# EVALUATION OF ULTRASOUND AND OTHER SOURCES OF INFORMATION TO PREDICT BEEF CARCASS TRAITS AND FINAL CARCASS VALUE

A Dissertation

by

DUSTIN TYLER DEAN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2006

Major Subject: Animal Science

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Approved by:

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| Committee Members, | Jason Sawyer |
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| | Ernie Davis |
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# ABSTRACT


Evaluation of Ultrasound and Other Sources of Information to Predict
Beef Carcass Traits and Final Carcass Value. (May 2006)
Dustin Tyler Dean, B.S., Texas Tech University;
M.S., Texas Tech University
Chair of Advisory Committee: Dr. Andy Herring

Purebred Beefmaster steers (n = 160) from five owners were fed at a commercial feedlot in South Texas beginning in November of 2004; 68 steers possessed pedigree information. Beginning in mid-November, steers were individually weighed and evaluated for ultrasound body composition at 56-d intervals by a certified technician. Feeder calf frame (FRM) and muscle (MUS) scores were assigned at initial ultrasound evaluation. Steers were fed and marketed through a lean-based, branded beef program and were harvested in two groups in May and June of 2005 at a commercial beef plant. Analyses were conducted to investigate the ability to predict carcass traits from the different sources of information available on these cattle. Evaluation of carcass traits were investigated using four sets of independent variables referred to as sources A, B, C, or D and ultrasound scan session (1 – 4). An analysis included initial weight at first scan session (IWT), FRM and MUS as independent variables through GLM procedures. B analyses utilized ultrasound measures of the longissimus area, intramuscular fat, fat thickness, rump fat, and gluteus medius depth along with IWT as independent variables. Multiple regression was performed on each carcass trait using IWT and ultrasound traits at each scan session. Mallow’s CP was used to select a model that best described each carcass trait. C analyses (GLM) utilized variables from A and B analyses combined plus ranch. D analyses (GLM) included variables from C analyses plus sire nested within ranch. Respective R-square values (scan 1 – 4) for marbling score were .02, .04, .05, and .10 using A information, .14, .17, .42, and .54, using B information, .35, .35, .47, and .55 using C information, and .56, .59, .65, and .76 using D information. R-square values ranged from .34 to .86 for carcass weight, .11 to .77 for fat thickness, .06 to .82 for ribeye area, and .10 to .81 for yield grade. Ultrasound data obtained closer to harvest and increasing amount of data related to genetic and management background showed increased R-square values, but may be best utilized in conjunction with one another to predict carcass traits and final carcass value.

## ACKNOWLEDGEMENTS

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I would also like to personally recognize Dr. Andy Herring, of whom I have known since my freshman year. Since that time, he has been a constant friend and adviser that has done his best to instill in me a respect and scientific admiration for the beef industry. I know that without him as my adviser no part of this dissertation would have been possible. A big thanks to Dr. Jason Sawyer, Dr. Jeff Savell, and Dr. Ernie Davis for serving as my additional committee members. By donating their time and effort, they allowed me to have one of the most effective and well represented doctoral committees in some time. Also to Ryan Rhoades, Emalee Bumpass, Ryan Oliphint, and all the other graduate students who temporarily put aside their projects to help construct this dissertation.

I finally like to thank Texas A&M University and the Department of Animal Science for the opportunity to study at College Station. I know that the knowledge I have gained at Texas A&M University will command respect in the workforce and provide me with the analytical and life skills necessary to succeed.

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# INTRODUCTION

Currently, more opportunities exist for managers of commercial cow/calf and feedyard operations to take advantage of increased amounts of information and technology in order to add value to their cattle. As programs like the National Animal Identification System grow closer to becoming reality and as technology such as Real-Time Ultrasound become more readily utilized, cattle will possess bountiful quantities of useful information that can aid in aligning them with the most optimal market. By acquiring accurate and timely information, managers can create more consistent loads that are highly valued by feeders and packers. However, in order to create these more streamlined loads, managers must acquire quality information about their animals and then attempt to accurately predict each animal's future performance on a carcass and end value basis. Perhaps the most important factor in creating more streamlined loads of animals is not the acquisition of such information, but the means in which managers use the information to predict and estimate each animal's future performance. The steps taken to add value in this fashion may be as simple as grouping loads of animals based solely on weight, to as complex as aligning animals based upon body composition and pedigree data to the most profitable grid marketing scenario. In addressing this issue, the objectives of this study were to 1) study the connections observed in early feedlot cattle measures and carcass performance among known sire groups in Beefmaster steers, 2) investigate prediction models where early measures of ultrasound data, initial feeder calf

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This dissertation follows the style and format of the *Journal of Animal Science.*

grade, and background (sire and ranch) information will be used individually and jointly to explain variation in carcass component traits and carcass value, and 3) calculate estimates of dollar values for individual sires based on progeny performance under the actual carcass grid pricing system as well as alternate grid pricing systems.

# LITERATURE REVIEW

## Introduction

The growing interest in marketing fed cattle on a value or grid basis, where prices are based on individual carcass merit, highlights the need for timely and accurate data on individual animals (Lusk et al., 2003). Currently the total cattle volume market break down is 44-51% cash basis, 42-46% formula and grid basis, 3% private contracts, and 4-7% are packer owned (USDA, 2005). There is considerable variation among cattle within pens, which diminishes opportunities for precision feeding and value based marketing. If cattle within a pen were more uniform, they could be fed more precisely according to their requirements, rather than feeding for the average which can over- or underfeed a portion of the cattle (Trenkle and Williams, 1997). Average revenue per animal can be markedly improved if cattle producers accurately know live animal characteristics and market them accordingly (Lusk et al., 2003). In Lusk et al., 2003, results indicated that using ultrasound information to selectively market cattle could have increased revenue by $25.53, $4.98, or $32.90 per animal, compared with simply marketing all animals on a live weight, dressed weight, or grid basis, respectively. Even if producers incorporate such information as placement weight, days on feed, and breed type into their expectations about final carcass characteristics, the results by Lusk et al., 2003 indicated that ultrasound measures could still improve average revenue by $4.16/head. This indicates the substantial need for producers to understand the kind of cattle they market, and target cattle to the best pricing opportunity (Shroeder and Graff, 2000).

Improving Marketability with More Information

Use of Ultrasound

In order to combine cattle into more uniform groups which are destined to be sold on a grid marketing basis, researchers, producers and feedyard managers routinely utilize real time ultrasound technology to give an immediate live animal assessment of economically valuable carcass traits. Ultrasound technology provides an opportunity to quickly and economically estimate carcass attributes on the live animal (Brethour, 2000). Longissimus muscle area is the most common estimator of total carcass muscle and is used in the USDA yield grade equation. Correlation estimates between ultrasound longissimus muscle area and carcass longissimus muscle area are more variable than measures of fat thickness over the 12$^{th}$ rib and intramuscular fat percentage, and can range from 0.43 to 0.85 on Brangus bulls (Waldner et al., 1992), to as high as 0.95 on Santa Gertrudis and Brangus bulls (Perkins et al., 1997). Kemp et al. (2002) found the genetic correlations of carcass and real-time ultrasound longissimus muscle area to be 0.69 and 0.58, respectively, for 2,855 Angus steers ranging in age from 391 to 443 days of age. Both models in that study contained the independent variables of ultrasound longissimus muscle area, ultrasound fat thickness, and ultrasound percentage intramuscular fat percentage. Model 1 used discrete fixed effects for age, and model 2 used group and age as covariates.

Correlation estimates between ultrasound and actual carcass fat thickness over the 12$^{th}$ rib have been shown to range from 0.76 to 0.93 (Perkins et al., 1992, 1997). Ultrasonic back fat determinations are fairly accurate, but may underestimate actual back fat in fatter cattle and overestimate in leaner cattle based on results from Brangus bulls

(Perkins et al., 1997, Charagu et al., 2000). Rouse et al. (2000) scanned cattle in the feedyard at 90, 46, and 6 days before slaughter and showed coefficients between ultrasound and carcass backfat of 0.53, 0.64, and 0.72, respectively. Kemp et al. (2002) found a correlation of 0.82 between carcass and real time ultrasound backfat on 2,855 Angus steers. Ultrasound estimates of back fat have been within 0.1 inch of actual carcass back fat in 72% (Perkins et al., 1992), 62% (Waldner et al., 1992), and 56% (Hassen et al., 1995) of animals scanned.

Correlations between ultrasound intramuscular fat and actual marbling scores have ranged from 0.35 to 0.87 on 16 different sire breeds (Wilson et al., 1992), on Angus steers (Hassen et al., 1995), and on Santa Gertrudis and Brangus steers (Perkins et al., 1997). Devitt and Wilton (2001) reported an average correlation between real time ultrasound predicted percent intramuscular fat and carcass marbling score of 0.80 in a population that included Simmental, Charolais, and Main Anjou crossbred steers and a line of Angus, Salers, and Hereford steers. Brethour (2000) indicated correlations between serial ultrasound marbling scores at 0.32 and 0.85 on Limousin and Simmental cross-bred steers scanned at day 0 and 123 of the feeding period. In a study conducted with stocker steers, animals were scanned at the end of the stocker grazing period prior to shipment to the feedyard. Correlations between actual carcass quality grade and pre-feeding ultrasound intramuscular fat was estimated at 0.49 (Field et al., 2000). Rouse et al. (2000) found that scans of intramuscular fat percentage at 90, 46, and 6 days before slaughter showed correlations with carcass intramuscular fat of 0.56, 0.56, and 0.66, respectively.

Rump fat and gluteus medius depth have been found to increase the predictive power of models estimating percent retail product. Johns et al. (1993) suggested the prediction accuracy of retail product yield could be improved through the measurement of gluteus medius depth and rump fat thickness. Tait et al. (2005) indicated that the inclusion of gluteus medius depth and rump fat in multiple regression equations could increase prediction accuracy for weight of retail product from the beef round.

Growth and Development

The rate of growth and development of economically valuable carcass traits on the live animal is extremely important in the prediction of future performance. Traditional thought has suggested that the rate of development of longissimus muscle area, intramuscular fat and external fat is the same for all types of beef cattle. However, because there is considerable variation between breeds and breed combinations for carcass traits, this may imply that there are differences in the rate of development of these traits. Because these biological type differences may exist, the same sorting methods for animals intended for value-based marketing programs usually do not apply to all types of cattle. Consideration needs to be paid to each biological type's growth and development pattern in order to accurately and economically predict their performance. Tissues of the body are known to develop in the order of bone, muscle, and finally fat (Aberle et al., 2001). With respect to body fat deposition, subcutaneous is first, inter-muscular second, and intra- muscular third. For one biological type, marbling may begin immediately after subcutaneous fat development has commenced, in another, marbling still may begin immediately after subcutaneous, but at a much slower and unnoticeable rate. This lends evidence to the idea that the relationship between the deposition curves of the major fat depots is not constant (Aberle et al., 2001).

Bruns et al. (2004) showed that subcutaneous fat thickness increased in a quadratic fashion for 85 Angus steers that were backgrounded for 70 days and scanned at 28 day intervals until slaughter, which is in contrast to the results reported by Brethour (2000), who reported an exponential increase. This contrast between these two studies is mainly due to Bruns et al., (2004) relating fat thickness to carcass weight, while Brethour (2000) related fat thickness to days on feed. Brethour (2000) reported that earlier in the finishing phase marbling was developing at a greater rate than back fat, however, towards the end of the finishing phase, back fat was increasing at a faster rate than marbling. Bruns et al. (2004) showed that marbling is an intrinsic component of growth developing throughout an animal's life in Angus steers slaughtered serially at 45 to 55 day intervals. The intramuscular fat content of the longissimus muscle increased linearly, similar to the increase found for marbling scores when regressed as a component of growth over hot carcass weight. Van Koevering et al. (1995) showed linear increases in fat depth and longissimus muscle ether extract for 256 British and Continental cross steers slaughtered at 2-wk intervals beginning at 105 days on feed; however, the duration of growth may have been too short to identify the inflection point of subcutaneous fat growth. Trenkle (1998) expressed back fat accretion rates of Charolais cross feedlot steers as an exponential growth equation and reported that coefficients for this function were affected by hip height and initial fat cover. Camfield et al. (1997) slaughtered British-Continental crossbred steers at the beginning of the feeding period and after 30, 60, and 90d on feed. Marbling scores increased linearly from practically devoid$^{90}$ in the initial group to slight$^{68}$

at day 90. This rate of increase was much more rapid than that observed by Brethour (2000). A relationship between breed type and the back fat rate coefficient also has been observed (Brethour, 1988). With fat rate coefficients higher for small framed, earlier-maturing breeds. To date, no studies have sequentially recorded growth and development data of carcass traits during the feeding period for Brahman derivative breeds. Given their considerable differences in performance and producer perceptions, data need to be collected on these types of cattle to quantify and track their development from early in the feeding period until slaughter.

Predicting Carcass Endpoints

Generating models to predict certain endpoints through the use of ultrasound requires accurate equipment as well as a thorough understanding of the rate of development of the traits measured. The structure of models may differ from study to study given logistics of breed type, prediction period, equipment used, etc. In most studies, prediction models generated from the collection of repeated ultrasound measurements have been used to estimate traits such as marbling, hot carcass weight, back fat, percent retail product and percent retail product weight. These traits have the greatest impact on carcass value in most grid marketing formulas used in the industry today. Of the models generated to predict hot carcass weight from live ultrasound measures, the model proposed by Hassen et al. (1999) showed that live weight accounted for a large proportion of the variation (66 to 73%). Hip height displayed a strong correlation with hot carcass weight, but did not provide a sufficient reduction in the partial sum of squares to warrant its inclusion in all the hot carcass weight final models.

In that study, the final model with the largest $R^2$ value (0.77) for predicting hot carcass weight included the variables of back fat, longissimus muscle area, and live weight with the respective regression coefficients of -6.575 kg, .4578 $cm^2$, and .5622 kg. Hassen et al. (1997) found a slightly different model for predicting hot carcass weight. In this model back fat, longissimus muscle area, live weight, hip height and intramuscular fat percentage were used. In both of these studies, the predictive power of the two models increased (0.56 to 0.77 and 0.47 to 0.79) as the time from scanning session to the slaughter date decreased.

Predicting final quality grade has proven to be a difficult task to many researchers. Many factors can influence the accuracy of the prediction, from the software used to outside factors that affect the animal later in the feeding period. Additionally, the point during the feeding period at which the cattle are scanned is a major factor. Like the prediction of other compositional traits, the earlier the measurement is taken in the feeding period, the less accurate the prediction will be. Rouse et al. (2000) ultrasound evaluated Angus and Simmental-sired steers at 90, 46, and 6 days prior to slaughter for measurements of external fat thickness and percent intramuscular fat that were used to predict carcass fat thickness and quality grade. The equations constructed for carcass quality grade showed $R^2$ values of 0.35, 0.41, and 0.51 with scan data taken at the 90, 46, and 6 day intervals, respectively. The equations constructed to predict carcass fat thickness provided similar results as well. Explanatory values of 0.29, 0.52, and 0.52 were observed for equations taken from scans at the 90, 46, and 6 day intervals prior to slaughter. The researchers stated that additional factors such as hip height, breed type, and other environmental and management factors need to be included to attain a more accurate model.

Traditional models to predict retail product from the use of live animal measurements have generally fallen into two categories; those that predict the percentage of retail product and those that predict the weight of retail product. Greiner et al. (2003) found that most of the variation in percent retail product was explained by ultrasound back fat taken 5 days prior to slaughter with an $R^2$ value of 0.54 when used alone on calf crops from the Cycle V of the USDA-ARS Germplasm Evaluation program. Ultrasonic rump fat was the second variable to enter the model and increased the $R^2$ value to 0.58. Back fat was also the first to enter the model when predicting retail product weight. Alone, ultrasound back fat and rump fat explained less than 5% of the variation in retail product weight. However, when back fat was combined with live weight, the $R^2$ value increased to 0.78, as compared to using live weight alone to predict retail product weight ($R^2 = 0.66$). Although a significant variable for the prediction of retail product weight, rump fat explained <1% of the variation after live weight, back fat, and longissimus muscle area were included in the model. Like Greiner et al. (2003), Tait et al. (2005) showed that ultrasound back fat thickness taken within one week before slaughter was the first variable to enter their model for predicting percent retail product by accounting for 32% of the variation on Angus, Limousin, and Simmental crossbred steers. Ultrasound longissimus muscle area (9.2%), live scan weight (3.2%), and the area of the gluteus medius anterior to the reference point (1.3%) were additional variables included in a model accounting for 46% of total variability. Ultrasound percent intramuscular fat was included later, but only increased the $R^2$ value to 0.48. Hassen et al. (1997) found higher

$R^2$ values when predicting retail product weight then when predicting percent retail product when the same explanatory variables were used. In both predictions, ultrasound back fat, ultrasound longissimus muscle area, live weight, hip height, ultrasound intramuscular fat, and a final component of age were used. Both of these models showed increasing $R^2$ values as each scanning session was conducted closer to the kill date. A breed composition covariate was used, but accounted for a 3% increase in $R^2$ value when predicting retail product percent and a 0% increase when predicting retail product weight. The final model for predicting percentage retail product showed an $R^2$ value of 0.48 and the final model for retail product weight showed an $R^2$ value of 0.76.

### Alternative Marketing Avenues

Today there are multiple pricing structures for selling slaughter ready cattle. For many years the norm was to sell all cattle on a live weight basis. Later a dressed weight basis gained popularity, and, currently there is a strong increase in the number of cattle that are marketed on a grid formula. All of these methods are still widely used; however, price variability occurs in all of them, and this variability can be decreased with increasing amounts of knowledge about the cattle marketed, i.e. breed type, ultrasound data, pedigree data. Live weight pricing refers to an average price paid for a lot of cattle before slaughter. Dressed weight pricing refers to prices paid for carcasses based upon their carcass weight and quality grade. Grid pricing involves a system in which animals are valued individually based upon carcass characteristics. This pricing structure gives premiums and discounts for performance in quality grades, carcass weights, yield grades, and other packer measurements. Fuez et al. (1993) investigated price distributions associated with marketing fed cattle using live, dressed, grade, and yield. They concluded from observations on 340 steers that simulated profits from marketing cattle live were statistically lower than the other methods mentioned, where as marketing the steers on a yield or quality grade basis proved statistically similar results. Fuez et al. (1999) observed the implications of pricing cattle on show list, pen level, and individual animal pricing methods (two separate packer grids) for 85 pens of fed cattle. The study was conducted for three different time periods with different market prices and choice-select spreads. He found that the mean price tended to increase in going from live weight ($813.19) to dressed weight ($818.90) to grid pricing ($824.58). Also, revenue variability on an individual animal basis increased with grid pricing.

