USING ULTRASOUND FOR PRECISION FEEDING AND MARKETING OF CATTLE

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INTRODUCTION

The purpose of this paper is to discuss the following aspects of ultrasound technology: 1) What is it?, 2) How is it used to measure carcass traits in live animals?, 3) Its accuracy, 4) Industry applications and 5) Its use in the WSU sire evaluation study.

What is ultrasound? Ultrasound refers to very high frequency sound waves. Ultrasound equipment converts electrical pulses to high frequency sound waves which are emitted from a transducer. When the transducer is placed in contact with the body of an animal the sound waves travel into the body of the animal until they reach the boundary between tissues such as between the skin and the outer fat layer and between fat and lean tissues. At these boundaries a portion of the sound wave continues through the tissue but some of the wave is reflected back to the transducer which acts as a receiver. When the reflected waves strike the transducer it produces mechanical energy which is converted to electrical energy that is then processed and displayed in various formats.

Ultrasound technology was first used for biological applications in the 1950's. Initially A-mode technology was used. A-mode ultrasound can only be used for linear measurements such as fat thickness and muscle depth because it involves only one transducer. B-mode ultrasound involves a linear array of several transducers that are fired successively. Real-time ultrasound (RTU) is a version of B-mode ultrasound in which the display image is updated almost instantaneously to create a live two dimensional image. This image can be used to measure ribeye area (REA), fat thickness and, with computer enhancement, marbling. The subsequent discussion will relate primarily to RTU.

How is ultrasound used to measure carcass traits? To measure fat thickness and REA on beef cattle, oil is placed on the back of the animal between the 12 and 13th rib and the transducer is placed on the oiled area perpendicular to the length of the loin muscle. The oil is required to make an acoustical coupling with the body of the animal. When measuring large numbers of cattle, a scan taken parallel to the loin muscle is often used. This scan is quicker to obtain, gives accurate measures of fat thickness and muscle depth and possibly a more representative estimate of marbling.

How accurate is ultrasound and what factors influence its accuracy? Table 1 summarizes some of the studies that have evaluated the ability of RTU to predict carcass measurements.

Table 1. Ability of Ultrasound to Predict Beef Carcass Traits

Traits	Range of Correlation Coefficients
Fat Thickness[a]	.74-.94
Ribeye Area[a]	.20 to.95
Marbling[b]	.22 to .75

[a]From a summary compiled by Duckett et al. 1997 for the Systems Approach to Livestock Evaluation Symposium. University of Idaho.
[b]From a comparison of nine RTU technicians using four predictive systems conducted by Herring et al. 1996. University of Missouri.

Generally, ultrasound is very accurate at predicting fat thickness, low to highly accurate for REA and low to moderately accurate for marbling. The following factors influence the accuracy of RTU:

1. The skill and experience of the technician is extremely important.

2. Ultrasound equipment and interpretive software play a major roles in determining the accuracy of marbling predictions.

2. Accuracy of carcass measurements.

3. Correlation coefficients are also greatly influenced by the variation in the cattle that are evaluated. If the cattle vary widely in the variable measured RTU is better able to pick up those differences than for a very uniform set of cattle.

APPLICATIONS OF ULTRASOUND IN THE BEEF INDUSTRY

Consumer concerns about fat and the results of the Beef Quality Audits have prompted the meat industry to seek ways to improve their end-product. Here are three ways the industry can improve their product:

1. Harvest animals after their most efficient gains, but before they get too fat.

2. Identify management and nutrition practices that optimize muscle deposition and palatability without producing excess fat.

3. Identify breeding animals that will produce rapidly growing offspring that deposit a high percentage of palatable muscle without depositing excess fat.

Ultrasound is a non-destructive means of quantifying fat deposition and muscle mass in live animals. Ultrasound generates "carcass" data on live animals that can be used to 1) evaluate market animals or show animals for carcass traits when actual carcass data are unattainable, 2) determine ideal slaughter endpoints for animals, 3) identify ideal feeding/management systems for market animals, and 4) select breeding animals.

