantom for calibration of machine. Be sure probe is inserted so metal ring is to operator's left.

5. Check temperature of phantom. Temperature of phantom should be between 68 and 74 degrees Fahrenheit for calibration. If outside this temperature range, refer to calibration adjustment directions included with the phantom (Appendix A).
6. Select the **QUIP INDEX CALIBRATION** function from the **ANIMAL SCIENCE-BEEF** menu. When the analysis box appears on the monitor screen, adjust the top gain (total gain) until the required value is obtained (Fig. 22). Note that the preprogrammed box should fall within the area identified by the white dots marking the four corners of the area to be analyzed (Fig 22). This will insure proper probe orientation on the live animal. Since the QUIP function will only read an image in the freeze mode, adjustments must be made between frozen images while in the active mode.

Figure 22. Phantom calibration image. Value reflected in analysis box (QIC) should equal value listed in Appendix B for the temperature of the phantom. Example is 60° F.



7. INSURE GAIN SETTING REMAINS CONSTANT WHILE SCANNING. Periodic checks are recommended to insure a constant reading while doing large numbers of animals. Be cautious to check temperature of phantom before making any adjustments to the gain setting.

RELATIONSHIP TO USDA QUALITY GRADES

While the QUIP index has been calibrated to estimate intramuscular fat, most producers may be more understanding of the relationship to the USDA quality grading system. Figure 23 illustrates the average intramuscular fat content of each USDA quality grade (Savell et al., 1986). The TRACES(TR) marbling score is typical of ***USDA STANDARD*** beef while SLIGHT(SL) degree of marbling is found in the ***USDA SELECT*** grade. SMALL(SM), MODEST(MST) and MODERATE(MOD) degrees of marbling are characteristic of Low, Average and High ***USDA CHOICE*** grades respectively. The upper levels of marbling, SLIGHTLY ABUNDANT(SA) and MODERATELY ABUNDANT(MA) are found in the ***USDA PRIME*** grade.

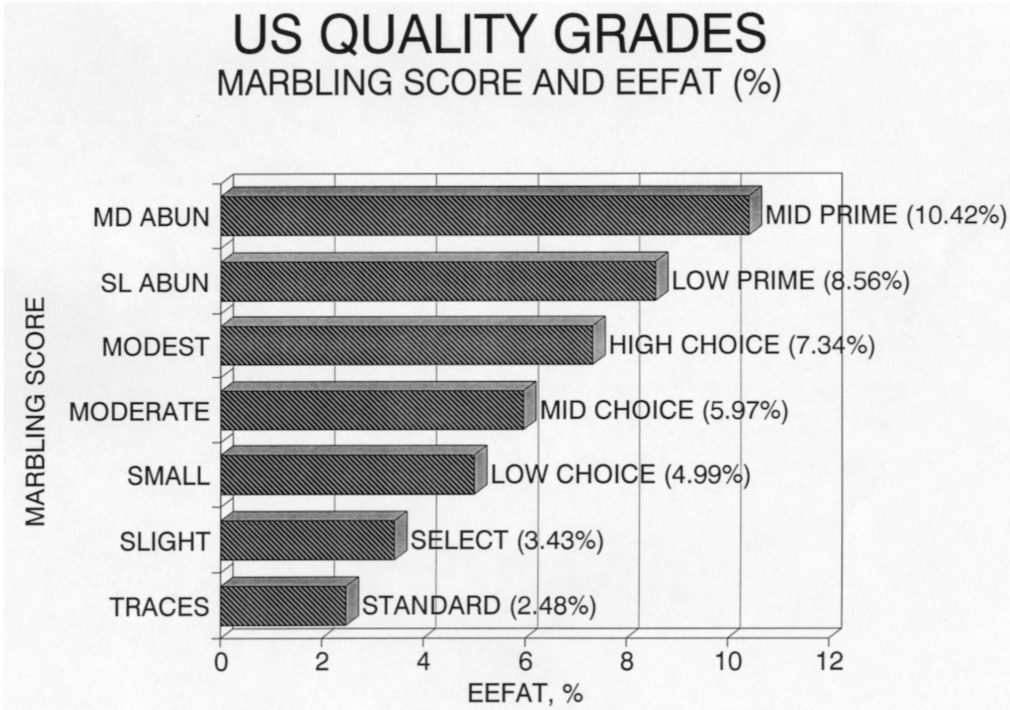


Figure 23. Average intramuscular fat content for USDA quality grades (Savell et.al., 1986).