Shroeder and Graff (2000) showed that when 71 pens comprising 11,703 head were sold on a live weight basis, the average price was $64.60/cwt with a standard deviation of $1.78/cwt. If all cattle were sold on a dressed weight basis, they would have brought an average price of $67.16/cwt (converted to a live weight basis) with a standard deviation of $1.84/cwt. When cattle were priced using the packer grid, the average was $66.90/cwt (live weight price) with a much larger standard deviation than either live or dressed weight pricing of $3.91/cwt. Grid pricing resulted in the highest price paid for high quality grade, better yield grade, and not excessively heavy or light carcasses. Only about half the cattle evaluated would have received the highest price if sold on a grid. This is not an indictment against grid pricing; rather it is a reinforcement that grid pricing leads to more price dispersion associated with cattle quality than live or dressed weight pricing. In the same study, if cattle could have been sorted prior to slaughter and sold to the option offering the highest price, an approximately $15/animal increase in profit could have been achieved relative to selling cattle using the next highest price method (dressed weight), $18/head increase over selling on a grid, and $35/animal more than live weight pricing. This indicates the substantial economic incentive for producers to understand the kind of cattle they market in order to target cattle to the best pricing opportunity.

For the 11,703 cattle in the study by Schroeder and Graff (2000), figures were presented for the amount of “over-pricing” and “under-pricing” that would have been present if the cattle had been sold by live weight or dressed weight instead of on a grid. For 3,650 head, the grid price was less than the live weight price by an average of $2.90/cwt or $36.80/head. This implies that if the cattle were sold on a live weight basis, they would have received $36.80/head more than they were actually worth relative to carcass characteristics. For the remaining 8,053 animals, the grid price exceeded the live weight price and if the animals were sold live rather than on a grid they would have received $40.04/head less than they were worth. There were similar pricing errors present for dressed pricing relative to grid pricing. Ward et al. (1999) summarized that closed sorting of cattle can reduce the incidence of heavy-weight and light-weight discounts and, to some extent, careful handling may reduce the incidence of dark cutters. Perhaps the adoption of ultrasound or other imaging technology at the feedlot can improve management of yield grades by helping signal when to market cattle to reduce the incidence of yield grade 4s and 5s. Pedigree information may also help target higher quality grades of beef, thus reducing risk associated with varying select and standard discounts.

Optimal Sorting

Sorting animals prior to slaughter can decrease variability associated with any marketing system. Sorting information can take on many forms such as ultrasound data, pedigree data, feeder calf grades, expected days on feed, breed type, and prediction equations. Initial feeder calf grades and weights are perhaps the most common pieces of information available on cattle once they enter the feedlot. Considerable research has been performed analyzing the impact of feeder calf grades and their connections with performance, however, limited information is available on their use in predicting final animal and carcass value. Trenkle (2001) sorted 480 Angus steer calves on frame size and backfat before entering the feedlot to assess their relationships with carcass value. Large framed steers brought an average of $894.66 while small framed steers received $834.49 on a commercial carcass marketing grid. The larger framed steers did have a greater final grid value that was due in large part to heavier carcasses and the smaller framed steers did have a greater percentage of yield grade 1s and 2s (60.7% vs. 54.1%) and a higher percentage of average and low choice carcasses (80.1% vs. 73.4%). In a study by Groeschke (2005), initial frame and muscle score did have significant effects on initial steer value, but not on carcass value in data from the 2003-2004 Texas A&M Ranch to Rail South program. Ranch of origin and sire breed type, however, showed to be significant predictors of carcass value, initial weight, and feedlot performance. In one of the few studies examining the economic use of ultrasound technology, Koontz et al. (2000) showed that sorting cattle in the feedlot with the use of ultrasound 80 days prior to harvest increased profitability and efficiency. They concluded that a gain of $11 to $25/animal could be achieved by sorting before harvest. This study also showed that simple sorting regimes using only a few factors returned more dollars than more complex regimes.

Within the current project the specific research objectives were to 1) study the connections observed in early feedlot cattle measures and carcass performance among known sire groups in Beefmaster steers, 2) investigate prediction models where early measures of ultrasound data, initial feeder calf grade, and background (sire and ranch) information could be used individually and jointly to explain variation in carcass component traits and carcass value, and 3) calculate values for individual sires based on progeny performance under the actual carcass grid pricing system as well as alternate grid pricing systems.

# MATERIALS AND METHODS

## Animals, Feeding Management and Marketing

One hundred and sixty purebred Beefmaster steers were received at a commercial feedyard in South Texas with November 11, 2004 as day one of the experiment. The steers originated from 5 different owners with 4 being from Texas and 1 from Georgia. Of the 160 steers, 68 possessed pedigree information and 92 did not. The animals were fed in three separate pens with all cattle from same owners fed in the same pen. When the steers began the feeding period they were administered a starter ration of 32.23% corn for 14 days, a step-up ration of 42.73% corn for 45 days, and a finishing ration of 59.48% corn fed for the remainder of the period. The length of the feeding period was not pre-set, thus the steers were fed and marketed according to the feedyard manager's typical marketing protocol. Over the course of the project 5 steers died, all of which were attributed to bloat. At arrival, all steers were implanted with Synovex S and at day 57 of the trial, 85 steers were given an additional growth promoting implant (Synovex S). The remaining 71 head were not given an implant. These animals began the project an average of more than 100 lbs heavier than the rest of the group, and because of this, they were projected to be marketed within 100 days of this date. The guidelines of the major marketing outlet that all of the animals were to be marketed through stated that no animal can qualify for the marketing program if it has received a growth enhancing hormone within 100 days prior to slaughter. The steers were grouped into two separate kill groups and slaughtered at a Beef Processor in Corpus Christi, TX. The steers were designated to be slaughtered by the feedyard manager when they were observed to possess approximately 1 cm of back fat. The first group was slaughtered on May 16th 2005 (179 days on feed) and contained 101 animals. The second group was harvested on June 21st 2005 (215 days on feed) and contained 54 animals.

Data Collection

On day one (Scan 1), as well as on days 57 (Scan 2), 112 (Scan 3), and 154 (Scan 4) of the project, all steers were evaluated for live compositional measurements by a certified ultrasound technician using an Aloka 500V ultrasound machine and a 17cm 3.5GHz probe. The measurements collected were 12th rib fat thickness (UFAT), longissimus muscle area between the 12th and 13th rib (UREA), intramuscular fat percentage between the 12th and 13th ribs (UIMF), as well as rump fat thickness (RUMP) and gluteus medius depth (GM). Live weights (WT) were taken at each scanning session and on day one, USDA feeder calf frame (FRAME) and muscle scores (MSCORE) were assigned to each animal (USDA). Technical problems with the scales prohibited the collection of live weights on 71 of the steers on day 57. At day 179 and 215, 101 and 54 of the steers, respectively, were harvested at Sam Kane's Beef Processors in Corpus Christi. At harvest, sequence numbers were recorded and brisket tags were assigned to each carcass by Texas A&M University (TAMU) Animal Science graduate students. Carcass measurements were collected after a 48 hour chill by Texas A&M University Meat Science personnel as well as the Smart Vision BeefCam®. The carcass measurements collected by TAMU personnel were ribeye area (REA), external fat thickness over the ribeye (FAT), marbling degree, which was later converted to a marbling score (MARB) (Figure 1), hot carcass weight (CWT), percent kidney pelvic and heart fat (KPH), and adjusted preliminary yield grade (AdjPYG). Measurements collected by the Smart Vision BeefCam® were REA, CWT, FAT, BeefCam® Score (BCSCORE), and Nolan Ryan Tender Aged Beef Certification approval (NRCERT). BCSCORE measured each carcass for ribeye area, fat thickness, and pH.

The carcass data on each steer was used to calculate its Yield Grade (YG), with the equation:

YG = 2.5 + (2.5*Adjusted Fat Thickness) + (0.2*Kidney Pelvic Heart Fat Percentage) + (0.0038*CWT) - (0.32*REA).

Each carcass' Percent Retail Product (Epley et al., 1970) was calculated by using the equation:

Epley = 77.44 – (0.04111*CWT) + (0.13*REA) + (2.78*FAT) – (1.51*KPH).

End values were assigned to each carcass by three different methods. Live Value (LiveValue) was calculated by multiplying the animal's final live off feed weight by the current market price per .45 Kg for finished steers on the day that the carcasses were graded. Carcass Value (Cvalue) was determined by multiplying the carcass weight by the price per .45 Kg for current Choice or Select carcasses, in that Choice carcasses received a separate price per .45 Kg than Select carcasses. A final end value was created with a simple grid pricing system. Three separate grids were created based on three different Choice/Select spreads. The base price for all three grids was the same and was calculated by taking the average between the prices for Choice carcasses on the first and second kill dates. The first grid (GridA) contained a Choice/Select spread of $5.00, the second grid (GridB) contained a spread of $15.00, and the third grid (GridC) contained a spread of $25.00. These different choice/select spreads were chosen to represent the variation observed between choice select prices throughout the year.

## Data Analysis

Initial values were calculated for all steers at the beginning of the project. Historical auction price data were obtained from the Texas Department of Agriculture Market News in Amarillo, TX (TDA). Data, within the week of November 11, 2004, for three different auction sales located within 100 miles from the project site were used to calculate the initial values. The average price slide across the three sales was determined within frame and muscle combinations for each weight range of feeder calves reported. The average slides found at the three different auction sales for the steer weight ranges of 500 – 600 lb, 600 – 700 lb, and 700 – 800 lb was $0.10, $0.10, and $0.10, respectively. The average base price for each weight range of steers across the three sales was also determined. All steers were then grouped according to the frame and muscle scores assigned to them on day one, and prices were estimated using the average feeder calf prices and slides reported over the three sales from the following example for steers in the 500 – 600 lb range:

$$\text{Initial Value} = ((\text{Wt1} - 500)*-0.10) + 109.33$$

The initial data analysis was performed on the total group of 155 steers. Simple linear correlations involving Wt, UREA, UFAT, UIMF, RUMP, GM, ADG, REA, FAT, MARB, CWT, YG, Epley, Cvalue, LiveValue, GridA, GridB, and GridC were calculated using the correlations procedure (PROC CORR) of SAS 9.0. Frequency procedures in SAS 9.0 were used to determine the incidence of NRCERT by Ranch, the number of carcasses grading Choice and Select within each Ranch, and the frequency of Sires per Ranch. Ultrasound measurements at scan sessions 1 and 3 were used to predict carcass measurements only when all 155 steers were evaluated. At scan session 2, problems were identified with the scales and thus weights were not able to be collected on the non-sire identified steers. Scan 4 was not used in the total analysis of the 155 head in that a significant number of the steers were scheduled to be slaughtered within a few weeks of the fourth scan session. These steers were not ultrasound evaluated because of the potential risk of bruising that could have occurred that close to harvest.

Before regressions were performed, Variance Inflation Factors (VIF) were analyzed in (PROC REG) of SAS 9.0 to determine the degree of multicollinearity between the ultrasound measurements at sessions 1 and 3. A VIF value of greater than 12 was used to indicate multicollinearity. According to the results, no multicollinearity was found.

Within the initial data analysis on the total group of 155 steers, the predictive power of using only the “traditionally collected” measurements of Wt, FRAME, and MSCORE as independent variables was evaluated (Phase 1) and used to predict ADG, REA, FAT, MarbScore, CWT, YG, Epley, Cvalue, LiveValue, GridA, GridB, and GridC. Later Mallows CP statistic, adjusted $R^2$ values, and logistics of the models were used to select the best model (Phase 2), containing only WT, UREA, UBFAT, UIMF, Rump and GM, to predict the traits REA, FAT, MarbScore, CWT, YG, Epley, Cvalue, LiveValue, GridA, GridB, and GridC (Tables 1 – 11). The number of independent variables in each model, containing only ultrasound data and weights, ranged from 1 to 6. Once each of model, containing only scan session data, to predict each trait was chosen, the categorical variables of Ranch, FRAME, MSCORE were added and the models evaluated. From this analysis, a final model containing Ranch, FRAME, MSCORE, and scan session data was selected (Phase 3) for each trait at each scan session.

The final independent variable evaluated was Sire. Data from all four scan sessions were available for use for the sire identified steers but not for the non-sire identified steers. After the variables Ranch, FRAME, MSCORE were added, an additional analysis was performed on only the 63 steers with known sires (Phase 4), with sire nested within Ranch as an additional variable to help predict the traits ADG, REA, FAT, MarbScore, CWT, YG, Epley, Cvalue, LiveValue, GridA, GridB, and GridC. The phases of model analysis are as follows: Phase 1 contains Wt, FRAME, and MSCORE only, Phase 2 contains scan session data only, Phase 3 is a combination of Phases 1 and 2 plus Ranch, and Phase 4 contains the exact model from Phase 3, but with Sire nested within Ranch. Least squares means for individual sires nested within ranch were calculated, but no tests among sires were conducted.

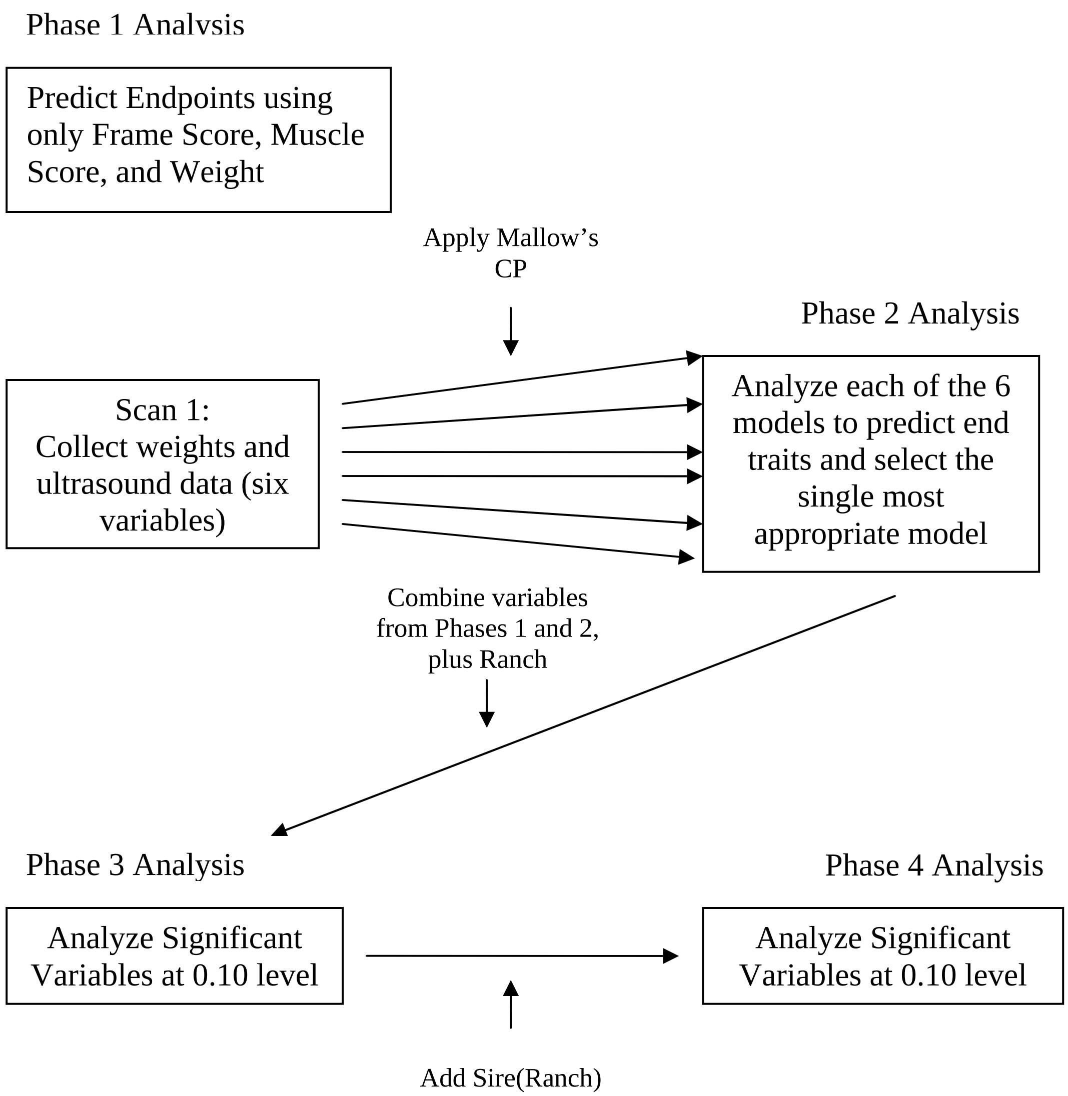


Figure 1. Steps taken to develop prediction equations for end traits from data taken at scan session 1 (steps repeated for sessions 2, 3, and 4).

# RESULTS AND DISCUSSION

General Statistical Summaries

At scan session 1, frame and muscle scores were taken, along with weights, to establish initial feeder calf values. Table 12 shows the mean initial value for all steers at the beginning of the project to be \$90.55/cwt, with a maximum value of \$107.66/cwt and a minimum value of \$69.00/cwt. Weights taken at each session increased substantially. At Wt1, steers ranged in weight from 226.8 – 435.45 kg, with mean of 324.21 kg. Means for Wt2 and Wt3 were 388.04 and 462.37 kg, respectively. At the final session the mean for Wt4 was 512.45 kg with a minimum of 390.09 kg and a maximum weight of 657.72 kg. The final OffWt mean was 560.20 kg and had a maximum and minimum value of 396.90 and 719.66 kg, respectively.

Means for UREA at scan sessions 1 – 4 (Table 13) were 52.18, 63.68, 75.94, and 80.07 $cm^2$, respectively. The minimum UREA values for scan session 1 and 4 were 39.39 and 53.93 $cm^2$, respectively, while the maximum values were 65.21 and 101.01 $cm^2$, respectively. Steers began the project with an average UFAT1 value of 0.25 cm and finished the project with an average UFAT 4 value of 0.65 cm. The largest and smallest UFAT1 measurement proved to be 0.15 and 0.74 cm. At session 4, the leanest steer had 0.15 cm of back fat while the fattest steer showed a UFAT4 value of 1.52 cm. UIMF1 in steers beginning the project fostered a mean of 2.04%, with the highest and lowest marbled steers at 0.62% and 3.72%, respectively. At sessions 2 and 3, steers showed an average UIMF of low select with values of 2.38% and 2.88%, respectively. The highest marbled steer at session 4 contained a UIMF4 figure of 4.22%, while the lowest marbled steer contained 1.68%.

Table 14 contains the summary values for Rump and GM measurements. Mean Rump measurements were larger than UFAT measurements at each scan session. Means for Rump values at sessions 1 – 4 were 0.40, 0.77, 0.97, and 1.09 cm, respectively. Maximum Rump thicknesses at each session were 0.81, 1.52, 1.68, and 1.80 cm,, respectively, while the lowest values were 0.18, 0.36, 0.36, and 0.58 cm, respectively. Average Gluteus Medius depths for scan sessions 1 – 4 were measured at 7.31, 8.04, 8.32, and 9.16 cm, respectively. At session 4, the thickest GM4 was calculated at 10.87 cm and the thinnest at 7.44 cm.