Use of ultrasound to evaluate market-ready cattle. RTU is widely used to obtain "carcass" information on show animals when actual carcass data are unavailable. This provides an excellent educational opportunity for youth and adults alike. Ultrasound can also be used to determine when commercial cattle are ready for market. This procedure may be effective but it requires extra handling of the cattle and catching the cattle in a squeeze chute right before slaughter could increase the incidence of carcass bruises. Thus systems that can be used upstream in the production cycle to sort cattle into outcome groups may be more useful.

Use of ultrasound to determine ideal slaughter endpoints. The cattle industry is moving toward marketing on carcass merit. This change has evoked immense interest in technologies that can evaluate live animals to predict future carcass quality and sort cattle into outcome groups. Cattle feeding has been a batch process in which all animals in a pen are marketed on the same date. That results in half being over fed and the other half underfed. More importantly, about 30% of the animals are more than 25 days away from their optimal marketing date and some cattle are

fed as much as 50 days too long and others are marketed 50 days early. There is at least $1 per head per day lost profit for each day that the optimal marketing day is missed. Overfed cattle waste feed while depositing excessive fat which is often penalized in formula pricing scenarios. Underfed cattle include animals with additional gain potential, undesirable quality grades, and low dressing percentages. Outliers on both sides may incur carcass weight penalties. Often, the date to market a pen is arbitrarily chosen. Clustering cattle into outcome groups based on days-on-feed and focused on carcass merit seems an obvious way to improve both production efficiency and product quality.

Ultrasound technology has advanced so that it provides the capability to evaluate cattle upstream to predict future carcass merit and to estimate the optimal number of days that each individual animal should be fed to maximize profit. That has resulted in building what is called an ultrasonic cattle sorting machine which has now been used on over 250,000 cattle. Backfat thickness and marbling are measured at processing time and future carcass merit as a function of days on feed is estimated. Research derived models objectively plot those changes and enable upstream evaluation with ultrasound. Recent advances exploit computer artificial intelligence to process the ultrasound image and automatically pipe that information into an economic decision model. Projected carcass quality and yield grades, along with carcass weight, are plotted and applied to a matrix of packer formula prices. The feedlot model includes economic constraints relating to production costs and projected carcass gain performance. For example, cattle routed to a grid that rewards leanness such as the Certified Hereford Beef program will benefit from shorter feeding periods than those held back to reach Certified Angus Beef specifications. And, one does not feed as long when corn is $5 per bushel as when it costs $3. The software determines the optimal day to market each individual animal to obtain maximum profit. It is not logistically reasonable to sell market-ready cattle on a day-to-day basis so the software assigns cattle to 3 or 4 outcome groups which captures most of the benefit from this procedure.

The ultrasound sorting machine's carcass merit and interfaced feedlot model are dynamic. A setup procedure provides rapid entry of changing schedules of premiums and discounts as well as cattle price-production cost relationships. In some situations, the largest component of the extra profit from sorting is generated by identifying candidates for retained feeding and recovering more gain from a pen of cattle. This is done simultaneously with avoiding over-fat and over-

weight carcasses. Sorting procedures will appeal more to feeders who market on a grade and yield (formula) pricing system. The apparent benefit in the traditional close-out report that focuses on live weight gain and feed efficiency will be small. That is because the system is built for carcass gain performance, not live weight gain. Retained cattle may have low live gains. However, end stage carcass gain is probably 80% of live weight gain and often exceeds two pounds per head per day.

Present premiums for Yield Grade #1 and #2 carcasses often do not offset the profit advantage from holding cattle for additional gain when the margin between gain costs and selling price is substantially positive. However, animal performance drops precipitously after backfat reaches .5 inch because that is the point when animals switch from a growing to a fattening mode. That and the huge discount for Yield Grade #4 carcasses causes the program to avoid over-fat cattle. If the proposed splitting of YG#3 carcasses into YG#3A and YG#3B (with a pronounced discount for the latter cutability grade) should become effective, ultrasound would be a powerful tool to focus into the narrower windows of acceptability.