ADDITIONAL ILLUSTRATIONS

While operators continue to strive for high quality scans, it is important that operators also be able recognize and interpret problems. Figure 24 illustrates the presence of a rib bone in the image causing the area calculation to be smaller. Figure 25 illustrates the presence of the spinous process which would occur when the probe is placed too "high" on the loin. Figure 26 presents "directional" terminology commonly used when describing scan images.

Figure 24. Poor quality scan with rib bone evident.

Figure 25. Improper probe placement, probe placed too far medial over mid-line of animal.

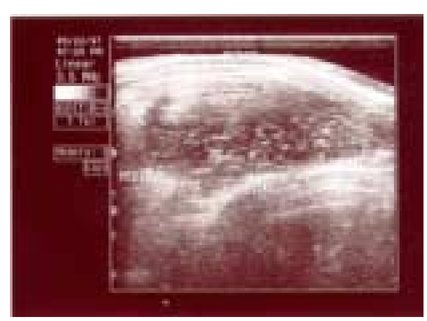


Figure 26. Cross-sectional scan with labels to identify terms used to describe direction as related to anatomical features of animal.

SUMMARY

Real-time ultrasonography is the most advanced and safest technology available for estimating composition and quality of live beef cattle. The Pie 200 Scanner SLC is the most advanced form of portable ultrasound for a variety of uses. It is inexpensive, accurate and highly repeatable for all criteria that may be used to describe the needs of the livestock industry in any part of the world.

LITERATURE CITED

Beal, W. E., R. C. Perry and L. R. Corah. 1992. The use of ultrasound in monitoring reproductive physiology of beef cattle. J. Anim. Sci. 70:924.

Boyd, J. S., S. N. Omran and T. R. Ayliffe. 1988. Use of a high frequency transducer with real time B-mode ultrasound scanning to identify early pregnancy in cows. Vet. Rec. 123:8.

Brethour, J. R., 1994. Estimating marbling score in live cattle from ultrasound images using pattern recognition and neural network procedures. J. Anim. Sci. 72:1425.

Goddard, P. J. 1995. In *Veterinary Ultrasonography*. CAB International, Wallingford, UK.

Gresham, J. D. 1995. Ultrasonography as an objective tool for evaluating live beef cattle: Using the Pie Scanner 200 Ultrasound Scanner. The Ultrasound Review. Classic Ultrasound Equipment, 19900 Mona Road, Suite 105, Tequesta, FL 33469.

Gresham, J. D. 1996. Introduction to characterization of live beef muscle tissue by use of the Pie 200 Scanner quality indexing program: An automated system for estimating quality grade of beef animals. The Ultrasound Review. Classic Ultrasound Equipment, 19900 Mona Road, Suite 105, Tequesta, FL 33469.

Hamlin, K E., R. D. Green, T. L. Perkins, L. V. Cundiff and M. F. Miller. 1995a. Real-time ultrasonic measurement of fat thickness and longissimus area: I. Description of age and weight effects. J. Anim. Sci. 73:1713.

Hamlin, K. E., R. D. Green, L. V. Cundiff, T. L. Wheeler and M. E. Dikeman. 1995b. Real-time ultrasonic measurement of fat thickness and longissimus muscle area: II. Relationship between real-time ultrasound measures and carcass retail yield. J. Anim. Sci. 73:1725.

