Accuracy and Application of Real-Time Ultrasound for Evaluation of Carcass Merit in Live Animals

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Introduction

Efforts to utilize ultrasound to evaluate carcass characteristics in livestock began in the late 1950's. Although the relationship between longissimus muscle area (ribeye area) and carcass cut-out value in beef cattle was known to be low, measurement was considered important. The relative value of retail cuts obtained from the loin combined with its inclusion by USDA in the beef yield grade equation justified these measurement efforts.

Ensuing studies using both backfat and loineye area measurements to predict pounds of lean cuts in swine also showed considerable promise. Researchers therefore continued their pursuit of ultrasonic measurement.

Mode of Action

As with computer technology, early machines were large and cumbersome, limiting their usefulness in the field. Technicians attempted to completely immobilize animals to overcome machine limitations and to improve measurement accuracy.

Most early systems employed single crystal transducers that represented distance measurements with a series of lights. Lighted points further up the scale denoted greater depths of consistent tissue density. Tissue interfaces and narrow bands of consistent tissue also excited the light scale.

More complex systems employed a series of scans on the same animal to improve measurement accuracy. However, any animal movement during the scanning process reduced the usefulness of measurements.

Technician interpretation of signals required a thorough understanding of anatomical tissues, as well as awareness of machine limitations. Reasonable success was demonstrated in fat and muscle measurement in spite of these conditions.

Dramatic advances in ultrasound technology have occurred since that time. Human medical research has driven these advances, benefiting both animal researchers and veterinarians.
Modern A-mode systems; single crystal machines more compact and accurate than the lighted scale machines described above, display readings as numeric measurements. Some units allow the user to enter animal weights and include prediction equations for carcass leanness. Much less expensive and more portable than most real-time machines, modern A-mode units are heavily used by the swine industry for pregnancy detection and backfat measurement and are becoming more common for total leanness evaluation.

Modern real-time units combine many crystals which fire in sequence emitting high frequency sound waves. These sound waves bounce off tissue interfaces (such as a change from fat to muscle) and bounce back to the sending unit. These reflections allow the system to measure elapsed time and create constantly updated two dimensional images. These images represent a cross-sectional view of the tissues scanned. Minor anatomical features are visible and can be assessed for deviations from normal anatomy.

Human obstetricians may use ultrasound for fetal evaluation while animal scientists use the same equipment to observe and manipulate reproductive functions or to evaluate carcass characteristics in live animals. Real-time ultrasound systems are quite costly and primarily used for research purposes. Nonetheless, some individuals and firms offer custom livestock scanning services with real-time machines.

Accuracy

Measurements made with ultrasound can be influenced by both technician experience and machine differences. Inexperienced technicians often confuse shadows and multiple reflections with anatomical features, leading to inaccurate diagnoses or faulty measurements. For precise comparisons, quality images must be captured from fixed locations on each animal and subsequently interpreted. Considerable knowledge of the muscle structure of tissues scanned is required for accurate assessment. Experience and dedication are crucial components if precise measurements are to be attained. Technicians must repeatedly follow scanned animals through the slaughter process to evaluate carcasses and use this information to improve both image capture and analysis.

Differences in ultrasound equipment can also influence image quality and subsequent analysis. First generation real-time units required the technician to combine two separate frozen images to evaluate the entire ribeye muscle in beef cattle. These units require considerable experience to make accurate measurements.

Second generation real-time machines can accommodate a longer transducer, capable of imaging the entire beef ribeye on a single screen. This improvement in technology allows less experienced technicians to improve muscle area measurement.

Technician accuracy is typically evaluated by comparing carcass measurements with ultrasound measurements of backfat and ribeye or loineye areas. Even though considerable changes in the fat and muscle arrangement are known to occur as a result of the slaughter and hanging process, carcass measurements are generally considered standards with which any other measurement technique must be compared.

Certification

The Beef Improvement Federation (BIF) and the National Swine Improvement Federation (NSIF) have each established guidelines which prospective technicians must meet in order to certify as qualified ultrasonic technicians. Protocols and accuracy requirements are determined by each organization. In these programs, prospective technicians scan test animals twice, interpret their own images, then follow the animals through processing. Carcass data is then compared with live
measurements to develop accuracy and repeatability ratings for participants. Minimum levels for each area must be attained prior to certification. (See Table 1).

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<th>Table 1. Certification Standards</th>
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<td><strong>Statistic</strong></td>
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<td>Technician Bias</td>
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<td>Standard Error of</td>
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<td>Prediction (SEP)</td>
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<td>Standard Error of</td>
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<td>Repeatability (SER)</td>
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The means or averages of the two measurement techniques are compared to establish a technician bias. For example, if the carcass loineye area measurements averaged 5.5 square inches and ultrasonic loineye measurements averaged 5.8 square inches, the technician bias would be 0.3 square inches. In other words, the technician typically overestimates loineye area by an average of three tenths of a square inch.