Average values calculated for CWT, REA, and FAT (Table 15) were 354.32 kg, 80.33 $cm^2$, and 0.88 cm, respectively. Minimum and maximum values for the same carcass traits showed to be 251.29 and 455.18 kg, 55.47 and 103.20 $cm^2$, and 0.25 and 2.54 cm, respectively. The average quality grade for all steers was high select at a MarbScore of 463.94. The smallest MarbScore was measured at 350 and the maximum measured at 650. YG ranges were quite large with the lowest calculated to be 1.49, the highest at 5.04, and the mean at 3.03. The average Epley value was estimated at 67.59%, while the lowest and highest percentage was at 41.65 and 72.82%, respectively.

Table 16 displays calculated summary statistics for all end values. The averages for Grid prices A, B and C, decreased consecutively at $1,039.25, $982.90, and $927.81, respectively. The highest valued carcass in each grid was $1,225.80, $1,223.41, and $1,223.41. Lowest priced carcasses were substantially less in grids A ($747.90), B ($692.50), and C ($637.10), due in most part to the increasing choice/select spreads.

LiveValues and Cvalues placed more emphasis on weight and showed mean prices of $1074.26 and $1084.89, respectively. Maximum and minimum prices for each pricing system were $1408.07 and $763.12, and $1535.17 and $758.32, respectively.

Correlation Coefficients

Measurements taken at each scan session included the ultrasound measurements UREA, UFAT, UIMF, Rump, and GM, as well as individual weights. At scan session 1 (Table 17), Wt1 was significantly correlated to Rump1 ($r = 0.4028$; $P < .0001$) and GM1 ($r = 0.2982$; $P = 0.0004$). As UREA1 increased UIMF1 decreased ($r = -0.1537$; $P = 0.0570$), and surprisingly UREA1 was not related to GM1 ($r= 0.0735$; $P = 3639$). A moderate relationship was seen between UFAT and UIMF ($r = 0.2428$; $P = .0024$) and UFAT and Rump1 ($r = 0.2649$; $P = 0.0018$). Finally a small, yet significant, correlation was observed between Rump1 and UIMF1 ($r = 0.1653$; $P = 0.0544$).

Scan session 2 (Table 18) showed Wt2 to be significantly correlated with UREA2 ($r = 0.6137$; $P < 0.0001$), UFAT ($r = 0.5512$; $P < 0.0001$), and UIMF2 ($r = 0.5871$; $P = <0.0001$). A stronger coefficient than at session 1 was observed between UFAT2 and UIMF2 ($r = 0.3471$;$P <0.0001$). At this session UREA2 proved to be significantly related to GM2 ($r = 0.2566$; $P = 0.0018$). As Rump2 increased, UIMF2 increased ($r = 0.2739$; $P = 0.0008$).

Scan session 3 (Table 19) showed Wt3 as significantly related to UREA3 ($r = 0.5256$; $P < 0.0001$), UFAT3 ($r = 0.4941$; $P < 0.0001$), and Rump3 ($r = 0.5892$; $P < 0.0001$). As UREA3 increased, UFAT3 and Rump3 increased as well ($r = 0.2211$; $P = 0.0057$) and ($r = 0.2513$; $P = 0.0035$), respectively. Rump3 was strongly correlated to

UFAT3 (r = 0.5958; P < 0.0001), as UIMF3 was moderately related to Rump3 (r = 0.3041; P = 0.0004).

The fourth and final scan session (Table 20) showed much of the same results as the previous sessions. UREA4 (r = 0.5065; P < 0.0001), UFAT4 (r = 0.5949; P < 0.0001), Rump4 (r = 0.5473; P < 0.0001), and GM4 (r = 0.3283; P = 0.0043) were all significantly related to Wt4. Unlike previous sessions, UREA4 was not significantly related to UFAT (r = 0.1555; P = 0.1577) and Rump4 (r = 0.1402; P = 0.2206). UFAT4 did show a small correlation with UIMF4 (r = 0.2315; P = 0.0341).

As anticipated, most correlation coefficients grew stronger between each consecutive scan session and final carcass traits. Carcass Weight showed strengthening coefficients with Wt1 (r = 0.5793; P < 0.0001) (Table 21), through Wt4 (r = 0.7903; P < 0.0001) (Table 13). REA showed increasing significant relationships with UREA1 (r = 0.1463; P = 0.0701) (Table 21) through UREA4 (r = 0.7514; P < 0.0001). Our results agree with those of (Waldner et al., 1992) and (Perkins et al., 1997). In both studies, ultrasound measurements were taken within one week prior to slaughter, however, coefficients were found between ultrasound ribeye area and carcass ribeye area of 0.43 to 0.95. Correlations became stronger between FAT and UFAT as scan sessions were performed closer to the slaughter date. Scan sessions 1 – 4 yielded correlations between FAT and UFAT of 0.29, 0.55, 0.68, and 0.70, respectively. Previous research of Perkins et al. (1992, 1997) found coefficients as high as 0.76 and 0.93 on purebred Angus, commercial Brown Swiss, and Mexican crossbred steers scanned within two weeks prior to slaughter. Rouse et al. (2000) found similar results on commercial feeder steers of varying *Bos taurus* breed type scanned at 90, 46, and 6 days prior to slaughter with back fat coefficients of 0.53, 0.64, and 0.72, respectively.

As Rump1 increased, calculated YG increased ($r = 0.4350$= $P < 0.0001$) and Epley decreased ($r = -0.3223$; $P< 0.0001$). Each consecutive session showed Epley to be significantly yet negatively correlated to Wt1 ($r = -0.3977$; $P < 0.0001$) (Table 21), Wt2 ($r = -0.2896$; $P = 0.0075$) (Table 22), Wt3 ($r = -0.3892$; $P < 0.0001$) (Table 23), and Wt4 ($r = -0.3861$; $P = 0.0003$) (Table 24). MarbScore showed to be significantly related to UIMF at each session, with the strongest coefficient observed at scan 4 (Table 24) ($r = 0.6567$; $P < 0.0001$). Our results agree with previous studies, but coefficients appear slightly lower. Devitt and Wilton (2001), Perkins et al. (1997), and Brethour (2000), indicated correlations between serial ultrasound intramuscular fat measurements and carcass marbling scores of 0.80, 0.69, and 0.85, respectively. It is important to note that in these studies, ultrasound data were taken on animals within two weeks before slaughter. At every scan session in this study, MarbScore was slightly correlated with UFAT. The highest occurred at session 4 ($r = 0.18$), indicating that UFAT is not a strong indicator of future quality grade.

Correlations among carcass traits are presented in Table 25. Carcass Weight proved to be moderately correlated with REA ($r = 0.3294$; $P < 0.0001$), FAT ($r = 0.4845$; $P <.0001$), and YG ($r = 0.4796$; $P < 0.0001$). Weaker, yet significant, coefficients for CWT were seen with MarbScore ($r = 0.2212$; $P = 0.0057$) and KPH ($r = 0.3061$; $P = 0.0001$), while a negative coefficient was observed with Epley ($r = -0.5049$; $P < .0001$). The negative correlation with Epley is attributed to the negative weighting of carcass weight in the Epley equation. REA showed a negative correlation with FAT ($r = -0.1149$;

P = 0.1545) and YG (r = -0.5194; P < .0001) and a small non-significant coefficient with MarbScore (r = 0.0838; P = 0.2994). REA did have a significant yet low positive correlation with KPH (r = 0.1496; P = 0.0631) and Epley (r = 0.2457; P = 0.0021). Evidence that FAT increased YG was shown by the strong coefficient (r = 0.7769; P < 0.0001). FAT was also significantly correlated with MarbScore (r = 0.3122; P < 0.0001), KPH (r = 0.4132; P < 0.0001), and Epley (r = -0.5994; P < 0.0001). A negative relationship was observed between MarbScore and Epley (r = -0.2095; P = 0.0089). Weak relationships existed between MarbScore and YG (r = 0.2357; P = 0.0031), and MarbScore and KPH (r = 0.3211; P < 0.0001). KPH was also observed as significantly effecting YG (r = 0.3657; P < 0.0001) and Epley (r = -0.3933; P < 0.0001). The final correlation between carcass traits was found as increased YG resulted in a decreasing Epley (r = -0.6904; P < 0.0001).

All measures of carcass end values were primarily influenced by a weight increment. Thus, the correlation coefficients between all end values and each weight taken at each scan session were significant and increased in strength closer to time of harvest (Tables 26 - 29). Table 26 showed UREA1 not to be significantly related to any end value, while UIMF1 was significantly correlated to GridB (r = 0.1752; P = 0.0297), GridC (r = 0.2058; P = 0.0104), and Cvalue (r = 0.2096; P = 0.0093). This is most likely due to these end values being partially determined by quality grade. Surprisingly, Rump1 proved to be significant, yet low, in its relationship to all end values of GridA (r = 0.2146; P = 0.0118), GridB (r = 0.2111; P = 0.0133), GridC (r = 0.1876; P = 0.0281), LiveValue (r = 0.3491; P < 0.0001), and Cvalue (r = 0.3824; P < 0.0001). Table 27 displays UFAT2 to be significant in its relationship with GridA (r = 0.3194; P < 0.0001), GridB (r = 0.3207; P< 0.0001), and GridC (r = 0.2937; P = 0.0002). In the same table, larger UREA2 increased LiveValue (r = 0.3691; P < 0.0001) and Cvalue (r = 0.3599; P < 0.0001). Significant low to moderate correlations were observed between UFAT2 and all end values. This is most likely due to the increasing amounts of back fat contributing to an increase in CWT, thus increasing end values. In Table 28, all ultrasound and weight measurements taken at scan session 3 proved to be significantly correlated with all end values. Ultrasound ribeye area taken at session 3 was moderately to strongly correlated with all end values, with the lowest coefficient being with that of GridC (r = 0.3609; P < 0.0001). At scan session 3, GridA was shown to be affected most by Wt3 (r = 0.5660; P < 0.0001), second by UREA3 (r = 0.4642; P < 0.0001), and the least by UIMF (r = 0.1642; P = 0.0435). Cvalue was most the most significantly related to Wt3 (r = 0.7564; P < 0.0001), next with UFAT3 (r = 0.5704; P < 0.0001), and the least with GM3 (r = 0.1473; P = .1000). Even though Cvalue was partially determined by quality grade, the second lowest coefficient was observed between it and UIMF3 (r = 0.2280; P = 0.0044). Table 29 reveals much of the same results as the previous session. All correlations between all measurements taken at session 4 with all end values were significant, except UIMF4 and LiveValue (r = 0.0766; P = 0.4882), and UIMF4 and Cvalue (r = 0.1227; P = 0.2689). For Cvalue, this may indicate that most steers reached a plateau in their intramuscular fat development before scan session 4. This would explain why UIMF4 did not significantly affect Cvalue. GridC was shown as being most highly correlated with UIMF at session 4 (r = 0.5071; P< 0.0001). This could be due to GridC having the largest choice/select spread, thus having the greatest dependence upon quality grade. Like grids B and C, Wt4 was very significant in its effects on GridC (r = 0.4261; P <

0.0001). GridA was shown as being approximately equal in being affected by Wt4 ($r = 0.6580$; $P < 0.0001$) and UREA4 ($r = 0.6171$; $P < 0.0001$).

Prediction Equations for Carcass Measurements

Percent Retail Product (Epley)

In predicting Epley (Table 30), the most important variable proved to be Wt taken at each scan session. Each final model from each scan session contained Wt regardless of any additional independent variables. In Phase 1 of the analysis, the variables FRAME, MSCORE, and Wt were not the optimal combination of independents to account for Epley. At each of the four sessions, Wt was significant in Phase 1 equations, however, the highest $R^2$ value was reported at 0.18. This proved that utilizing only the traditional data, FRAME, MSCORE and Wt was not satisfactory and thus more information was needed to explain percent retail product for these cattle. The second most significant variable was Rump taken at each scan session. Unlike Greiner et al. (2003), who found back fat to be the single most vital independent variable in the prediction of percent retail product, Wt and Rump proved to be the most important variables measured during each session in this study. Ultrasound data and weights alone explained a small amount of the variation seen in Epley, with the maximum $R^2$ value being 0.55 at session 4. When the variables from Phases 1 and 2 were combined, $R^2$ values quickly began to rise. However, the greatest rise in $R^2$ value occurred once Sire(Ranch) entered each of the four final models. At scan session 1, the model from Phase 4 accounted for 63% of the variation seen in Epley. Within this model the significant variables at the $P < 0.10$ level proved to be Ranch and Rump1. Even more variation was accounted for at scan session 4 with the model from phase 4 which posted an $R^2$ value of 0.80. Unlike Greiner et al. (2003) and Tait et al. (2005), this study showed Wt and Rump to be more vital independent variables in predicting percent retail product rather than back fat. This analysis also highlights the importance of including Ranch and Sire in the model to boost $R^2$ values and to give a more complete and accurate estimation of percent retail product predicted in this study. It is also important to note that FRAME and MSCORE did not significantly contribute to the prediction of Epley at any scan session. This could be due to the fact that frame and muscle scores alone do not depict yield grades or external fat thicknesses.

Yield Grade (YG)

Yield Grade results are in Table 31; Wt, FRAME, and MSCORE collectively were not sufficient predictors of YG. These results are similar with those found for Epley. Even though Wt and MSCORE were significant variables in each of the four equations in Phase 1, explanatory values were not high enough to justify them as the only information required to predict YG. More information was needed to account for a higher percentage of the variability found in YG. Using only scan session data (Phase 2) to predict YG fostered different models for each scan session. However, the two measurements included in each of the four models for Phase 2 due to the level of their significance were Rump first and UFAT second. At session 1, using scan data alone did not account for much variation seen in carcass YG. Session 1 provided the model YG = Wt Rump1, which only provided an $R^2$ value of 0.25. Mallow’s CP analysis recommended the equation YG = Wt3 UFAT3 Rump3 as the best prediction model at scan session 3 when only using scan data. This equation provided an $R^2$ value of 0.41. At session 4 using the scan variables UFAT4, Rump4, Gm4, and UREA4 resulted in an $R^2$ of 0.47. Like Epley, including Ranch, FRAME, and MSCORE accounted for more disparity in YG, but only slightly. Still, Ranch was significant at each session when estimating YG along with Rump. Incorporating Sire(Ranch) explained more variation in YG at each scan session. At session 1, including Sire(Ranch) increased the $R^2$ value by 27% to 0.61. At scan session 2 the $R^2$ value rose 38% to 0.69 by the inclusion of Sire(Ranch). This inclusion yielded the same results at sessions 3 and 4, with an increase of 23% from 0.58 to 0.81 at scan 4. The final model at session 4 included the independent variables of Sire(Ranch), Ranch, FRAME, MSCORE, UFAT4, Rump4, Gm4, and UREA4. These results provide evidence that when attempting to estimate YG, a manager should place a considerable amount of emphasis on including pedigree data along with traditional ultrasound measurements as well as Ranch. It is also interesting to note that scan sessions 3 and 4 were conducted almost 103 and 60 days prior to slaughter, and still notable $R^2$ values of 0.76 and 0.81 were achieved.

### Carcass Weight (CWT)

Weight had the greatest influence when forecasting CWT at any scan session in any phase of analysis (Table 32). In Phase 1 of the model analysis, FRAME and MSCORE were not found to be significant as was Wt1 ($P < 0.0001$). In this phase, $R^2$ values increased from sessions 1 through 4 rather moderately with the values of 0.36, 0.42, 0.49, and 0.68, respectively. Although scan session 4 was conducted 60 days before the slaughter date, Wt4 serves as evidence that it can help account for 68% of the variation seen in CWT. With the industry applying such large discounts to carcasses that fall outside the preferred carcass weight range, our results suggest that utilizing Wt as a predictor of CWT can help managers sort out animals that may pose a threat and result in price discounts that could have been avoided. It is important to remember that even though individual animals that have a high potential for CWT discounts can be sorted and managed separately from others, packers in the industry prefer to operate in 40,000 lb load increments. When removing animals that are expected to produce unwanted carcass weights, managers need to be able to group these separated animals into groups that make a complete "load" of animals that can be sold together in one group. At session 1, in Phase 2, utilizing Wt1 alone accounted for 34% of the variation seen in CWT. At session 3, Wt3, UREA3, and UFAT3 were chosen as the best combination of variables to predict CWT, and provided an $R^2$ value of 0.50. The predictive power of scan session measurements increased even more when data from session 4 were used. At this period, Wt4 and UREA4 combined to provide an $R^2$ of 0.70. In the next phase of analysis Ranch, FRAME, and MSCORE were included, and Ranch was found to be significant at every scan session while MSCORE was significant only during session 1. Even with these additional measurements, $R^2$ values did not increase by a significant amount. The models for sessions 1, 3, and 4 increased by only 12%, 8%, and 6%, respectively. After Sire(Ranch) was combined with the final models in phase 3 of the analysis, $R^2$ values increased by a more substantial figure. Session 1 increased by 18%, session 2 by 23%, session 3 by 17%, and session 4 by 10%. These results agree with those of Hassen et al. (1999) who found that live weight accounted for a large portion (66 to 73%) of the variation seen in CWT. This study also found similar results with that of Hassen et al.

(1999) in that back fat, longissimus muscle area, and live weight were found to be an optimal combination of variables as in the final model for scan session 3. Hassen et al. (1997) also showed that fat, longissimus muscle area, live weight, hip height and intramuscular fat percentage were the best predictors of CWT on Red Angus and Simmental-sired progeny. The results of our analysis concur in that Wt, UREA, and UFAT were the most optimal variables for prediction of CWT at each session.

Live Value (LiveValue)

LiveValue (Table 33) was calculated by multiplying the current fat cattle cash price by the shrunk OffWt of each steer. Given that this value is a direct function of weight, Wt at each scan session was the most significant factor to consider when constructing prediction equations for LiveValue in any phase of analysis. For many managers who own cattle in the feedyard gaining access to information such as FRAME, MSCORE, and Wt is a relatively simple task. Fortunately, these three variables are reasonable predictors of final LiveValue, a pricing system still used by many today. Although Wt was the primary significant variable in each of the models within Phase 1, the combination of independent variables was capable of explaining 50%, 59%, 62% and 85% of the LiveValue for each steer at scan sessions 1, 2, 3, and 4, respectively. This indicated that producers and managers could utilize the readily available data of frame and muscle score, as well as current weight, to give them an accurate prediction of the steer's future value on a forecasted LiveValue basis. In Phase 2, using Wt as the only independent variable, 48%, 60%, 61%, and 80% of the differences in LiveValue were accounted for at sessions 1, 2, 3, and 4, respectively. Ranch and MSCORE proved to be significant, along with Wt1, but only increased the $R^2$ value by 5% to 0.53 over the model in Phase 1 of the analysis. At the remaining sessions Wt was the only significant variable in the models. Once Sire(Ranch) was incorporated, explanatory values did increase to slightly higher levels, however, Wt was still the only significant variable in Phase 4 of the model analysis at scan sessions 1 – 4. According to the analysis, additional variables such as Ranch, Frame and Muscle Score, and Sire did not warrant their inclusion into models predicting LiveValue. This calculation of this end value depended entirely upon weight; therefore using Wt alone provided the most optimal predictive model.