Present procedures rely on a backfat measurement to project future yield grade. Backfat thickness can be measured accurately with ultrasound, and the increase in backfat as a function of days on feed can be plotted with usable accuracy. Backfat thickness is the best single predictor of lean proportion in cattle and it accounts for about 70% of the variation in the USDA yield grade equation. Moreover, graders subjected to chain speeds of several hundred carcasses per hour say backfat thickness accounts for over 80% of their yield grade decision. The system's present accuracy for predicting quality and cutability grade 60 days after evaluation is about 75%. There are four sources of error in a system: (1) Operator and machine error at processing time; (2) Errors in the equations that project to future dates; (3) Normal biological variability among animals in growth and development; and (4) Subjectivity of the grading system and differences among packing plants and graders.

For widespread commercial application, there are number of essential specifications in a cattle sorting machine:

1. Minimal human input to reduce variation from technician to technician.

2. Dynamic so it can respond to user needs and changing price relationships.

3. Sorting should correspond to an existing processing activity, such as reimplanting and operate fast enough to avoid delaying that procedure.

4. Accurate.

5. The benefit must exceed the cost.

The system developed at Kansas State University does not completely avoid the chance for operator error, but the computer system does reduce it. The system is adaptable to different environments and pricing grids, it can be used at reimplantation or even earlier, speeds of 80 head per hour are possible and it is relatively accurate.

It is difficult to accurately measure the increase in profit resulting from sorting procedures. It departs from classical experimental protocols because the evaluation is confounded with differences in marketing dates and locations and cattle numbers per pen. It is difficult to create and measure a valid control group. Several hundred cattle are needed for each replication, so the task of collecting high quality data is enormous. Also, the interpretation must include a combination of animal performance and carcass merit. Response will depend on cattle type and variability, as well as price relationships. The best estimate of response to a three way sort, based on research facility and field experiences, indicates profit can be improved $20 per head. That is significant, considering feedlot profits have averaged $20 to $30 per head over an extended period. With more precise pricing grids that more accurately reflect the real differences in value among carcasses, profit response to sorting procedures will be substantially larger.

Use of ultrasound to identify ideal feeding/management systems for market animals. There is immense diversity in the cattle population. In the past, cattle were forced to adapt to whatever management system was convenient for an operation. Ultrasound technology may enable the industry to recognize and exploit the variability in the herd and create production systems that fit the cattle. Two particular areas of interest are to evaluate cattle at initial processing and estimate individual profitability with the intent of culling animals with poor profit expectations. Another is to evaluate calves at weaning to select the appropriate management strategy for individual animals (calf fed or a deferred program) as well as direct animals toward their appropriate

pricing program (lean beef versus quality beef grids). Sorting procedures will not increase quality grade substantially because the increase in marbling progresses at a very slow rate and genetic deficiencies cannot be easily overcome by increasing time on feed, but cattle can be targeted for the appropriate feeding system. For example, low marbling cattle should be identified and targeted for a lean beef program while highly marbled calves could be targeted for a Prime or Japanese feeding program.

Use of ultrasound to select breeding animals. Ultrasound can be used to evaluate fatness, muscling and perhaps marbling of breeding animals, but it is critical that these results be interpreted properly. When using ultrasound measurements to evaluate breeding animals it is very important that you account for management practices and animal weights. Remember we are dealing with an unadjusted measurement taken at one point in time. Measurements taken on a mature animal certainly are not comparable to measurements on younger animals. Even in the case of yearling cattle these measurement mean no more than an unadjusted weights. Moreover, individual weights and measures should not be interpreted as an EPD or transmitting ability. Adequate data with proper contemporary groupings must be collected and analyzed before we can determine the extent to which ultrasound data can be used to generate carcass EPD's. On the other hand, traditional means of gathering carcass information is time consuming and expensive, so overcoming the obstacles to the use of ultrasound is important.