Houghton, P. L. 1988. Application of ultrasound in commercial feedlots and beef breeding programs. pp 89-99. Beef Improvement Federation Proc., Albuquerque, NM.

Houghton, P. L., D. D. Simms and J. J. Higgins. 1990. Comparison of steer feedlot performance and carcass trait uniformity by method of sorting. pp 75-77. KSU Cattlemen's

Day Rep. of Prog.

Houghton, P. L., and L. M. Turlington. 1992. Application of ultrasound for feeding and finishing animals: A review. J. Anim. Sci. 70:930.

Muller, E., and G. Wittkowski. 1986. Visualization of male and female characteristics of bovine fetuses by real-time ultrasonics. Theriogenology 25:571
Powis, R. L. 1996. *Personal Communication.*

Rouse, G., S. Greiner and D. Wilson. 1995. Alternative methods of determining carcass merit in live cattle. p 259. Proc. Beef Improvement Federation, Sheridan, WY.

Savell, J. W., H. R. Cross and G. C. Smith. 1986. Percentage ether extractable fat and moisture content of beef longissimus muscle as related to USDA marbling score. J. Food Sci. 51:838.

Stouffer, J. R., M. V. Valentine, G. H. Wellington and A. Dickman. 1961. Development and application of ultrasonic methods for measuring fat thickness and ribeye area in cattle and hogs. J. Anim. Sci. 20:942.

Whittaker, A. D., B. Park, B. R. Thane, R. K. Miller and J. W. Savell. 1992. Principles of ultrasound and measurement of intramuscular fat. J. Anim. Sci. 70:942.

Wideman, D., C. G. Dorn and D. C. Kraemer. 1989. Sex detection of the bovine fetus using linear array real-time ultrasonography. Theriogenology 31:272 (Abstr.).

Wild, J.J. 1950. The use of ultrasonic pulses for the measurement of biological tissues and the detection of tissue density changes. Surgery 27:183.

Wilson, D. E., G. Rouse, K. Steinkamp, S. Greiner, H. Chang and C. Crawley. 1995. Real-time ultrasound measurements for body composition traits in the Iowa Cattlemen's Association test station bulls. A. S. Leaflet 215. 1995 Beef Research Report. Iowa State University, Ames, Iowa.

PHANTOM CALIBRATION
PIE 200 SCANNER

TEMP	QUIP
40	1.45
44	1.85
48	2.25
52	2.65
56	3.05
60	3.45
64	**3.85**
68	**4.25**
72	**4.65**
76	**5.05**
80	5.45
84	5.85
88	6.25

Each one degee Fahrenheit equals 0.10 QUIP index

RECOMMENDED CALIBRATION RANGE FOR BEST RESULTS (64–76, boxed)

APPENDIX B

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 Add  Maintain (by Record)  Search  List  End

Active Recs:    1 Rec:    3                                DOC 21.

'CMQDFFM'               % Fat Calculations           10:39:26  09-23-1

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   ¤    2.....Description:                                          ¤
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   ¤    3..........QUIP 1:   5.46                                   ¤
   ¤                                                                ¤
   ¤    4..........QUIP 2:   3.66                                   ¤
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   ¤    5...........Depth:   2.27                                   ¤
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 Add  Maintain (by Record)  Search  List  End

Active Recs:    1 Rec:    3                                DOC 21.

'CMQDFFM'               % Fat Calculations           10:39:26  09-23-1

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   ¤    2.....Description:                                          ¤
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   ¤    4..........QUIP 2:   3.66                                   ¤
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Dr. Gresham is a Professor of Animal Science in the Department of Agriculture and Natural Resources at The University of Tennessee at Martin, Martin, Tennessee, USA. He has several years experience in ultrasound applications to live animal evaluation and is the developer of the Pie Medical system for food animal evaluation. Dr. Gresham has presented training seminars for Pie Medical in the U.S., The Netherlands, Belgium, Australia, Uruguay, Venezuela, Chile, Brazil, and Korea as their International Consultant for Technical Development and Education.

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