<u>Carcass Value (Cvalue)</u>

Cvalue (Table 34) is a derivative of carcass weight and quality grade. Carcasses that graded choice received a separate price from those that graded select. Still, Wt was found to be the single most important factor when predicting Cvalue. Like the equations predicting LiveValue, the combination of FRAME, MSCORE, and Wt in Phase 1 were reasonable forecasters of Cvalue. FRAME and MSCORE proved to be significant when combined with Wt from each scan session. Although Cvalue is primarily a function of carcass weight, its value is also calculated from the designated quality grade. Like LiveValue, $R^2$ values increased substantially as weights from each scan session were combined with FRAME and MSCORE. The explanatory values were similar to that of LiveValue where sources 1, 2, 3, and 4 yielded $R^2$ values of 0.49, 0.62, 0.59, and 0.86, respectively. Marketing harvested fed steers in this form is widely used. It is a relatively simple process and for many loads of steers that are not expected to have discounts in areas such as CWT, marketing them on a Cvalue basis may be a good option for producers. It allows them to profit from the actual pounds of carcass but also to capitalize on the animal's quality grade as well. It should also be noted that accurately estimating future carcass value is partially dependent upon a targeted dressing percentage. Once the steers are slaughtered, a decrease in their dressing percentage could cause lower than expected prices to occur. When using scan session data alone, explanatory values were first observed at 0.47 and increased to 0.80 for scan session 4. The model using only scan session data for session 3 did include the significant variables UIMF3 along with Wt3 ($R^2$ 0.58), however this was the only instance when UIMF was included as a dependent variable. FRAME and MSCORE were found to be significant in explaining Cvalue. In the second phase of model analysis MSCORE along with Wt1 were the two significant variables in a model that provided an $R^2$ value of 0.51. At session three, FRAME was significant, as was Wt3 and UIMF3, however they only increased the $R^2$ value by 5% to 0.63. As expected Sire(Ranch) did increase all explanatory values. However, it was not found to be a significant variable in any of the final models. Wt 1 – 4 were the only significant variables observed even after Sire(Ranch) was included. Like LiveValue, Cvalue is greatly dependent upon Wt for its calculation. It does contain a quality grade component, but in this analysis Wt was found to be the most important measurement to utilize in prediction models at sessions 1 – 4.

<u>Carcass Ribeye Area (REA)</u>

Predicting Carcass Ribeye Area (Table 35) was found to be a difficult task in this study in that the interpretation process of UREA may contain error that inhibits prediction models of the final carcass trait. Like other biological components, the longissimus dorsi muscle can develop at different rates from animal to animal. In Phase 1, the traditional variables of FRAME, MSCORE, and Wt did not do an adequate job of forecasting REA. The highest $R^2$ value was observed at 0.27, which included Wt4. This is most likely due to each steer's individual ability to express different potential for REA. Although some animals may have heavier body weights, at times slightly lighter animals can have larger REA due to their genetic potential for larger REA development. This is why an individual measurement of UREA is the most accurate predictor of final REA. Using scan session data alone was found to be somewhat weak in its ability to predict final REA until session 4. At session 1, UREA1 accounted for an $R^2$ value of only 0.02. At session 2, variables used were UREA2, GM2, and Wt2, still, these variables combined to only explain 22% of the differences observed in REA. At the final session, Wt4 and GM4 were utilized as independent variables and provided an $R^2$ value of 0.61. The inclusion of Ranch, FRAME, and MSCORE increased the predictive power of the models used in phase 2 of the model analysis, but only slightly. At this point, Ranch and UREA were the only significant variables identified in predicting final REA at each of the four sessions. Larger $R^2$ values were seen in each session's model, but the most predictive model, the session 4 model, had an explanatory value that was only 4% more powerful at 0.65. In phase 4, Sire(Ranch) was added to the independent variables. Scan session 1 saw the greatest increase in $R^2$ value, an increase from 0.20 in phase 2 to 0.65 once Sire(Ranch) was included. It is important to note that Sire(Ranch) was not significant within this model. Rather, Ranch and MSCORE were observed as being the most significant in their ability to account for REA. Sire(Ranch) proved to be significant only at session 3, along with Ranch, MSCORE, UREA2, and GM2. For sessions 3 and 4, Ranch and UREA3 and UREA4 were found to be significant. Given the fact that Ranch was found to be significant in each of the four final models, this could be possibly due in part to each Ranch's genetic selection for sires who exhibit larger actual ribeye areas.

### Carcass 12th Rib Fat Thickness (FAT)

In each phase of model analysis (Table 36) for scan session 1, which included the scan session data of UFAT1 and Rump1, each model increased in its predictive ability. At Phase 1, similar $R^2$ values to that of REA were observed when FRAME, MSCORE, and Wt were used to predict FAT. It was evident that this combination of independent variables was not sufficient in their prediction of FAT. Of the steers that were harvested, a considerable amount of variation was observed in FAT across animals that had similar FRAME, MSCORE, and Wt. Using only the variables UFAT1 and Rump1, the $R^2$ value was 0.25, with both variables significant at the $P < 0.10$ level. In phases 3 and 4 the value was observed at 0.28 and 0.47, respectively. At phase 4, however, no significant variables were found within the model. UFAT and Rump proved to be the most predictive combination of independent variables in each of the three remaining final models. In phase 2, scan 4 provided the largest explanatory value at 0.56, utilizing only the variables UFAT4 and Rump4. When Ranch, FRAME, and MSCORE were included, $R^2$ values did rise, however of the three categorical variables added, Ranch at scan session 4 was the only significant one. At each session within phase 3, UFAT and Rump provided the majority of explanation behind the differences seen in FAT. After Sire(Ranch) was added, differences in significant variables were observed. At session 3, UFAT3 and Rump3 were still significant, as was FRAME, providing a model $R^2$ value of 0.61. This was a 23% increase from the model used in phase 3. At scan session 3 the significant variables identified were Sire(Ranch), UFAT3, and Rump3. In its entirety, this model accounted for 77% of the variation found in FAT. Scan session 4 posted an $R^2$ value of 0.77 with only UFAT4 being significant at the $P < 0.10$ level. The research performed by Rouse et al. (2000) found similar results in the predictive power of models estimating carcass backfat on mixed breed commercial feeder steers in Iowa. In that study, a $R^2$ value of 0.29 was computed from an equation used to predict backfat from an ultrasound measurement taken 90 days prior to slaughter. In our study, a more powerful model was achieved at scan session 3, 103 days prior to the kill date, with a $R^2$ value of 0.51 by using only UFAT 3 as the single independent variable. Again within our study a stronger predictive model for carcass backfat was found than by Rouse et al. (2000). In their study, a $R^2$ value of 0.51 was found from data taken at 46 and 6 days before harvest. In this study, however, the explanatory value of 0.56 was calculated on equations using UFAT measurements at 61 days prior to the kill date. It should be considered that ultrasound technology has been known to over estimate backfat thickness on leaner cattle (Perkins et al., 1997). Reasoning behind why Sire(Ranch) was significant only in the final model for session 3 is difficult to project. Perhaps the genetic component of the Sire is not strong enough to affect the steer's ability to attain external fat during days on feed after scan session 3, or possibly that this was a result of the small number of progeny from certain sires. It is also possible for outside effects such as feed resources and management to have a greater affect on external fat accretion during the final days on feed rather than a genetic effect. Still, the effect of Sire(Ranch) on final FAT was evident in the final model for session 3.

Carcass Marbling (MarbScore)

MarbScore (Table 37) proved to be difficult to estimate on steers early in the feeding period. Using FRAME and MSCORE with a Wt from any scan session did not account for much variation seen in MarbScore. The highest explanatory value seen in the final models from phase 1 was with Wt4 at 0.10. In phase 2, ultrasound data did provide higher $R^2$ values than those from phase 1. Although sessions 1 and 2 showed UIMF to be significant, the $R^2$ values were at best 0.17. The largest increase came at sessions 3 (0.42) and 4 (0.54). At these sessions UIMF was the only significant variable along with GM3 at session 3. The fourth scan session was performed approximately 60 days before slaughter. With the final model containing only ultrasound data (accounting for 54% of the variation seen in MarbScore), one could conclude that significant changes in the steers' intramuscular fat percentage did occur between scan session 4 and slaughter. When the independent variables from phases 1 and 2 were combined, little increases in predictive power of the models were observed. Sessions 1 and 2 did increase to 0.35 and 0.35, respectively, however sessions 3 and 4 saw almost no increase. It was not until Sire(Ranch) was incorporated into the models did the highest $R^2$ values appear. It is possible that the managers of the Ranches may have selected sires for marbling, but could also reflect genetic differences on cow herds or non-genetic differences at ranch level. Scan session 1 displayed a $R^2$ value of 0.56, however FRAME was the only significant variable observed at the 0.10 level. Session 2 posted a value of 0.59, with FRAME and

UIMF2 being significant. Sessions 3 and 4 showed the same significant variables with higher explanatory values of 0.65 and 0.76, respectively. It is interesting that FRAME was significant along with UIMF. Like other biological measurements of carcass performance, MarbScore was more directly affected by UIMF and FRAME than a single measurement of Wt. Our results show that considerable $R^2$ values for MarbScore can be achieved, however even higher values are expected to be seen in equations containing measurements taken closer to the actual slaughter date. In the study by Rouse et al. (2000), more moderate $R^2$ values were found when the researchers predicted quality grade from scan data taken at 90, 46, and 6 days prior to slaughter. They included only the variables of percent intramuscular fat and back fat to predict quality grade with resulting explanatory values of 0.31, 0.41, and 0.51, respectively. Our results showed different equations in that Rump was a better predictor than UFAT. Still, the results of this study provide evidence that MarbScore can be predicted on steers at various points during the feeding period with reasonable accuracy by utilizing the traditional measurement of frame score as well as ultrasound intramuscular fat percentage and Sire(Ranch).

Grids A, B and C End Value (GridA, GridB, GridC)

Within Tables 38, 39, and 40, results show that careful consideration should be given when relying on the conventional measurements FRAME, MSCORE, and Wt to predict final grid value. In each of the four models that included these traditional measurements, Wt was found to be the most important factor influencing end values. The largest $R^2$ value of 0.51 was seen in equation 4 for GridA. For grid values A, B, and

C, the equations in Phase 1 did not provide a sufficient level of explanation in the variation of the final end grid values. For each grid value, the $R^2$ values decreased for each of the four equations. The results of the analysis in Phase 1 offer evidence that managers and producers should consider additional information to assist them in predicting the final grid price of their steers. End values could not be accurately estimated early in the feeding period, even when Sire(Ranch) was included. In phase 2, Wt1 was the only variable used to estimate GridA ($R^2 = 0.19$) for scan session 1. At later sessions UIMF was added, however for GridA, Wt remained the only significant predictor. For GridB and GridC, UIMF1 was combined with Wt1; however, $R^2$ values did not change for either pricing prediction model, 0.19 and 0.14, respectively for Grids B and C. For Grids B and C, UIMF was most likely included with Wt because of the grids added emphasis on final quality grade differences. In phase 3, Ranch was the only categorical variable significant in any of the session models, and was found significant only in the model for session 1 along with Wt1. In this phase of analysis, it was clear that including information such as Ranch, frame score and muscle score did not significantly help in increasing the predictive power of the equations. The $R^2$ values for GridA did not increase enough (model 1 (9%), model 2 (7%), model 3 (5%), and model 4 (6%)) to justify the economic cost of collecting an including additional variables such as Ranch, FRAME, and MSCORE. With Sire(Ranch) incorporated, explanatory values did noticeably increase. It is puzzling, however, that each $R^2$ value increased by a significant amount, yet Sire(Ranch) was not a significant independent variable in any of the final equations. At session 1, no variables were found to be significant, thus the results from this study indicate that more analyses and information are needed to construct predictive equations for final grid prices on cattle at the beginning of the feeding period. Results from scan session 1 may also have been different if the predictive equations were constructed on steers that posted a higher percent choice than the ones used in this study. In that scenario, more steers would have commanded higher grid prices due to more carcasses grading choice. In each of the other 3 models of Phase 4 for GridA, Wt was significant in all of them, with UIMF being significant at sessions 2 ($R^2$ = 0.61) and 4 ($R^2$ = 0.73). For GridB and GridC, UIMF was found to be significant in each model, except for session 1 when Sire(Ranch) was included. The significance of UIMF is most notably due to the choice/select spread of $15.00 for GridB and $25.00 for GridC. A decrease in the level of explanatory values was observed in all models predicting Grid B and C, when compared to Grid A. In phase 4 for GridB, each model's $R^2$ value for consecutive sessions decreased, with the highest of these occurring at session 4 ($R^2$ = 0.69), a 4% decline from GridA. For GridC, the highest $R^2$ value was again found with the model for session 4 at 0.65, which was a 4% decline as compared to GridB. It is also important to note that for GridB and GridC, the final model constructed for scan session 1 did not contain any significant variables. This concurs with the results found for GridA and strengthens the evidence for the need of more research and analysis to construct a more accurate prediction equation for final grid prices for cattle entering the feeding cycle. Again, results may have been different for equations from scan 1 if more steers had been in the study or if there had been a higher percent make the choice grade. However, the number animals and methods used in this study suggest that more information in needed to accurately forecast final carcass value on cattle at the beginning of the feeding cycle. The models developed for scan session 4 illustrate that a considerable percentage of the variation in final grid price can be accounted for. This evidence highlights the economic opportunity for producers to collect ultrasound, performance, and pedigree data to utilize in sorting their cattle on final grid price at a period that is approximately 30 to 60 days prior to slaughter. In doing do, these operators can group animals based upon their estimated final value. This will allow operators to apply management decisions to individual animals and groups of animals that are expected to deliver different levels of economic return.

## Sire Least Squares Means

Sire Least squares means (Tables 41 – 51) were calculated for each sire across each scan session for each carcass trait and end value. Equations used to calculate the LS means were the 4 final models examined in Phase 4 of the analysis. Least squares means across each scan session tended to be less variable for sires with more progeny represented as compared to those sires with few progeny. Also, LS means were closer to the actual value for most sires that had more progeny in the study.

## CONCLUSIONS AND IMPLICATIONS

In today's increasingly competitive beef marketplace, producers and feedyard managers are more aggressively seeking to increase their potential profit by producing superior products, as well as matching cattle types to specialized market outlets. With this in mind, it is of utmost importance that these operators understand the ability of different categories of information to predict and give accurate estimations of the final performance of the animals in question. Our study shows that there are two general categories of traits that can be predicted with relatively good accuracy even with information gathered early in the feeding period. These two categories of traits are those such as CWT, Cvalue, and other end values that are derived mostly from final CWT, and those traits that give a compositional measurement such as REA, FAT, and YG. In attempting to create more homogeneous groups of animals that are channeled into the most favorable marketing scenario, the most easily available pieces of information that operators can utilize in predicting these end traits are traditional pieces of data such as feeder calf frame and muscle scores as well as body weights. According to this study, the traits that were best predicted by FRAME, MSCORE, and weight were end traits and values that are directly derived from final carcass and live weights. Equations predicting end traits such as MarbScore, REA, FAT, YG, and Epley, show low explanatory values even when FRAME and MSCORE are combined with a body weight taken within 2 months prior to slaughter. Aside from these compositional traits, results indicate that managers can use FRAME, MSCORE, and Wt to give them accurate indications of animals that will deliver optimum levels of performance.

Another category of information that operators can utilize to help them procure cattle into uniform loads is ultrasound data taken during the feeding period. As more and more packer operations increase their effort to locate and source a more consistent and stable supply of beef, greater economic incentives arise for managers to group their cattle accordingly. This study provides evidence that if managers can measure and analyze ultrasound data taken at different points throughout the feeding period, accurate estimations of each animal's carcass traits and value can be obtained, thus creating more consistent loads of cattle available for specific end markets. In agreeing with past studies, it was found that ultrasound measures taken closer to the date of slaughter can give more accurate predictions of carcass and economic performance. Still, results in this study show that ultrasound data collected early to half way through the feeding period can provide reasonable levels of prediction accuracy for certain end traits, especially when combined with other categories of information such as frame and muscle score and pedigree data. The most important measurement taken by ultrasound at the beginning of the project to help in the prediction of end traits and values was Rump. Rump proved to be significant at the beginning of the feeding period when predicting YG, Epley, and FAT, although the $R^2$ values for these equations were at 0.25, 0.20, and 0.25, respectively. Data collected at the final scan session were the most predictive. It should be noted that for the sire identified steers, the final scan session was 61 days before there slaughter date. However, this study found prediction equations utilizing only ultrasound data taken at this point to still be notably reliable. REA was capable of estimation with an $R^2$ value of 0.61, with using the measurements UREA4 and GM4. Using Wt4 and

UREA4, CWT was assessed with an accuracy of 0.70. LiveValue and Cvalue posted even higher results with values of 0.80 and 0.80, respectively.

The two previously discussed categories of information available to cattle operators have shown their potential to assist these operators in predicting the final carcass performance and economic value of cattle in the feedyard. This study found that even more powerful predictive models could be created when these two categories of information are combined. Along with these variables being combined, Ranch was included in the analysis as an independent variable. Although there were only 5 ranches represented in the study, Ranch was found to be significant in its ability to help predict many of the final variables. Ranch of origin was also found to be significant in its effects on final carcass value in the analysis by Groeschke et el. (2005). This highlights opportunities for managers to explore tactics of identifying the most optimal prediction and sorting techniques for their cattle on feed. In combining the two categories of information, the most immediate boost in $R^2$ value, 0.35, at the beginning of the feeding period was in predicting MarbScore. In this phase of the analysis, the most improvement in predictive power was found in models estimating specific carcass end traits such as YG, REA, FAT, etc. End values such as CWT, Cvalue, LiveValue, and Grid values were not as affected. This is most likely due to their high dependence upon Wt and not from compositional measurements such as UREA, UFAT, and UIMF. It should be noted that the importance of Ranch in affecting final carcass end measurements was largely due to the fact that there was more that one Ranch represented. This allowed for a comparison between Ranches. If all steers were from one enterprise, no such comparison could have been reported. It is important to highlight that the use of Ranch to help sort cattle on feed would be utilized more by feedyard managers and by operators who own volume of cattle in the yard that are from several sources.