It is also noteworthy that Marbling appears to be controlled much more by genetics than management. Perhaps seedstock producers should concentrate on quality attributes rather than leanness because the latter can be more easily manipulated by management strategies.

WSU Sire Evaluation Study: Effectiveness of Ultrasound

The cattle used in this study have been described in detail by Elías Calles et al. (1997). Briefly, nine Angus-sired steers and 95 Wagyu-sired steers and heifers were scanned using the Cattle Performance Evaluation Company (CPEC) ultrasound system, 105 and 27 days before slaughter. The half Wagyu cattle represented eight different sires, two of which were recently imported (new genetics) and six were either imported in 1976 or were descendants of those bulls (old

genetics). Correlation coefficients between ultrasound marbling scores and carcass marbling scores are shown in Table 2.

Table 2. Correlation coefficients between marbling estimates[a]

	Ultrasound Marbling 105 d antemortem	Ultrasound Marbling 27 d antemortem	Carcass Marbling
Ultrasound Marbling 105 d antemortem	1.0	.72	.68
Ultrasound Marbling 27 d antemortem		1.0	.71
Carcass Marbling			1.0

[a]Correlation coefficients above .2 are significant ($P < .05$).

The ultrasound system was relatively effective at predicting marbling especially when you take into consideration that the correlation between marbling and adjusted fat thickness (the factor that has the greatest influence on subjective visual appraisal of marbling) was -.18. These results indicate the ultrasound measurements can account for about 50 % of the variation in marbling but with this set of cattle, if you selected the fattest cattle you would have had a tendency to pick the ones with the least marbling. Figures 1 and 2 illustrate the success you would have had using the ultrasound measurement obtained 105 days before slaughter to select cattle that should be fed to reach the Prime grade.

Figure 1 shows the true positive and false positive fractions as a function of the first ultrasound marbling estimates. For example, if a marbling score of 7.0 had been selected as a threshold, then 78% of the potential Prime cattle would have been correctly kept, and 18% of the non Prime would have been included erroneously. Lowering the cut off point to 6.9 and 6.5, respectively would have resulted in keeping 81% and 92% of the potential Prime cattle and erroneously including 20% and 38% of the non-Prime cattle. Figure 2 shows that if you chose the 6.9 cutoff which would have yielded 20% false positives, you would get 81% of the cattle that actually graded prime classified correctly. The area under the curve represents the % accuracy of discrimination of Prime versus non-Prime. The value of 89.7 is very good.

How Much is that worth? Using the following assumptions:

1. 100 head of cattle, 50 that will ultimately grade Prime and 50 will grade Choice

2. Premium for Prime - $200/head

3. Dock for YG 4 Choice - $200/head

4. 80% of Choice cattle will go YG 4 if long fed (this was true in our study)

We select 6.9 as our cutoff which means we correctly keep 40 head (81%), but do not keep 10 head that would have graded Prime. We also correctly sort off 40 of the 50 head that will not grade Prime. 80% (32 head) of those 40 would be YG 4's if long fed.

Thus in comparison to long feeding the entire 100 head, the following calculations apply:

1. Reduced losses from YG 4 cattle – 32head x $200/hd = $6400.

2. Reduced revenue – 10 head x $200 = $2000.

3. Net savings - $6400 - $2000 = $4400.

4. Net savings per head ultrasounded - $4400 / 100 head = $44 / head.

This $44 per head savings does not include feed cost savings or penalties for overweight cattle and it only involved sorting into two production systems. Further economic research is needed on larger numbers of cattle to quantitate the value of ultrasound in identifying cattle that should be fed for Japanese markets.