A second measure of accuracy is known as the standard error of prediction (SEP). This statistic establishes an amount we would expect individual ultrasonic measurements to differ from carcass measurements. For a technician with a SEP for backfat of .08 inches, we would expect two thirds of his ultrasonic backfat measurements to be within .08 inches of the carcass measurements.

A third measure of technician accuracy is known as the standard error of repeatability (SER). This statistic establishes an amount we expect repeated measurements on the same animal to differ. A technician with a SER for ribeye area of 1.0 square inch would be expected to arrive at two measurements on the same animal within one square inch of each other, at least two thirds of the time.

Implications

Recent research efforts using ultrasonic measurements to predict weights of lean in pork carcasses have show considerable promise. When a model including backfat, loineye area and carcass weight was used, approximately 80 percent of the variation in carcass leanness was predicted. Similar accuracy’s have been demonstrated using live swine measurements. Overall swine leanness is somewhat easy to predict because ultrasonic backfat measurements are quite accurate and swine lean yield is relatively fat dependent.

Estimating weight of lean in cattle with similar measurements has been more difficult. The amount of total body lean in cattle is less fat dependent than similar leanness in swine, thus our predictions for cattle must place more emphasis on less accurate muscle area measurement. Although Brethour has demonstrated reasonable accuracy in predicting yield grade in cattle with this technology, more work needs to be completed comparing ultrasonic estimates with actual product yield.

Beef researchers at Iowa State have developed a large database of ultrasonic information on breeding cattle. However, relating this information to it’s impact on slaughter weight of offspring is just beginning. A recent Colorado State study summarized ultrasound research relating backfat thickness and ribeye area in both yearling bulls and/or heifers and in slaughter steers.
Interestingly, most of the data shows a positive genetic correlation between the two measurements in yearling breeding animals but a negative correlation in slaughter steers. Because of these relationships, they surmised that selection for lower backfat in breeding animals may actually increase backfat in slaughter progeny. They, like many others, conclude that selection for larger ribeye area without consideration of accurate quality grade measurement could have unfavorable consequences for breeders.

Researchers at several universities and private firms are now attempting to quantify marbling differences in beef cattle and swine with ultrasound. Current ultrasound equipment is capable of detecting small flecks of intramuscular fat, or marbling, but quantifying these amounts is more difficult. Technicians cannot visually differentiate between signals reflected by marbling from those reflected by other structures, such as connective tissue, blood veins and arteries, which permeate muscle tissue.

Research efforts have concentrated on statistical analysis of ultrasonic images. Gray scale differences (the level of brightness of pixels in ultrasonic display screens) between images of loin muscles of different animals have been evaluated as well as pattern differences between images. The accuracy of these systems to quantify marbling in yearling breeding cattle and in feedlot cattle is not well documented. Although recent work from Kansas shows promise relating ultrasound speckle to marbling scores, the Colorado State study demonstrates flaws in certain processes.

As with most new technology, businesses arise to capitalize on advancements. Custom sonographers typically carry from $25,000 to $30,000 worth of equipment to perform these services. Most groups charge a per head fee in addition to reimbursement of travel expenses. Fees are based on the number of animals to be scanned. Per head charges range from $4.00/head to $15.00/head, depending on the species, type of measurements made, and number of animals scanned.

As with most services, quality of the information received varies with the experience and ability of the technician. National organizations publish lists of certified technicians that have met minimum requirements for certification, and may be able to provide some additional information on available technicians.

**Summary**

The use of real-time ultrasound has had a considerable impact in reducing excess fat in swine herds as major breeding companies have employed the technology in their selection process. Similar advances in total lean production in beef cattle, due to the use of ultrasonic measurements or any other selection tool, have not materialized. Many breeders of both cattle and swine have used ultrasonic information for promotional purposes, with a poor understanding of measurement accuracy or implication for selection decisions. Without validated research on the ramifications of selection, valuable use of this information is limited.

When one considers the structural changes between the live animal and the hanging carcass, combined with the margin of error in ultrasonic measurements, discrepancies between the two measurement techniques are expected. An experienced ultrasound technician can accurately rank contemporaries on carcass differences. However, the ability to differentiate between individuals on relatively minor muscle size differences is beyond the current capability of ultrasound technology.

To date, the accuracy of ultrasound speckle scores to estimate marbling in cattle or swine lacks adequate support in the scientific data. Some technologies have demonstrated reasonable accuracy while others failed. These differences should be considered prior to substantial
expenditures by animal breeders. Further development in equipment and analysis techniques, substantiated by published data, is needed. Regardless of this predicament, ultrasound may still be the most accurate system available for evaluating the live animal for carcass merit.

References


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