The final effect evaluated the model analyses was that of Sire(Ranch). This was also performed with the ability to compare progeny between Sires as progeny were compared between Ranches. A significant effect of Sire(Ranch) was not seen in any models estimating final end values, even though $R^2$ values did increase once Sire(Ranch) was included. The greatest enhancement in $R^2$ value, once Sire(Ranch) was included, was for models predicting Epley, YG, MarbScore, REA and FAT. In each Ranch's own breeding program, managers may have selected sires with an emphasis on their genetic potential for each of these carcass traits. Thus, it is not surprising when explanatory values increase substantially when Sire(Ranch) is included in the models. What is confusing to the researchers is why Sire(Ranch) is not listed as a significant variable at the 0.10 level, although $R^2$ values are observed notably higher in phase 4 of the analysis.

Feedyard managers and cattle operators are constantly searching for ways to enhance their ability of creating a stable supply of raw material that is more consistent. With more marketing avenues being created, more importance arises for operators to gain as much knowledge as possible about their animal's future performance in order to strategically market them on a grid, live, or carcass basis. Producers and managers must remember that each marketing avenue contains its own level of risk, of which is usually price and final value variation. When on a live value basis, low performing cattle are compensated by the higher performing animals. At the same time, higher performing animals do not command a higher price because of the lack of performance in the lower quality cattle. Even though this level of variation and risk may be present, this pricing system may be best for loads of cattle that do not posses accurate information, if any, that can aid managers in their sorting and prediction practices. When marketing cattle on a grid value system, more price variation occurs than in the live value based systems. However, higher performing animals do command greater values than lower performing animals, and thus final grid value can be manipulated by managers who collect and utilize accurate information on their cattle. Although more variation can occur, this pricing system matches the most appropriate value to each animal and allows for clearer signals to be sent back to producers on how their cattle perform and the steps necessary to increase their sorting ability. This study has shown that operators can utilize different categories, and combinations of categories of information, to help them in predicting the future performance of an individual animal on a carcass or end value basis at different points during the feeding process. Certain categories of information are best suited for predicting end values, and other categories are best suited for predicting specific carcass traits. Still, these prediction model opportunities allow managers to augment their current procurement efforts into systems that align individual animals and groups of animals with their most optimal end marketing avenue.

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# APPENDIX A

Table 1. Investigation of different multiple regression models for carcass ribeye area evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

| Scan 1 | | | |
|---|---|---|---|
| Models | Var | R-Square | CP |
| 1 | UREA1 | 0.02 | 0.96 |
| 2 | UREA1,UFAT1 | 0.04 | 0.55 |
| 3 | UREA1,UFAT1,Rump1 | 0.05 | 1.93 |
| 4 | Wt1,UREA1,UFAT1,Rump1 | 0.05 | 3.26 |
| 5 | Wt1,UREA1,UFAT1,Rump1,GM1 | 0.05 | 5.01 |
| 6 | Wt1,UREA1,UFAT1,Rump1,GM1 | 0.05 | 7.00 |

| Scan 2 | | | |
|---|---|---|---|
| Models | Var | R-Square | CP |
| 1 | UREA2 | 0.12 | 7.81 |
| 2 | UREA2,GM2 | 0.17 | 6.25 |
| 3 | UREA2,Wt2,GM2 | 0.22 | 4.24 |
| 4 | Wt2,UREA2,UIMF2,Rump2 | 0.24 | 4.91 |
| 5 | Wt2,UREA2,UIMF2,GM2,Rump2 | 0.27 | 5.07 |
| 6 | Wt2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.27 | 0.19 |

| Scan 3 | | | |
|---|---|---|---|
| Models | Var | R-Square | CP |
| 1 | UREA3 | 0.24 | 0.13 |
| 2 | UREA3,GM3 | 0.24 | 1.93 |
| 3 | WT3,UREA3,GM3 | 0.25 | 3.11 |
| 4 | UREA3,UFAT3,UIMF3,GM3 | 0.25 | 4.06 |
| 5 | WT3,UREA3,UFAT3,UIMF3,GM3 | 0.26 | 5.61 |
| 6 | WT3,UREA3,UFAT3,UIMF3,GM3,Rump3 | 0.26 | 7.00 |

| Scan 4 | | | |
|---|---|---|---|
| Models | Var | R-Square | CP |
| 1 | UREA4 | 0.59 | 5.74 |
| 2 | UREA4,GM4 | 0.61 | 2.19 |
| 3 | UREA4,GM4,Wt4 | 0.62 | 5.66 |
| 4 | UREA4,GM4,Wt4,Rump4 | 0.63 | 6.60 |
| 5 | UREA4,GM4,Wt4,Rump4,UFAT4 | 0.63 | 4.64 |
| 6 | UREA4,GM4,Wt4,Rump4,UFAT4,UIMF4 | 0.64 | 7.00 |

Table 2. Investigation of different multiple regression models for carcass fat thickness evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Rump1 | 0.22 | 14.71 |
| 2 | UFAT1,Rump1 | 0.26 | 9.52 |
| 3 | Wt1,UFAT1,Rump1 | 0.28 | 7.39 |
| 4 | Wt1,UREA1,UFAT1,Rump1 | 0.3 | 7.20 |
| 5 | Wt1,UREA1,UFAT1,UIMF1,Rump1 | 0.31 | 6.44 |
| 6 | Wt1,UREA1,UFAT1,UIMF1,Rump1,GM1 | 0.32 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Rump2 | 0.19 | 4.49 |
| 2 | UFAT2,Rump2 | 0.27 | 1.42 |
| 3 | Wt2,UFAT2,Rump2 | 0.29 | 1.92 |
| 4 | Wt2,UFAT2,Rump2,GM2 | 0.30 | 3.31 |
| 5 | Wt2,UREA2,UFAT2,Rump2,GM2 | 0.30 | 5.01 |
| 6 | Wt2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.30 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT3 | 0.48 | 0.26 |
| 2 | UFAT3,Rump3 | 0.49 | 0.82 |
| 3 | UFAT3,UIMF3,Rump3 | 0.49 | 2.18 |
| 4 | UIMF3,UFAT3,Rump3,UREA3 | 0.49 | 4.06 |
| 5 | WT3,UREA3,UFAT3,UIMF3,Rump3 | 0.49 | 5.63 |
| 6 | WT3,UREA3,UFAT3,UIMF3,Rump,GM3 | 0.50 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT4 | 0.50 | 7.21 |
| 2 | UFAT4,Rump4 | 0.56 | 3.89 |
| 3 | UFAT4,Rump4,UIMF4 | 0.57 | 5.10 |
| 4 | UFAT4,Rump4,UIMF4,Wt4 | 0.59 | 4.52 |
| 5 | UFAT4,Rump4,UIMF4,Wt4,UREA4 | 0.59 | 6.66 |
| 6 | UFAT4,Rump4,UIMF4,Wt4,UREA4,GM4 | 0.59 | 7.00 |

Table 3. Investigation of different multiple regression models for carcass marbling score evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | IMF1 | 0.09 | 1.53 |
| 2 | IMF1,Rump1 | 0.11 | 1.38 |
| 3 | IMF1,Rump1,UREA1 | 0.12 | 1.76 |
| 4 | IMF1,Rump1,UREA1,Wt1 | 0.12 | 3.48 |
| 5 | IMF1,Rump1,UREA1,Wt1,GM1 | 0.12 | 5.21 |
| 6 | IMF1,Rump1,UREA1,Wt1,GM1,UFAT1 | 0.12 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UIMF2 | 0.18 | 0.66 |
| 2 | BF2,UIMF2 | 0.18 | 2.53 |
| 3 | WT2,REA2,UIMF2 | 0.20 | 3.01 |
| 4 | UREA2,UFAT2,UIMF2,GM2 | 0.23 | 3.31 |
| 5 | UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.23 | 5.04 |
| 6 | WT2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.23 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UIMF3 | 0.28 | 3.87 |
| 2 | UIMF3,GM3 | 0.30 | 2.31 |
| 3 | WT3,GM3,UIMF3 | 0.31 | 3.39 |
| 4 | WT3,UREA3,UIMF3,GM3 | 0.31 | 4.85 |
| 5 | Wt3,UREA3,UFAT3,UIMF3,GM3 | 0.32 | 5.09 |
| 6 | Wt3,UREA3,UFAT3,UIMF3,GM3,Rump3 | 0.32 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UIMF4 | 0.51 | 0.35 |
| 2 | UIMF4,Rump4 | 0.54 | 1.56 |
| 3 | UIMF4,Rump4,Wt4 | 0.55 | 2.58 |
| 4 | UIMF4,Rump4,Wt4,UFAT4 | 0.55 | 3.00 |
| 5 | UIMF4,Rump4,Wt4,UFAT4,Rump4 | 0.56 | 5.00 |
| 6 | UIMF4,Rump4,Wt4,UFAT4,Rump4,GM4 | 0.56 | 7.00 |

Table 4. Investigation of different multiple regression models for carcass weight evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.33 | 1.03 |
| 2 | Wt1,Rump1 | 0.34 | 0.54 |
| 3 | Wt1,Rump1,GM1 | 0.36 | 1.55 |
| 4 | Wt1,Rump1,GM1,UIMF1 | 0.36 | 3.12 |
| 5 | Wt1,Rump1,GM1,UIMF1,UFAT1 | 0.36 | 5.04 |
| 6 | Wt1,Rump1,GM1,UIMF1,UFAT1,UREA1 | 0.36 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | WT2 | 0.45 | -2.65 |
| 2 | Wt2,UFAT2 | 0.45 | -0.87 |
| 3 | Wt2,UREA2,Rump2 | 0.45 | 1.34 |
| 4 | Wt2,UREA2,Rump2,UFAT2 | 0.45 | 3.02 |
| 5 | Wt2,UREA2,BF2,UIMF2,Rump2 | 0.45 | 5.02 |
| 6 | Wt2,UREA2,BF2,UIMF2,Rump2,GM2 | 0.45 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.47 | 7.47 |
| 2 | Wt3,UFAT3 | 0.49 | 4.63 |
| 3 | Wt3,UREA3,UFAT3 | 0.50 | 4.04 |
| 4 | Wt3,UREA3,UFAT3,GM3 | 0.51 | 3.83 |
| 5 | Wt3,UREA3,UFAT3,Rump3,GM3 | 0.51 | 5.65 |
| 6 | Wt3,UREA3,UFAT3,Rump3,GM3,UIMF3 | 0.52 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.61 | 5.63 |
| 2 | Wt4,UREA4 | 0.70 | 1.97 |
| 3 | Wt4,UREA4,Rump4 | 0.70 | 3.74 |
| 4 | Wt4,UREA4,Rump4,UIMF4 | 0.71 | 3.16 |
| 5 | Wt4,UREA4,Rump4,UIMF,GM4 | 0.71 | 5.00 |
| 6 | Wt4,UREA4,Rump4,UIMF,GM4,UFAT4 | 0.72 | 7.00 |

Table 5. Investigation of different multiple regression models for carcass yield grade evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Rump1 | 0.19 | 10.37 |
| 2 | Rump1,Wt1 | 0.25 | 2.05 |
| 3 | Rump1,Wt1,UIMF1 | 0.26 | 2.43 |
| 4 | Rump1,Wt1,UIMF1,GM1 | 0.26 | 3.66 |
| 5 | Rump1,Wt1,UIMF1,GM1,UREA1 | 0.27 | 5.05 |
| 6 | Rump1,Wt1,UIMF1,GM1,UREA,UFAT1 | 0.23 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Rump2 | 0.13 | 5.49 |
| 2 | BF2,Rump2 | 0.17 | 5.54 |
| 3 | Wt2,UIMF2,Rump2 | 0.23 | 2.62 |
| 4 | Wt2,UFAT2,UREA2,Rump2 | 0.24 | 4.15 |
| 5 | Wt2,UFAT2,UIMF2,Rump2,GM2 | 0.25 | 5.15 |
| 6 | Wt2,UFAT2,UIMF2,Rump2,GM2,UREA2 | 0.25 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT3 | 0.33 | 18.10 |
| 2 | UFAT3,Rump3 | 0.37 | 10.56 |
| 3 | Wt3,Rump3,UFAT3 | 0.4 | 8.57 |
| 4 | WT3,UREA3,UFAT3,Rump3 | 0.42 | 4.04 |
| 5 | WT3,UREA3,UFAT3,Rump3,GM3 | 0.42 | 6.02 |
| 6 | WT3,UREA3,UFAT3,Rump3,GM3,UIMF3 | 0.43 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT4 | 0.27 | 26.41 |
| 2 | UREA4,UFAT4 | 0.33 | 16.46 |
| 3 | UFAT4,UIMF4,GM4 | 0.42 | 11.77 |
| 4 | UFAT4,Rump4,GM4,REA4 | 0.47 | 5.99 |
| 5 | UFAT4,Rump4,GM4,REA4,UIMF4 | 0.49 | 5.16 |
| 6 | UFAT4,Rump4,GM4,REA4,UIMF4,Wt4 | 0.52 | 7.00 |

Table 6. Investigation of different multiple regression models for Epley evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.16 | 2.36 |
| 2 | Wt1,Rump1 | 0.19 | -0.18 |
| 3 | Wt1,Rump1,UREA1 | 0.2 | 1.05 |
| 4 | Wt1,Rump1,UREA1,UIMF1 | 0.2 | 3.02 |
| 5 | Wt1,Rump1,UFAT1,UIMF1,UREA1 | 0.2 | 5.10 |
| 6 | Wt1,Rump1,GM1,UIMF1,UREA1,UFAT1 | 0.21 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Rump2 | 0.17 | 1.88 |
| 2 | Rump2,GM2 | 0.2 | 1.73 |
| 3 | Wt2,GM2,Rump2 | 0.21 | 3.20 |
| 4 | UREA2,UIMF2,Rump2,GM2 | 0.23 | 3.91 |
| 5 | UREA2,UFAT2,IMF2,Rump2,GM2 | 0.24 | 5.21 |
| 6 | UREA2,UFAT2,IMF2,Rump2,GM2,Wt2 | 0.24 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT3 | 0.41 | 25.60 |
| 2 | Wt3,UFAT3 | 0.48 | 10.52 |
| 3 | WT3,UFAT3,UREA3 | 0.51 | 5.95 |
| 4 | WT3,REA3,UFAT3,Rump3 | 0.55 | 3.97 |
| 5 | Wt3,UFAT3,UREA3,Rump3,GM3 | 0.53 | 5.96 |
| 6 | Wt3,UFAT3,UIMF3,Rump3,GM,UREA3 | 0.54 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | UFAT4 | 0.35 | 15.98 |
| 2 | UFAT4,UIMF4 | 0.44 | 8.54 |
| 3 | UREA4,UFAT4,UIMF4 | 0.48 | 6.86 |
| 4 | Wt4,UREA4,UFAT4,Rump4 | 0.55 | 4.65 |
| 5 | UREA4,UFAT4,UIMF4,Rump4,GM4 | 0.55 | 4.62 |
| 6 | UREA4,UFAT4,UIMF4,Rump4,GM4,Wt4 | 0.56 | 7.00 |

Table 7. Investigation of different multiple regression models for carcass value evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.47 | 6.01 |
| 2 | Wt1,UIMF1 | 0.49 | 3.13 |
| 3 | Wt1,UIMF1,Rump1 | 0.50 | 2.39 |
| 4 | Wt1,UREA1,UIMF1,Rump1 | 0.50 | 3.80 |
| 5 | Wt1,UREA1,UIMF1,Rump1,GM1 | 0.48 | 5.14 |
| 6 | Wt1,UREA1,UFAT1,UIMF1,Rump1,GM1 | 0.50 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt2 | 0.58 | -1.38 |
| 2 | Wt2,UIMF2 | 0.61 | -0.22 |
| 3 | Wt2,UIMF2,Rump2 | 0.61 | 1.72 |
| 4 | Wt2,UREA2,UIMF2,Rump2 | 0.60 | 3.71 |
| 5 | Wt2,UFAT2,UIMF2,Rump2,GM2 | 0.62 | 5.01 |
| 6 | Wt2,UFAT2,UIMF2,Rump2,GM2,UREA2 | 0.62 | 7 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.55 | 23.04 |
| 2 | Wt3,UFAT3 | 0.62 | 3.68 |
| 3 | Wt3,UFAT3,GM3 | 0.63 | 3.45 |
| 4 | Wt3,UFAT3,UIMF3,GM3 | 0.63 | 4.59 |
| 5 | Wt3,UREA3,UFAT3,UIMF3,GM3 | 0.63 | 5.71 |
| 6 | Wt3,UREA3,UFAT3,UIMF3,GM3,Rump3 | 0.63 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.80 | 2.55 |
| 2 | Wt4,UREA4 | 0.82 | 2.62 |
| 3 | Wt4,UREA4,Rump4 | 0.83 | 2.64 |
| 4 | Wt4,UREA4,Rump4,UFAT4 | 0.83 | 4.69 |
| 5 | Wt4,UREA4,Rump4,UFAT4,GM4 | 0.84 | 5.16 |
| 6 | Wt4,UREA4,Rump4,UFAT4,GM4,UIMF4 | 0.85 | 7.00 |

Table 8. Investigation of different multiple regression models for live value evaluationg Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.48 | 0.38 |
| 2 | Wt1,Rump1 | 0.48 | 0.79 |
| 3 | Wt1,Rump1,UIMF1 | 0.49 | 1.60 |
| 4 | Wt1,Rump1,UIMF1,GM1 | 0.49 | 3.11 |
| 5 | Wt1,Rump1,UIMF1,GM1,UFAT1 | 0.49 | 5.00 |
| 6 | Wt1,Rump1,UIMF1,GM1,UFAT1,UREA1 | 0.49 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt2 | 0.60 | -2.13 |
| 2 | Wt2,UREA2 | 0.60 | -0.13 |
| 3 | Wt2,UREA2,UFAT2 | 0.60 | 1.85 |
| 4 | Wt2,UFAT2,UREA2,Rump2 | 0.60 | 3.68 |
| 5 | Wt2,UFAT2,UIMF2,Rump2,GM2 | 0.60 | 5.01 |
| 6 | Wt2,UFAT2,UIMF2,Rump2,GM2,UREA2 | 0.60 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.60 | 14.04 |
| 2 | Wt3,UFAT3 | 0.63 | 6.72 |
| 3 | Wt3,UFAT3,UREA3 | 0.64 | 3.86 |
| 4 | Wt3,UREA3,UFAT3,Rump3 | 0.65 | 5.16 |
| 5 | Wt3,UREA3,UFAT3,Rump3,GM3 | 0.65 | 5.73 |
| 6 | Wt3,UREA3,UFAT3,Rump3,GM,UIMF3 | 0.65 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.80 | 3.21 |
| 2 | Wt4,UREA4 | 0.81 | 2.54 |
| 3 | Wt4,UREA4,Rump4 | 0.82 | 2.19 |
| 4 | Wt4,UREA4,Rump4,GM4 | 0.85 | 3.59 |
| 5 | Wt4,UREA4,Rump4,GM4,UFAT4 | 0.85 | 5.00 |
| 6 | Wt4,UREA4,Rump4,GM4,UFAT4,UIMF4 | 0.85 | 7.00 |