SUMMARY AND IMPLICATIONS

Ultrasound is a non-destructive means of quantifying fat deposition and muscle mass in live animals. Generally, ultrasound is very accurate at predicting fat thickness, low to highly accurate for REA and low to moderately accurate for marbling depending on the skill of the technician, equipment used (especially for marbling), and accuracy of carcass measurements. Ultrasound can be used to 1) evaluate market animals or show animals for carcass traits when carcass data are unattainable, 2) determine ideal slaughter endpoints for animals, 3) identify ideal feeding/management systems for market animals, and 4) select breeding animals. Ultrasound can contribute to a valuable educational experience when show animals are evaluated. It can also be used to determine when commercial cattle are ready for market, but this procedure requires extra handling of the cattle. Thus systems that can be used upstream in the production cycle to sort

cattle into outcome groups may be more useful. The best estimate of response to an upstream three way sort, indicates profit can be improved $20 per head. With more precise pricing grids profit response to sorting procedures will be substantially larger. Scanning cattle early in the feeding period can also be used to target cattle for the appropriate feeding system. For example, low marbling cattle can be targeted for a lean beef program while highly marbled calves could be fed longer for the Japanese market. Our results with Wagyu cattle indicate that using ultrasound 105 days prior to slaughter to identify and market cattle that had a low probability of grading Prime would have increased profitability by $44. Ultrasound can also be used to evaluate fatness, muscling and perhaps marbling of breeding animals, but it is critical to account for age, management practices and animal weights.

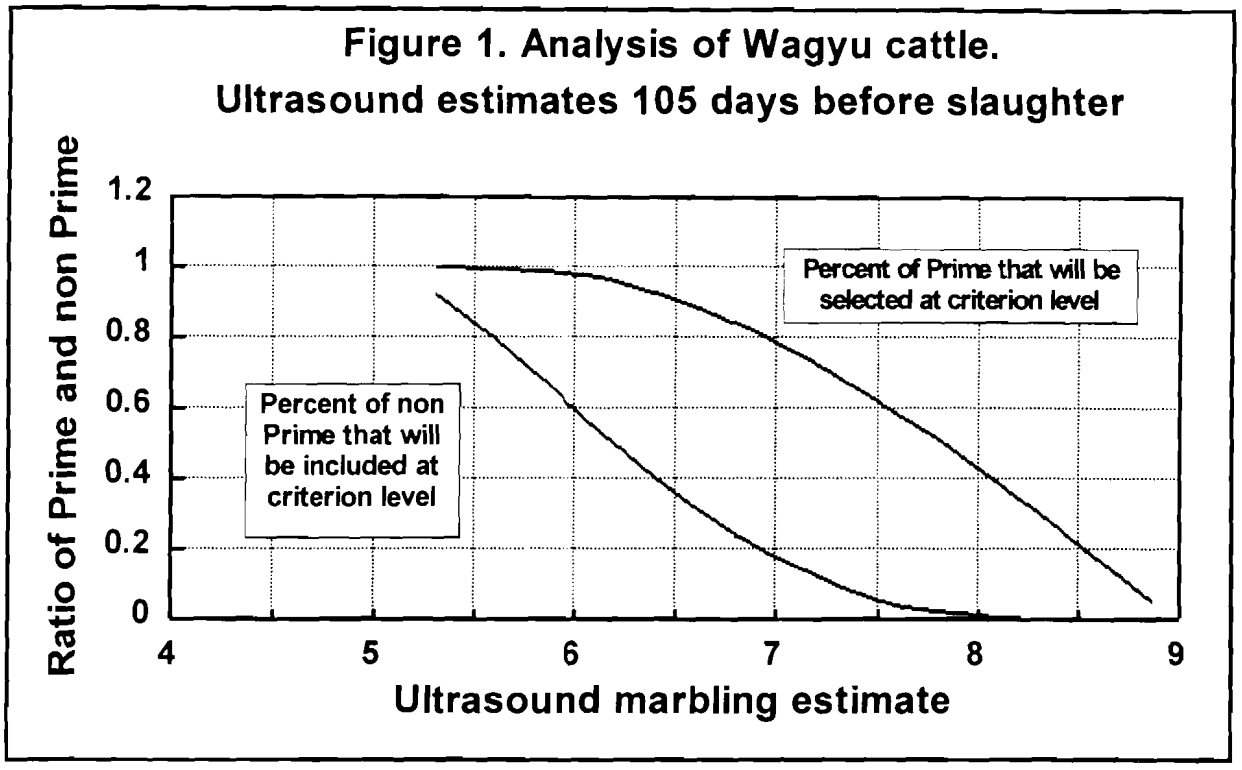
Figure 1. Analysis of Wagyu cattle.
Ultrasound estimates 105 days before slaughter
Ratio of Prime and non Prime
1.2
1
0.8
0.6
0.4
0.2
0
4
5
6
7
8
9
Ultrasound marbling estimate
Percent of Prime that will be selected at criterion level
Percent of non Prime that will be included at criterion level

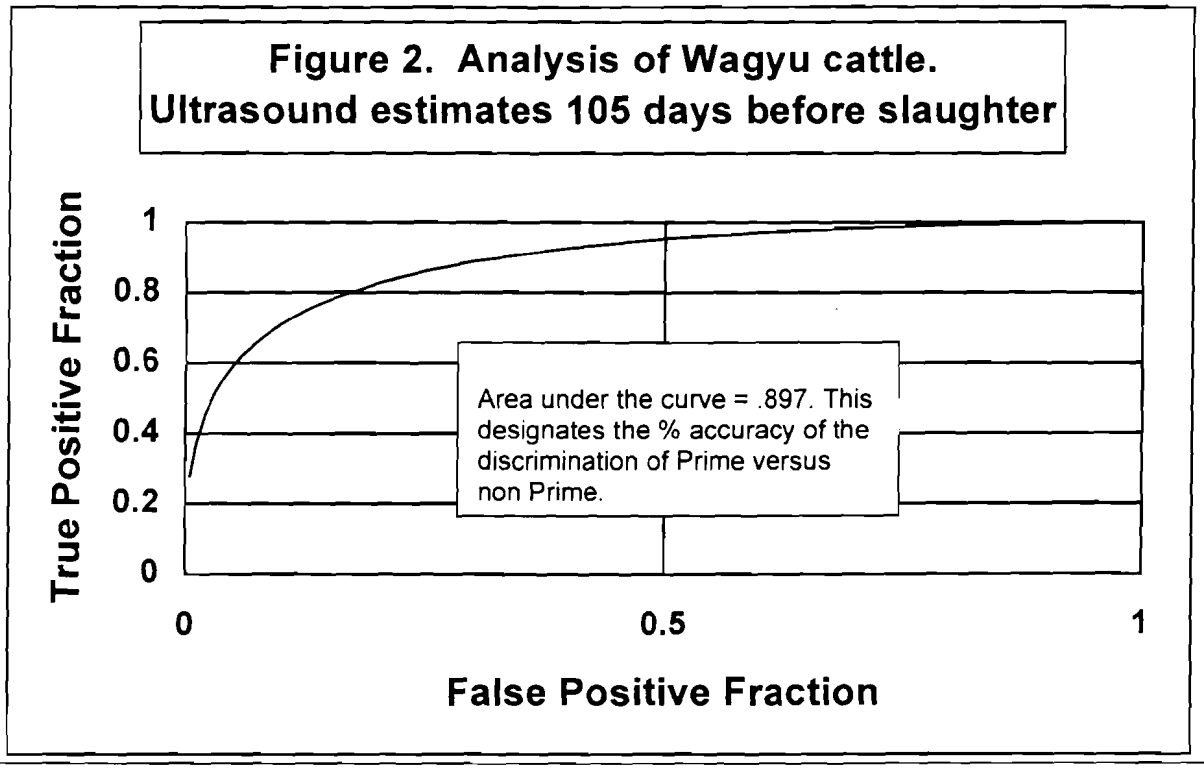
Figure 2. Analysis of Wagyu cattle.
Ultrasound estimates 105 days before slaughter
True Positive Fraction
1
0.8
0.6
0.4
0.2
0
0
0.5
1
False Positive Fraction
Area under the curve = .897. This designates the % accuracy of the discrimination of Prime versus non Prime.