Table 9. Investigation of different mulriple regression models for Grid A evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.19 | -1.83 |
| 2 | Wt1,UIMF1 | 0.19 | -0.31 |
| 3 | Wt1,UIMF1,GM1 | 0.19 | 1.35 |
| 4 | Wt1,UIMF1,Rump1,GM1 | 0.19 | 3.08 |
| 5 | Wt1,UREA1,UIMF1,Rump1,GM1 | 0.19 | 5.03 |
| 6 | Wt1,UREA1,UFAT1,UIMF1,Rump1,GM1, | 0.19 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt2 | 0.29 | 1.97 |
| 2 | Wt2,UIMF2 | 0.31 | 2.42 |
| 3 | Wt2,UREA2,UIMF2 | 0.33 | 2.66 |
| 4 | Wt2,UREA2,UFAT2,UIMF2 | 0.35 | 3.67 |
| 5 | Wt2,UREA2,UFAT2,UIMF2,GM2 | 0.35 | 5.26 |
| 6 | Wt2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.36 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.29 | 11.11 |
| 2 | Wt3,UREA3 | 0.35 | 3.22 |
| 3 | Wt3,UREA3,UIMF3 | 0.35 | 3.67 |
| 4 | WT3,UREA3,UIMF3,GM3 | 0.36 | 3.75 |
| 5 | WT3,UREA3,UIMF3,Rump3,GM3 | 0.36 | 6.59 |
| 6 | WT3,UREA3,UFAT3,Rump3,GM3,UIMF3 | 0.37 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.48 | 6.55 |
| 2 | Wt4,UREA4 | 0.55 | 2.71 |
| 3 | Wt4,UREA4,UIMF4 | 0.57 | 3.33 |
| 4 | Wt4,UREA4,UIMF4,GM4 | 0.58 | 5.98 |
| 5 | Wt4,UREA4,UIMF4,GM4,UFAT4 | 0.58 | 6.16 |
| 6 | Wt4,UREA4,UIMF4,GM4,UFAT4,Rump4 | 0.59 | 7.00 |

Table 10. Investigation of different mulriple regression models for Grid B evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.16 | -1.09 |
| 2 | Wt1,UIMF1 | 0.19 | 0.41 |
| 3 | Wt1,UIMF1,GM1 | 0.20 | 1.77 |
| 4 | Wt1,UIMF1,UREA1,GM1 | 0.20 | 3.21 |
| 5 | Wt1,UREA1,UIMF1,Rump1,GM1 | 0.20 | 4.44 |
| 6 | Wt1,UFAT1,UFAT1,UIMF1,Rump1,GM1, | 0.20 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt2 | 0.21 | 0.27 |
| 2 | Wt2,UIMF2 | 0.25 | 1.92 |
| 3 | Wt2,UREA2,UIMF2 | 0.25 | 3.33 |
| 4 | Wt2,UREA2,Rump2,UIMF2 | 0.25 | 6.49 |
| 5 | Wt2,UREA2,Rump2,UIMF2,GM2 | 0.25 | 5.42 |
| 6 | Wt2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.27 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.29 | 9.07 |
| 2 | Wt3,UIMF3 | 0.32 | 2.68 |
| 3 | Wt3,UREA3,UIMF3 | 0.32 | 4.31 |
| 4 | WT3,UREA3,UIMF3,GM3 | 0.32 | 6.20 |
| 5 | WT3,UREA3,UIMF3,Rump3,GM3 | 0.32 | 6.55 |
| 6 | WT3,UREA3,UFAT3,Rump3,GM3,UIMF3 | 0.33 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.37 | 4.39 |
| 2 | Wt4,UIMF4 | 0.41 | 2.93 |
| 3 | Wt4,GM4,UIMF4 | 0.41 | 4.71 |
| 4 | Wt4,UREA4,UIMF4,GM4 | 0.41 | 6.29 |
| 5 | Wt4,UREA4,UIMF4,GM4,UFAT4 | 0.42 | 6.77 |
| 6 | Wt4,UREA4,UIMF4,GM4,UFAT4,Rump4 | 0.42 | 7.00 |

Table 11. Investigation of different mulriple regression models for Grid C evaluating Mallow's CP at ultrasound scan sessions 1 - 4.

Scan 1

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt1 | 0.14 | 0.21 |
| 2 | Wt1,UIMF1 | 0.14 | 2.27 |
| 3 | Wt1,UIMF1,Rump1 | 0.14 | 2.94 |
| 4 | Wt1,UIMF1,UREA1,Rump1 | 0.15 | 4.83 |
| 5 | Wt1,UREA1,UIMF1,Rump1,GM1 | 0.15 | 6.88 |
| 6 | Wt1,UFAT1,UFAT1,UIMF1,Rump1,GM1, | 0.17 | 7.00 |

Scan 2

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt2 | 0.18 | 0.39 |
| 2 | Wt2,UIMF2 | 0.21 | 1.67 |
| 3 | Wt2,GM2,Rump2 | 0.21 | 4.20 |
| 4 | Wt2,UREA2,Rump2,GM2 | 0.21 | 4.46 |
| 5 | Wt2,UREA2,Rump2,UIMF2,GM2 | 0.22 | 6.31 |
| 6 | Wt2,UREA2,UFAT2,UIMF2,Rump2,GM2 | 0.22 | 7.00 |

Scan 3

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt3 | 0.23 | 4.22 |
| 2 | Wt3,UIMF3 | 0.31 | 3.85 |
| 3 | Wt3,UIMF3,UREA3 | 0.36 | 4.44 |
| 4 | WT3,UREA3,UIMF3,Rump3 | 0.36 | 6.20 |
| 5 | WT3,UREA3,UIMF3,Rump3,GM3 | 0.37 | 8.39 |
| 6 | WT3,UREA3,UFAT3,Rump3,GM3,UIMF3 | 0.37 | 7.00 |

Scan 4

| Models | Var | R-Square | CP |
|---|---|---|---|
| 1 | Wt4 | 0.31 | 1.12 |
| 2 | Wt4,UIMF4 | 0.37 | 3.47 |
| 3 | Wt4,UREA4,UIMF4 | 0.44 | 4.82 |
| 4 | Wt4,UREA4,UIMF4,UFAT4 | 0.44 | 6.31 |
| 5 | Wt4,UREA4,UIMF4,GM4,UFAT4 | 0.45 | 6.99 |
| 6 | Wt4,UREA4,UIMF4,GM4,UFAT4,Rump4 | 0.46 | 7.00 |

Table 12. Summary of initial value, weights, and average daily gains.

| Trait | n | mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| InPrice[a]($) | 154 | 90.55 | 7.65 | 69.00 | 107.66 |
| InValue[b]($) | 154 | 641.01 | 36.63 | 538.30 | 680.63 |
| WT1[c](kg) | 155 | 324.21 | 41.09 | 226.80 | 435.45 |
| WT2[d](kg) | 84 | 388.04 | 43.87 | 290.30 | 496.69 |
| WT3[e](kg) | 152 | 462.37 | 53.91 | 337.93 | 603.20 |
| WT4[f](kg) | 84 | 512.45 | 48.77 | 390.09 | 657.72 |
| OffWT[g](kg) | 155 | 560.20 | 50.10 | 396.90 | 719.66 |
| ADG[h](kg) | 155 | 1.23 | 0.20 | 0.44 | 1.70 |

[a]Price of steers in dollars per cwt at scan 1

[b]Value of steers in total dollars at scan 1

[c-f]Weight of steers at scans 1, 2, 4, 4, respectively

[g]Weight of steers at end of feeding period

[h]Average daily gain from steers during test

Table 13. Summary of ultrasound ribeye area, ultrasound 12th rib fat thickness, and ultrasound intramuscular fat percentage.

| Trait | n | mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| UREA1[a]($cm^2$) | 154 | 52.18 | 5.40 | 39.35 | 65.21 |
| UREA2[b]($cm^2$) | 155 | 63.68 | 7.62 | 47.92 | 82.56 |
| UREA3[c]($cm^2$) | 155 | 75.94 | 7.83 | 52.83 | 95.59 |
| UREA4[d]($cm^2$) | 84 | 80.07 | 8.18 | 53.92 | 101.01 |
| UFAT1[e](cm) | 154 | 0.25 | 0.06 | 0.15 | 0.74 |
| UFAT2[f](cm) | 155 | 0.41 | 0.15 | 0.18 | 0.89 |
| UFAT3[g](cm) | 155 | 0.54 | 0.20 | 0.18 | 1.27 |
| UFAT4[h](cm) | 84 | 0.65 | 0.25 | 0.15 | 1.52 |
| UIMF1[i](%) | 154 | 2.04 | 0.61 | 0.62 | 3.72 |
| UIMF2[j](%) | 155 | 2.38 | 0.67 | 0.59 | 4.16 |
| UIMF3[k](%) | 155 | 2.88 | 0.61 | 1.52 | 4.16 |
| UIMF4[l](%) | 84 | 3.20 | 0.58 | 1.68 | 4.22 |

[a-d]Actual ribeye area at scans 1, 2, 3, 4, respectively

[e-h]Subcutaneous fat depth over 12th rib at scans 1, 2, 3, 4, respectively

[i-l]Percent intramuscular fat at scans 1, 2, 3, 4, respectively

Table 14. Summary of ultrasound rump fat and ultrasound gluteus medius depth.

| Trait | n | mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| RUMP1[a](cm) | 137 | 0.40 | 0.11 | 0.18 | 0.81 |
| RUMP2[b](cm) | 146 | 0.77 | 0.22 | 0.36 | 1.52 |
| RUMP3[c](cm) | 133 | 0.97 | 0.31 | 0.36 | 1.68 |
| RUMP4[d](cm) | 78 | 1.09 | 0.28 | 0.58 | 1.80 |
| GM1[e](cm) | 135 | 7.31 | 0.74 | 5.72 | 8.84 |
| GM2[f](cm) | 145 | 8.04 | 0.90 | 4.50 | 10.39 |
| GM3[g](cm) | 126 | 8.32 | 0.64 | 6.50 | 10.06 |
| GM4[h](cm) | 74 | 9.16 | 0.75 | 7.44 | 10.87 |

[a-d]Depth of rump fat at scans 1, 2, 3, 4, respectively

[e-h]Depth of gluteus medius muscle at scans 1, 2, 3, 4, respectively

Table 15. Summary of carcass traits.

| Trait | n | mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| CWT[a](kg) | 155 | 354.32 | 31.68 | 251.29 | 455.18 |
| REA[b]($cm^2$) | 155 | 80.33 | 9.38 | 55.47 | 103.20 |
| FAT[c](cm) | 155 | 0.88 | 0.39 | 0.25 | 2.54 |
| MARB[d](score) | 155 | 463.94 | 52.48 | 350.00 | 650.00 |
| KPH[e](%) | 155 | 2.05 | 0.42 | 1.00 | 3.00 |
| YG[f] | 155 | 3.03 | 0.74 | 1.49 | 5.04 |
| Epley[g] | 155 | 67.59 | 3.26 | 41.65 | 72.82 |

[a]Carcass weight

[b]Carcass ribeye area

[c]Carcass rib fat thickness

[d]Marbling score

[e]Kidney, pelvic and heart fat percentage

[f]Yield grade

[g]Percent retail product

Table 16. Summary of end values.

| Trait | n | mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| GridA[a]($) | 155 | 1039.25 | 87.06 | 747.90 | 1225.80 |
| GridB[b]($) | 155 | 982.90 | 99.12 | 692.50 | 1223.41 |
| GridC[c]($) | 155 | 927.81 | 119.03 | 637.10 | 1223.41 |
| LiveValue[d]($) | 155 | 1074.26 | 105.63 | 763.12 | 1408.07 |
| Cvalue[e]($) | 155 | 1084.89 | 124.36 | 758.32 | 1535.17 |

[a]Carcass value on GridA

[b]Carcass value on GridB

[c]Carcass value on GridC

[d]Live animal value

[e]Carcass value

Table 17. Correlation coefficients and levels of significance involving measurements at scan 1.

| Trait | UREA1[b] | UFAT1[c] | UIMF1[d] | Rump1[e] | GM1[f] |
|---|---|---|---|---|---|
| WT1[a] | 0.0789 | 0.1410 | 0.0957 | 0.4028 | 0.2982 |
| | 0.3303 | 0.0810 | 0.2374 | <.0001 | 0.0004 |
| UREA1[b] | | -0.1126 | -0.1537 | 0.0360 | 0.0735 |
| | | 0.1642 | 0.0570 | 0.6773 | 0.3639 |
| UFAT1[c] | | | 0.2428 | 0.2649 | 0.0520 |
| | | | 0.0024 | 0.0018 | 0.5486 |
| UIMF1[d] | | | | 0.1653 | 0.1176 |
| | | | | 0.0544 | 0.1742 |
| Rump1[e] | | | | | 0.1395 |
| | | | | | 0.1052 |

[a]Weight at scan 1

[b]Ribeye area at scan 1

[c]Backfat thickness at scan 1

[d]Percent intramuscular fat at scan 1

[e]Rump fat thickness at scan 1

[f]Depth of gluteus medius at scan 1

Table 18. Correlation coefficients and levels of significance involving measurements at scan 2.

| Trait | UREA2[b] | BF2[c] | UIMF2[d] | Rump2[e] | GM2[f] |
|---|---|---|---|---|---|
| WT2[a] | 0.6137 | 0.5512 | -0.0082 | 0.5871 | 0.1888 |
| | <.0001 | <.0001 | 0.9409 | <.0001 | 0.0934 |
| UREA2[b] | | 0.2684 | -0.2463 | 0.2805 | 0.2566 |
| | | 0.0007 | 0.0020 | 0.0006 | 0.0018 |
| UFAT2[c] | | | 0.3471 | 0.5511 | 0.1420 |
| | | | <.0001 | <.0001 | 0.0883 |
| UIMF2[d] | | | | 0.2739 | 0.0239 |
| | | | | 0.0008 | 0.7749 |
| Rump2[e] | | | | | 0.2453 |
| | | | | | 0.0029 |

[a]Weight at scan 2

[b]Ribeye area at scan 2

[c]Backfat thickness at scan 2

[d]Percent intramuscular fat at scan 2

[e]Rump fat thickness at scan 2

[f]Depth of gluteus medius at scan 2

Table 19. Correlation coefficients and levels of significance involving measurements at scan 3.

| Trait | UREA3[b] | UFAT3[c] | UIMF3[d] | Rump3[e] | GM3[f] |
|---|---|---|---|---|---|
| WT3[a] | 0.5256 | 0.4941 | 0.1847 | 0.5892 | 0.0859 |
| | <.0001 | <.0001 | 0.0227 | <.0001 | 0.3447 |
| UREA3[b] | | 0.2211 | -0.0146 | 0.2513 | 0.2355 |
| | | 0.0057 | 0.8562 | 0.0035 | 0.0079 |
| UFAT3[c] | | | 0.2845 | 0.5958 | 0.0873 |
| | | | 0.0003 | <.0001 | 0.3308 |
| UIMF3[d] | | | | 0.3041 | -0.0112 |
| | | | | 0.0004 | 0.9007 |
| Rump3[e] | | | | | 0.0640 |
| | | | | | 0.4764 |

[a]Weight at scan 3

[b]Ribeye area at scan 3

[c]Backfat thickness at scan 3

[d]Percent intramuscular fat at scan 3

[e]Rump fat thickness at scan 3

[f]Depth of gluteus medius at scan 3

Table 20. Correlation coefficients and levels of significance involving measurements at scan 4.

| Trait | UREA4[b] | UFAT4[c] | UIMF4[d] | Rump4[e] | GM4[f] |
|---|---|---|---|---|---|
| WT4[a] | 0.5065 | 0.5949 | 0.1107 | 0.5473 | 0.3283 |
| | <.0001 | <.0001 | 0.3159 | <.0001 | 0.0043 |
| UREA4[b] | | 0.1555 | 0.1752 | 0.1402 | 0.4467 |
| | | 0.1577 | 0.1108 | 0.2206 | <.0001 |
| UFAT4[c] | | | 0.2315 | 0.6939 | 0.2163 |
| | | | 0.0341 | <.0001 | 0.0641 |
| UIMF4[d] | | | | 0.1684 | 0.0038 |
| | | | | 0.1403 | 0.9743 |
| Rump4[e] | | | | | 0.2118 |
| | | | | | 0.0699 |

[a]Weight at scan 4

[b]Ribeye area at scan 4

[c]Backfat thickness at scan 4

[d]Percent intramuscular fat at scan 4

[e]Rump fat thickness at scan 4

[f]Depth of gluteus medius at scan 4

Table 21. Correlation coefficients and levels of significance involving measurements taken at scan 1 and carcass traits.

| Trait | CWT[a] | REA[b] | FAT[c] | MarbScore[d] | KPH[e] | YG[f] | Epley[g] |
|---|---|---|---|---|---|---|---|
| Wt1[h] | 0.5793 | 0.0904 | 0.2979 | 0.0962 | 0.3805 | 0.3696 | -0.3977 |
| | <.0001 | 0.2629 | 0.0002 | 0.2334 | <.0001 | <.0001 | <.0001 |
| UREA1[i] | 0.0104 | 0.1463 | 0.0657 | 0.0857 | 0.0822 | -0.0579 | 0.0530 |
| | 0.8980 | 0.0701 | 0.4177 | 0.2902 | 0.3103 | 0.4752 | 0.5137 |
| UFAT1[j] | 0.0831 | 0.0935 | 0.2971 | 0.0841 | 0.2024 | 0.1225 | -0.0934 |
| | 0.3052 | 0.2484 | 0.0002 | 0.2992 | 0.0118 | 0.1301 | 0.2491 |
| UIMF1[k] | 0.1091 | 0.0208 | 0.2061 | 0.2975 | 0.0583 | 0.1440 | -0.0550 |
| | 0.1779 | 0.7971 | 0.0103 | 0.0002 | 0.4723 | 0.0747 | 0.4975 |
| Rump1[l] | 0.3334 | -0.0264 | 0.4728 | 0.1468 | 0.2704 | 0.4350 | -0.3223 |
| | <.0001 | 0.7586 | <.0001 | 0.0868 | 0.0014 | <.0001 | 0.0001 |
| GM1[m] | 0.1134 | 0.0740 | 0.0507 | 0.3614 | 0.2830 | 0.0759 | -0.1288 |
| | 0.1886 | 0.3915 | 0.5577 | 0.6762 | 0.0008 | 0.3797 | 0.1350 |

[a]Carcass weight

[b]Ribeye area

[c]Fat thickness over ribeye

[d]Marbling score

[e]Percent kidney, pelvic and heart fat

[f]Yield grade

[g]Percent retail product

[h]Weight at scan 1

[i]Ribeye area at scan 1

[j]Back fat at scan 1

[k]Percent intramuscular fat at scan 1

[l]Rump fat thickness at scan 1

[m]Depth of gluteus medius at scan 1

Table 22. Correlation coefficients and levels of significance involving measurements taken at scan 2 and carcass traits.

| Trait | CWT[a] | REA[b] | FAT[c] | MarbScore[d] | KPH[e] | YG[f] | Epley[g] |
|---|---|---|---|---|---|---|---|
| Wt2[h] | 0.6308 | 0.3436 | 0.2214 | 0.0444 | 0.2662 | 0.1431 | -0.2896 |
| | <.0001 | 0.0014 | 0.0430 | 0.6883 | 0.0144 | 0.1940 | 0.0075 |
| UREA2[i] | 0.2761 | 0.2989 | 0.0698 | 0.0465 | 0.3442 | 0.0302 | -0.2231 |
| | 0.0005 | 0.0002 | 0.3881 | 0.5654 | <.0001 | 0.7085 | 0.0053 |
| UFAT2[j] | 0.4195 | 0.0915 | 0.5519 | 0.1724 | 0.3003 | 0.4202 | -0.4667 |
| | <.0001 | 0.2572 | <.0001 | 0.0319 | 0.0001 | <.0001 | <.0001 |
| UIMF2[k] | 0.7814 | -0.1066 | 0.3144 | 0.4065 | 0.0690 | 0.2568 | -0.1567 |
| | 0.3338 | 0.1865 | <.0001 | <.0001 | 0.3932 | 0.0013 | 0.0515 |
| Rump2[l] | 0.4431 | -0.0261 | 0.5023 | 0.1592 | 0.3589 | 0.5131 | -0.4009 |
| | <.0001 | 0.7540 | <.0001 | 0.0549 | <.0001 | <.0001 | <.0001 |
| GM2[m] | 0.1120 | 0.0703 | 0.0346 | 0.1098 | 0.3314 | 0.0631 | -0.0857 |
| | 0.1796 | 0.4007 | 0.6795 | 0.1886 | <.0001 | 0.4504 | 0.3054 |

[a]Carcass weight

[b]Ribeye area

[c]Fat thickness over ribeye

[d]Marbling score

[e]Percent kidney, pelvic and heart fat

[f]Yield grade

[g]Percent retail product

[h]Weight at scan 2

[i]Ribeye area at scan 2

[j]Back fat at scan 2

[k]Percent intramuscular fat at scan 2

[l]Rump fat thickness at scan 2

[m]Depth of gluteus medius at scan 2

Table 23. Correlation coefficients and levels of significance involving measurements taken at scan 3 and carcass traits.

| Trait | CWT[a] | REA[b] | FAT[c] | MarbScore[d] | KPH[e] | YG[f] | Epley[g] |
|---|---|---|---|---|---|---|---|
| Wt3[h] | 0.6937 | 0.2215 | 0.4192 | 0.1733 | 0.4388 | 0.4190 | -0.3892 |
| | <.0001 | 0.0061 | <.0001 | 0.0327 | <.0001 | <.0001 | <.0001 |
| UREA3[i] | 0.4244 | 0.4933 | 0.0739 | 0.1147 | 0.2940 | -0.0463 | -0.3892 |
| | <.0001 | <.0001 | 0.3603 | 0.1550 | 0.0002 | 0.5672 | <.0001 |
| UFAT3[j] | 0.4357 | -0.0002 | 0.6869 | 0.1828 | 0.3980 | 0.5711 | -0.5852 |
| | <.0001 | 0.9976 | <.0001 | 0.0228 | <.0001 | <.0001 | <.0001 |
| UIMF3[k] | 0.0919 | 0.0560 | 0.3002 | 0.5285 | 0.1604 | 0.1611 | -0.0682 |
| | 0.2551 | 0.4889 | 0.0001 | <.0001 | 0.0461 | 0.0451 | 0.3987 |
| Rump3[l] | 0.4478 | -0.0044 | 0.4971 | 0.1987 | 0.5170 | 0.5252 | -0.5786 |
| | <.0001 | 0.9596 | <.0001 | 0.0218 | <.0001 | <.0001 | <.0001 |
| GM3[m] | 0.1870 | 0.1634 | 0.0173 | 0.1468 | 0.0377 | 0.0094 | -0.0358 |
| | 0.0359 | 0.0675 | 0.8471 | 0.1009 | 0.6747 | 0.9167 | 0.6899 |

[a]Carcass weight

[b]Ribeye area

[c]Fat thickness over ribeye

[d]Marbling score

[e]Percent kidney, pelvic and heart fat

[f]Yield grade

[g]Percent retail product

[h]Weight at scan 3

[i]Ribeye area at scan 3

[j]Back fat at scan 3

[k]Percent intramuscular fat at scan 3

[l]Rump fat thickness at scan 3

[m]Depth of gluteus medius at scan 3

Table 24. Correlation coefficients and levels of significance involving measurements taken at scan 4 and carcass traits.

| Trait | CWT[a] | REA[b] | FAT[c] | MarbScore[d] | KPH[e] | YG[f] | Epley[g] |
|---|---|---|---|---|---|---|---|
| Wt4[h] | 0.7903 | 0.4578 | 0.3410 | 0.0469 | 0.3676 | 0.2046 | -0.3861 |
| | <.0001 | <.0001 | 0.0015 | 0.6714 | 0.0006 | 0.0618 | 0.0003 |
| UREA4[i] | 0.5153 | 0.7514 | -0.0238 | 0.1606 | 0.2253 | -0.2839 | 0.1324 |
| | <.0001 | <.0001 | 0.8298 | 0.1443 | 0.0393 | 0.0089 | 0.2297 |
| UFAT4[j] | 0.4557 | 0.1652 | 0.7044 | 0.1876 | 0.5282 | 0.5014 | -0.6079 |
| | <.0001 | 0.1330 | <.0001 | 0.0278 | <.0001 | <.0001 | <.0001 |
| UIMF4[k] | 0.0355 | 0.2194 | 0.2132 | 0.6567 | 0.1130 | 0.0066 | -0.0205 |
| | 0.7483 | 0.0449 | 0.0515 | <.0001 | 0.3058 | 0.9524 | 0.8532 |
| Rump4[l] | 0.4478 | 0.1479 | 0.6113 | 0.0118 | 0.4343 | 0.4886 | -0.5384 |
| | <.0001 | 0.1960 | <.0001 | 0.9183 | <.0001 | <.0001 | <.0001 |
| GM4[m] | 0.3812 | 0.4593 | 0.1378 | -0.0093 | 0.2785 | -0.1048 | -0.0535 |
| | 0.0008 | <.0001 | 0.2414 | 0.9370 | 0.0163 | 0.3741 | 0.6504 |

[a]Carcass weight

[b]Ribeye area

[c]Fat thickness over ribeye

[d]Marbling score

[e]Percent kidney, pelvic and heart fat

[f]Yield grade

[g]Percent retail product

[h]Weight at scan 4

[i]Ribeye area at scan 4

[j]Back fat at scan 4

[k]Percent intramuscular fat at scan 4

[l]Rump fat thickness at scan 4

[m]Depth of gluteus medius at scan 4

Table 25. Correlation coefficients and levels of significance involving carcass trait measurements.

| Trait | REA[b] | FAT[c] | MarbScore[d] | KPH[e] | YG[f] | Epley[g] |
|---|---|---|---|---|---|---|
| CWT[a] | 0.3294 | 0.4845 | 0.2212 | 0.3061 | 0.4796 | -0.5049 |
| | <.0001 | <.0001 | 0.0057 | 0.0001 | <.0001 | <.0001 |
| REA[b] | | -0.1149 | 0.0838 | 0.1496 | -0.5194 | 0.2457 |
| | | 0.1545 | 0.2994 | 0.0631 | <.0001 | 0.0021 |
| FAT[c] | | | 0.3122 | 0.4132 | 0.7769 | -0.5994 |
| | | | <.0001 | <.0001 | <.0001 | <.0001 |
| MarbScore[d] | | | | 0.3211 | 0.2357 | -0.2095 |
| | | | | <.0001 | 0.0031 | 0.0089 |
| KPH[e] | | | | | 0.3657 | -0.3933 |
| | | | | | <.0001 | <.0001 |
| YG[f] | | | | | | -0.6904 |
| | | | | | | <.0001 |

[a]Carcass weight

[b]Ribeye area

[c]Fat thickness over ribeye

[d]Marbling score

[e]Percent kidney, pelvic and heart fat

[f]Yield grade

[g]Percent retail product

Table 26. Correlation coefficients and levels of significance involving measurements taken at scan 1 and end values.

| Trait | GridA[a] | GridB[b] | GridC[c] | LiveValue[d] | Cvalue[e] |
|---|---|---|---|---|---|
| Wt1[f] | 0.4385 | 0.3803 | 0.3115 | 0.6968 | 0.6904 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UREA1[g] | 0.0161 | 0.0425 | 0.0545 | 0.0109 | 0.0527 |
| | 0.8420 | 0.6002 | 0.5021 | 0.8932 | 0.5175 |
| UFAT1[h] | 0.0828 | 0.1136 | 0.1227 | 0.1410 | 0.1573 |
| | 0.3068 | 0.1604 | 0.1294 | 0.0810 | 0.0520 |
| UIMF1[i] | 0.1089 | 0.1752 | 0.2058 | 0.1536 | 0.2096 |
| | 0.1784 | 0.0297 | 0.0104 | 0.0571 | 0.0093 |
| Rump1[j] | 0.2146 | 0.2111 | 0.1876 | 0.3491 | 0.3824 |
| | 0.0118 | 0.0133 | 0.0281 | <.0001 | <.0001 |
| GM1[k] | 0.0952 | 0.0957 | 0.0863 | 0.1760 | 0.1737 |
| | 0.2699 | 0.2674 | 0.3173 | 0.0404 | 0.0439 |

[a]Grid A carcass price

[b]Grid B carcass price

[c]Grid C carcass price

[d]Steer end value on a live basis

[e]Carcass value by quality grade basis

[f]Weight at scan 1

[g]Ribeye area at scan 1

[h]Backfat at scan 1

[i]Percent intramuscular fat at scan 1

[j]Rump fat thickness at scan 1

[k]Depth of gluteus medius at scan 1

Table 27. Correlation coefficients and levels of significance involving measurements taken at scan 2 and end values.

| Trait | GridA[a] | GridB[b] | GridC[c] | LiveValue[d] | Cvalue[e] |
|---|---|---|---|---|---|
| Wt2[f] | 0.5290 | 0.4413 | 0.3580 | 0.7521 | 0.7651 |
| | <.0001 | <.0001 | 0.0008 | <.0001 | <.0001 |
| UREA2[g] | 0.2336 | 0.1780 | 0.1387 | 0.3691 | 0.3599 |
| | 0.0034 | 0.0198 | 0.0851 | <.0001 | <.0001 |
| UFAT2[h] | 0.3194 | 0.3207 | 0.2937 | 0.4980 | 0.5377 |
| | <.0001 | <.0001 | 0.0002 | <.0001 | <.0001 |
| UIMF2[i] | 0.0975 | 0.2229 | 0.2842 | 0.0985 | 0.1915 |
| | 0.2272 | 0.0053 | 0.0003 | 0.2225 | 0.0173 |
| Rump2[j] | 0.3294 | 0.3067 | 0.2645 | 0.4866 | 0.4976 |
| | <.0001 | 0.0002 | 0.0013 | <.0001 | <.0001 |
| GM2[k] | 0.1024 | 0.0953 | 0.0818 | 0.2228 | 0.2311 |
| | 0.2200 | 0.2540 | 0.3280 | 0.0071 | 0.0053 |

[a]Grid A carcass price

[b]Grid B carcass price

[c]Grid C carcass price

[d]Steer end value on a live basis

[e]Carcass value by quality grade basis

[f]Weight at scan 2

[g]Ribeye area at scan 2

[h]Backfat at scan 2

[i]Percent intramuscular fat at scan 2

[j]Rump fat thickness at scan 2

[k]Depth of gluteus medius at scan 2

Table 28. Correlation coefficients and levels of significance involving measurements taken at scan 3 and end values.

| Trait | GridA[a] | GridB[b] | GridC[c] | LiveValue[d] | Cvalue[e] |
|---|---|---|---|---|---|
| Wt3[f] | 0.5660 | 0.5160 | 0.4450 | 0.7846 | 0.7564 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UREA3[g] | 0.4642 | 0.4203 | 0.3609 | 0.4988 | 0.4415 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UFAT3[h] | 0.3108 | 0.3230 | 0.3082 | 0.5127 | 0.5704 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UIMF3[i] | 0.1624 | 0.3306 | 0.4168 | 0.1302 | 0.2280 |
| | 0.0435 | <.0001 | <.0001 | 0.1063 | 0.0044 |
| Rump3[j] | 0.3011 | 0.2923 | 0.2599 | 0.5282 | 0.5545 |
| | 0.0004 | 0.0006 | 0.0025 | <.0001 | <.0001 |
| GM3[k] | 0.1853 | 0.1793 | 0.1750 | 0.1777 | 0.1473 |
| | 0.0378 | 0.0445 | 0.0500 | 0.0464 | 0.1000 |

[a]Grid A carcass price

[b]Grid B carcass price

[c]Grid C carcass price

[d]Steer end value on a live basis

[e]Carcass value by quality grade basis

[f]Weight at scan 3

[g]Ribeye area at scan 3

[h]Backfat at scan 3

[i]Percent intramuscular fat at scan 3

[j]Rump fat thickness at scan 3

[k]Depth of gluteus medius at scan 3

Table 29. Correlation coefficients and levels of significance involving measurements taken at scan 4 and end values.

| Trait | GridA[a] | GridB[b] | GridC[c] | LiveValue[d] | Cvalue[e] |
|---|---|---|---|---|---|
| Wt4[f] | 0.6580 | 0.5363 | 0.4261 | 0.8954 | 0.8934 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UREA4[g] | 0.6171 | 0.5446 | 0.4535 | 0.5602 | 0.5145 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| UFAT4[h] | 0.3234 | 0.2945 | 0.2594 | 0.5626 | 0.6021 |
| | 0.0027 | 0.0065 | 0.0172 | <.0001 | <.0001 |
| UIMF4[i] | 0.2197 | 0.4132 | 0.5071 | 0.0766 | 0.1227 |
| | 0.0446 | <.0001 | <.0001 | 0.4882 | 0.2689 |
| Rump4[j] | 0.3051 | 0.2557 | 0.2034 | 0.5062 | 0.4920 |
| | 0.0066 | 0.0238 | 0.0740 | <.0001 | <.0001 |
| GM4[k] | 0.3256 | 0.2544 | 0.2057 | 0.4428 | 0.4422 |
| | 0.0046 | 0.0287 | 0.0786 | <.0001 | <.0001 |

[a]Grid A carcass price

[b]Grid B carcass price

[c]Grid C carcass price

[d]Steer end value on a live basis

[e]Carcass value by quality grade basis

[f]Weight at scan 4

[g]Ribeye area at scan 4

[h]Backfat at scan 4

[i]Percent intramuscular fat at scan 4

[j]Rump fat thickness at scan 4

[k]Depth of gluteus medius at scan 4

Table 30. Final models to predict Epley for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.16 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.12 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.16 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.18 |
| | Phase 2[b] | | |
| Scan 1 | Wt1,Rump1 | Wt1,Rump1 | 0.20 |
| Scan 2 | Wt2,GM2,Rump2 | Rump2 | 0.21 |
| Scan 3 | Wt3,UFAT3,Rump3,UREA3 | UFAT3 | 0.30 |
| Scan 4 | Wt4,UFAT4,UREA4,Rump4 | Wt4,UFAT4,UREA4,Rump4 | 0.55 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1,Rump1 | Wt1,Rump1 | 0.23 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2,GM2,Rump2 | Wt2,Rump2 | 0.27 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UFAT3,Rump3,UREA3 | Ranch,UFAT3 | 0.48 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4,UFAT4,UREA4,Rump4 | Ranch,UREA4,UFAT4 | 0.63 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1,Rump1 | Ranch,Rump1 | 0.63 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2,GM2,Rump2 | Sire(Ranch),Rump2 | 0.66 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3,UFAT3,Rump3,UREA3 | Sire(Ranch),Ranch,UFAT3,Rump3 | 0.76 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4,UFAT4,UREA4,Rump4 | Sire(Ranch),Ranch,UFAT4,UREA4,Rump4 | 0.80 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 31. Final models to predict yield grade for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | MSCORE,Wt1 | 0.20 |
| Scan 2 | FRAME,MSCORE,Wt2 | MSCORE,Wt2 | 0.10 |
| Scan 3 | FRAME,MSCORE,Wt3 | MSCORE,Wt3 | 0.21 |
| Scan 4 | FRAME,MSCORE,Wt4 | MSCORE,Wt4 | 0.10 |
| | Phase 2[b] | | |
| Scan 1 | Rump1,Wt1 | Rump1,Wt1 | 0.25 |
| Scan 2 | Wt2,UFAT2,UREA2,Rump2 | Rump2 | 0.24 |
| Scan 3 | Wt3,UFAT3,Rump3 | UFAT3,Rump3 | 0.41 |
| Scan 4 | UFAT4,Rump4,GM4,UREA4 | UFAT4,Rump4,UREA4 | 0.47 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Rump1,Wt1 | Ranch,Rump1,Wt1 | 0.34 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2,UFAT2,UREA2,Rump2 | Ranch,Rump2 | 0.31 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UFAT3,Rump3 | Ranch,Wt3,UFAT3,Rump3 | 0.54 |
| Scan 4 | Ranch,FRAME,MSCORE,UFAT4,Rump4,GM4,UREA4 | Ranch,UFAT4,Rump4,UREA4 | 0.58 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Rump1,Wt1 | Ranch,Rump1 | 0.61 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2,UFAT2,UREA2,Rump2 | Sire(Ranch),Ranch,Rump2 | 0.69 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3,UFAT3,Rump3 | Ranch,Rump3 | 0.76 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,UFAT4,Rump4,GM4,UREA4 | Ranch,Rump4,GM4 | 0.81 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 32. Final models to predict carcass weight for different phases of analysis at each scan session

| | Phase 1[a] | | |
|---|---|---|---|
| Scan Sessions | Variables | P < 0.10 | R-Square |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.36 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.42 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.49 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.68 |
| | Phase 2[b] | | |
| Scan 1 | Wt1 | Wt1 | 0.34 |
| Scan 2 | Wt2 | Wt2 | 0.40 |
| Scan 3 | WT3,UREA3,UFAT3 | Wt3,UFAT3 | 0.50 |
| Scan 4 | Wt4,UREA4 | Wt4,UREA4 | 0.70 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1 | Ranch,MSCORE,Wt1 | 0.46 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2 | Ranch,Wt2 | 0.49 |
| Scan 3 | Ranch,FRAME,MSCORE,WT3,UREA3UFAT3 | Ranch,Wt3,UREA3,UFAT3 | 0.58 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4,UREA4 | Ranch,Wt4,UREA4 | 0.76 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1 | MSCORE,Wt1 | 0.64 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2 | Wt2 | 0.72 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,WT3,UREA3,UFAT3 | Wt3 | 0.75 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4,UREA4 | Wt4 | 0.86 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 33. Final models to predict live value for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Hmuscle,Wt1 | 0.50 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.59 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.62 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.85 |
| | Phase 2[b] | | |
| Scan 1 | Wt1 | Wt1 | 0.48 |
| Scan 2 | Wt2 | Wt2 | 0.60 |
| Scan 3 | Wt3 | Wt3 | 0.61 |
| Scan 4 | Wt4 | Wt4 | 0.80 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1 | Ranch,Hmuscle,Wt1 | 0.53 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2 | Wt2 | 0.61 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3 | Wt3 | 0.63 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4 | Wt4 | 0.81 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1 | Wt1 | 0.65 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2 | Wt2 | 0.74 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3 | Wt3 | 0.78 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4 | Wt4 | 0.92 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 34. Final models to predict carcass value for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | MSCORE,Wt1 | 0.49 |
| Scan 2 | FRAME,MSCORE,Wt2 | FRAME,MSCORE,Wt2 | 0.62 |
| Scan 3 | FRAME,MSCORE,Wt3 | FRAME,Wt3 | 0.59 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.86 |
| | Phase 2[b] | | |
| Scan 1 | Wt1 | Wt1 | 0.47 |
| Scan 2 | Wt2 | Wt2 | 0.58 |
| Scan 3 | Wt3,UIMF3 | Wt3,UIMF3 | 0.58 |
| Scan 4 | Wt4 | Wt4 | 0.80 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1 | MSCORE,Wt1 | 0.51 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2 | Wt2 | 0.63 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UIMF3 | FRAME,Wt3,UIMF3 | 0.63 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4 | Wt4 | 0.81 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1 | Wt1 | 0.64 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2 | Wt2 | 0.73 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3,UIMF3 | Wt3 | 0.79 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4 | Wt4 | 0.91 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 35. Final models to predict arcas carcass ribeye area for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | MSCORE | 0.06 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.16 |
| Scan 3 | FRAME,MSCORE,Wt3 | Hmuscle,Wt3 | 0.16 |
| Scan 4 | FRAME,MSCORE,Wt4 | Hframe,Wt4 | 0.27 |
| | Phase 2[b] | | |
| Scan 1 | UREA1 | MSCORE | 0.02 |
| Scan 2 | UREA2,Wt2,GM2 | UREA2,GM2 | 0.22 |
| Scan 3 | UREA3,GM3 | UREA3 | 0.24 |
| Scan 4 | UREA4,GM4 | UREA4,GM4 | 0.61 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,UREA1 | Ranch | 0.20 |
| Scan 2 | Ranch,FRAME,MSCORE,UREA2,Wt2,GM2 | Ranch,UREA2 | 0.40 |
| Scan 3 | Ranch,FRAME,MSCORE,UREA3,GM2 | Ranch,UREA3 | 0.38 |
| Scan 4 | Ranch,FRAME,MSCORE,UREA4,GM4 | Ranch,UREA4 | 0.65 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,HframeHmuscle,UREA1 | Ranch,MSCORE | 0.65 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,UREA2,Wt2,GM2 | Sire(Ranch),Ranch,MSCORE,UREA2,GM2 | 0.75 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,UREA3,GM3 | Ranch,UREA3 | 0.78 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,UREA4,GM4 | Ranch,UREA4 | 0.82 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 36. Final models to predict carcass fat thickness for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.11 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.12 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.18 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.18 |
| | Phase 2[b] | | |
| Scan 1 | UFAT1,Rump1 | UFAT1,Rump1 | 0.25 |
| Scan 2 | UFAT2,Rump2 | UFAT2,Rump2 | 0.36 |
| Scan 3 | UFAT3,Rump3 | UFAT3 | 0.51 |
| Scan 4 | UFAT4,Rump4 | UFAT4,Rump4 | 0.56 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,UFAT1,Rump1 | UFAT1,Rump1 | 0.28 |
| Scan 2 | Ranch,FRAME,MSCORE,UFAT2,Rump2 | UFAT2,Rump2 | 0.38 |
| Scan 3 | Ranch,FRAME,MSCORE,UFAT3,Rump3 | UFAT3,Rump3 | 0.54 |
| Scan 4 | Ranch,FRAME,MSCORE,UFAT4,Rump4 | Ranch,UFAT4 | 0.62 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,UFAT1,Rump1 | none | 0.47 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,UFAT2,Rump2 | FRAME,UFAT2,Rump2 | 0.61 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,UFAT3,Rump3 | Sire(Ranch),UFAT3,Rump3 | 0.77 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,UFAT4,Rump4 | UFAT4 | 0.77 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 37. Final models to predict carcass marbling score for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | none | 0.02 |
| Scan 2 | FRAME,MSCORE,Wt2 | none | 0.04 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.05 |
| Scan 4 | FRAME,MSCORE,Wt4 | FRAME | 0.10 |
| | Phase 2[b] | | |
| Scan 1 | UIMF1, Rump1 | UIMF1 | 0.14 |
| Scan 2 | UIMF2, UFAT2 | UIMF2 | 0.17 |
| Scan 3 | UIMF3, GM3 | UIMF3, GM3 | 0.42 |
| Scan 4 | UIMF4, Rump4 | UIMF4 | 0.54 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,UIMF1,Rump1 | Ranch, FRAME | 0.35 |
| Scan 2 | Ranch,FRAME,MSCORE,UIMF2,UFAT2 | UIMF2, FRAME | 0.35 |
| Scan 3 | Ranch,FRAME,MSCORE,UIMF3,GM3 | UIMF3 | 0.47 |
| Scan 4 | Ranch,FRAME,MSCORE,UIMF4,Rump4 | UIMF4 | 0.55 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,UIMF1,Rump1 | FRAME | 0.56 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,UIMF2,UBF2 | UIMF2, FRAME | 0.59 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,UIMF3,GM3 | UIMF3, FRAME | 0.65 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,UIMF4,Rump4 | UIMF4, FRAME | 0.76 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 38. Final models to predict GridA for different phases of analysis at each scan session

| Scan Sessions | Variables | $P < 0.10$ | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.20 |
| Scan 2 | FRAME,MSCORE,Wt2 | Wt2 | 0.29 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.32 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.51 |
| | Phase 2[b] | | |
| Scan 1 | Wt1 | Wt1 | 0.19 |
| Scan 2 | Wt2,UREA2 | Wt2,UREA2 | 0.33 |
| Scan 3 | Wt3,UREA3 | Wt3,UREA3 | 0.36 |
| Scan 4 | Wt4,UREA4 | Wt4,UREA4 | 0.55 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1 | Ranch,Wt1 | 0.28 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2,UREA2 | Wt2 | 0.40 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UREA3 | Wt3,UREA3 | 0.41 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4,UREA4 | Wt4,UREA4 | 0.57 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1 | none | 0.49 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2,UREA2 | Wt2,UREA2 | 0.61 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3,UREA3 | Wt3 | 0.64 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4,UREA4 | Wt4,UREA4 | 0.73 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 39. Final models to predict GridB for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
| --- | --- | --- | --- |
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.14 |
| Scan 2 | FRAME,MSCORE,Wt2 | FRAME,Wt2 | 0.22 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.26 |
| Scan 4 | FRAME,MSCORE,Wt4 | Wt4 | 0.31 |
| | Phase 2[b] | | |
| Scan 1 | Wt1,UIMF1 | Wt1,UIMF1 | 0.19 |
| Scan 2 | Wt2,UIMF2 | Wt2,UIMF2 | 0.25 |
| Scan 3 | Wt3,UIMF3 | Wt3,UIMF3 | 0.32 |
| Scan 4 | Wt4,UIMF4 | Wt4,UIMF4 | 0.41 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1,UIMF1 | FRAME,Wt1,UIMF1 | 0.23 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2,UIMF2 | Wt2,UIMF2 | 0.30 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UIMF3 | Wt3,UIMF3 | 0.35 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4,UIMF4 | Wt4,UIMF4 | 0.51 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1,UIMF1 | none | 0.42 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2 | FRAME,Wt2,UIMF2 | 0.56 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3 | Wt3,UIMF3 | 0.60 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4,UIMF4 | Wt4,UIMF4 | 0.69 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 40. Final models to predict GridC for different phases of analysis at each scan session

| Scan Sessions | Variables | P < 0.10 | R-Square |
|---|---|---|---|
| | Phase 1[a] | | |
| Scan 1 | FRAME,MSCORE,Wt1 | Wt1 | 0.09 |
| Scan 2 | FRAME,MSCORE,Wt2 | FRAME,Wt2 | 0.16 |
| Scan 3 | FRAME,MSCORE,Wt3 | Wt3 | 0.20 |
| Scan 4 | FRAME,MSCORE,Wt4 | FRAME,Wt4 | 0.26 |
| | Phase 2[b] | | |
| Scan 1 | Wt1,UIMF1 | Wt1,UIMF1 | 0.14 |
| Scan 2 | Wt2,UIMF2 | Wt2,UIMF2 | 0.21 |
| Scan 3 | Wt3,UREA3,UIMF3 | Wt3,UREA3,UIMF3 | 0.36 |
| Scan 4 | Wt4,UREA4,UIMF4 | Wt4,UREA4,UIMF4 | 0.44 |
| | Phase 3[c] | | |
| Scan 1 | Ranch,FRAME,MSCORE,Wt1,UIMF1 | Wt1,UIMF1 | 0.17 |
| Scan 2 | Ranch,FRAME,MSCORE,Wt2,UIMF2 | Wt2,UIMF2 | 0.26 |
| Scan 3 | Ranch,FRAME,MSCORE,Wt3,UREA3,UIMF3 | Wt3,UREA3,UIMF3 | 0.39 |
| Scan 4 | Ranch,FRAME,MSCORE,Wt4,UIMF4 | Wt4,UREA4,UIMF4 | 0.48 |
| | Phase 4[d] | | |
| Scan 1 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt1,UIMF1 | none | 0.38 |
| Scan 2 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt2 | FRAME,Wt2,UIMF2 | 0.51 |
| Scan 3 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt3 | UREA3,UIMF3 | 0.61 |
| Scan 4 | Sire(Ranch),Ranch,FRAME,MSCORE,Wt4,UIMF4 | Wt4,UIMF4 | 0.65 |

[a]Final models using FRAME, MSCORE, and Wt only

[b]Final models using ultrasound data and Wt only

[c]Final models combining data from Phases 1 and 2 with Ranch

[d]Final models using variables from Phase 3 with Sire nested within Ranch

Table 41. Least squares means for Sires when predicting Epley at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 68.71 | 68.83 | 69.51 | 69.63 | 68.41 | 12 |
| 2 | A | 68.30 | 68.76 | 68.41 | 68.34 | 68.66 | 10 |
| 3 | A | 70.84 | 68.40 | 68.13 | 67.90 | 69.20 | 4 |
| 4 | A | 72.35 | 69.66 | 68.29 | 68.34 | 70.77 | 1 |
| 5 | A | 69.09 | 69.79 | 69.08 | 69.29 | 69.40 | 2 |
| 6 | B | 65.08 | 67.32 | 69.40 | | 67.02 | 1 |
| 7 | B | 65.12 | 64.23 | 65.63 | 66.15 | 64.76 | 1 |
| 8 | B | 68.63 | 68.28 | 67.34 | 67.30 | 69.79 | 1 |
| 9 | B | 69.36 | 68.96 | 68.96 | 69.55 | 69.58 | 2 |
| 10 | B | 66.50 | 67.55 | 67.17 | 66.02 | 65.85 | 1 |
| 11 | B | 70.27 | 69.15 | 70.84 | 68.38 | 67.95 | 1 |
| 12 | C | 70.08 | 70.22 | 69.75 | 69.18 | 70.04 | 4 |
| 13 | C | 71.87 | 67.38 | 70.48 | 69.26 | 69.10 | 2 |
| 14 | C | 68.28 | 66.05 | 67.90 | 67.04 | 68.18 | 1 |
| 15 | C | 69.79 | 68.70 | 67.53 | 67.55 | 66.40 | 1 |
| 16 | C | 71.94 | 71.76 | 71.08 | 68.52 | 70.71 | 1 |
| 17 | C | 65.15 | 65.25 | 64.88 | 64.32 | 64.41 | 1 |
| 18 | D | 67.59 | 66.85 | 66.79 | 67.00 | 67.44 | 2 |
| 19 | D | 68.12 | 68.31 | 65.59 | 66.60 | 67.67 | 2 |
| 20 | D | 70.30 | 67.70 | 67.83 | 68.29 | 67.88 | 4 |
| 21 | D | 67.75 | 68.94 | 69.38 | 68.29 | 69.78 | 3 |
| 22 | D | 64.37 | 63.94 | 65.35 | 65.21 | 65.59 | 2 |
| 23 | D | 67.45 | 66.17 | 66.66 | 67.28 | 67.04 | 2 |
| 24 | D | 68.59 | 68.51 | 65.36 | 66.86 | 67.80 | 2 |

Table 42. Least square means for Sires when predicting marbling score at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 459.71 | 441.82 | 436.07 | 438.67 | 458.00 | 12 |
| 2 | A | 484.82 | 476.81 | 473.48 | 453.58 | 483.00 | 10 |
| 3 | A | 470.72 | 446.59 | 461.57 | 459.32 | 465.00 | 4 |
| 4 | A | 522.47 | 518.46 | 483.91 | 463.17 | 550.00 | 1 |
| 5 | A | 489.89 | 473.49 | 485.97 | 487.53 | 495.00 | 2 |
| 6 | B | 460.58 | 483.55 | 445.00 | 443.25 | 440.00 | 1 |
| 7 | B | 505.21 | 506.54 | 515.19 | 509.03 | 440.00 | 1 |
| 8 | B | 514.58 | 511.09 | 516.36 | 538.90 | 480.00 | 1 |
| 9 | B | 421.05 | 403.82 | 441.78 | 451.98 | 410.00 | 2 |
| 10 | B | 433.05 | 432.57 | 454.58 | 436.13 | 420.00 | 1 |
| 11 | B | 422.24 | 418.50 | 407.55 | 407.25 | 400.00 | 1 |
| 12 | C | 428.96 | 438.41 | 438.27 | 435.45 | 462.50 | 4 |
| 13 | C | 396.26 | 435.36 | 404.34 | 438.72 | 455.00 | 2 |
| 14 | C | 482.32 | 460.86 | 480.00 | 483.73 | 470.00 | 1 |
| 15 | C | 511.53 | 493.30 | 492.89 | 471.38 | 530.00 | 1 |
| 16 | C | 390.09 | 421.77 | 412.16 | 428.69 | 420.00 | 1 |
| 17 | C | 376.00 | 392.27 | 404.72 | 424.62 | 400.00 | 1 |
| 18 | D | 435.98 | 445.59 | 465.73 | 469.65 | 410.00 | 2 |
| 19 | D | 431.73 | 418.94 | 458.08 | 514.82 | 420.00 | 2 |
| 20 | D | 450.58 | 456.30 | 451.39 | 449.06 | 447.50 | 4 |
| 21 | D | 422.72 | 430.50 | 464.72 | 471.94 | 420.00 | 3 |
| 22 | D | 454.67 | 475.29 | 490.09 | 483.46 | 425.00 | 2 |
| 23 | D | 427.30 | 439.26 | 466.28 | 440.13 | 450.00 | 2 |
| 24 | D | 472.22 | 503.85 | 468.70 | 501.01 | 457.00 | 2 |

Table 43. Least square means for Sires when predicting yield grade at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 2.77 | 2.82 | 2.67 | 2.60 | 2.89 | 12 |
| 2 | A | 2.93 | 2.86 | 2.86 | 2.74 | 2.78 | 10 |
| 3 | A | 2.33 | 2.69 | 2.50 | 2.58 | 2.35 | 4 |
| 4 | A | 2.05 | 2.59 | 3.09 | 3.38 | 2.28 | 1 |
| 5 | A | 2.83 | 2.40 | 2.68 | 2.45 | 2.53 | 2 |
| 6 | B | 3.52 | 2.90 | 2.38 | | 2.99 | 1 |
| 7 | B | 3.62 | 3.77 | 3.38 | 2.61 | 3.71 | 1 |
| 8 | B | 3.03 | 3.00 | 3.12 | 2.84 | 2.29 | 1 |
| 9 | B | 2.72 | 2.58 | 2.87 | 2.77 | 2.53 | 2 |
| 10 | B | 3.65 | 3.41 | 3.59 | 3.60 | 3.66 | 1 |
| 11 | B | 2.68 | 2.72 | 2.46 | 2.65 | 3.17 | 1 |
| 12 | C | 2.54 | 2.56 | 2.71 | 2.74 | 2.50 | 4 |
| 13 | C | 1.94 | 3.10 | 2.31 | 2.70 | 2.74 | 2 |
| 14 | C | 2.78 | 3.18 | 2.76 | 3.13 | 2.65 | 1 |
| 15 | C | 2.55 | 3.08 | 3.40 | 3.48 | 3.66 | 1 |
| 16 | C | 1.77 | 1.75 | 1.88 | 3.00 | 2.05 | 1 |
| 17 | C | 3.58 | 3.86 | 3.54 | 4.16 | 3.81 | 1 |
| 18 | D | 3.57 | 3.87 | 3.86 | 3.45 | 3.65 | 2 |
| 19 | D | 3.31 | 3.18 | 3.80 | 3.41 | 3.32 | 2 |
| 20 | D | 2.43 | 3.14 | 3.05 | 2.95 | 3.17 | 4 |
| 21 | D | 3.10 | 2.74 | 2.76 | 2.82 | 2.68 | 3 |
| 22 | D | 4.00 | 4.15 | 3.85 | 3.78 | 3.75 | 2 |
| 23 | D | 3.56 | 3.88 | 3.69 | 3.57 | 3.54 | 2 |
| 24 | D | 3.07 | 2.73 | 3.28 | 3.38 | 3.12 | 2 |

Table 44. Least square means for Sires when predicting carcass weight at each ultrasound scan session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 731.93 | 727.18 | 734.34 | 738.25 | 761.88 | 12 |
| 2 | A | 752.28 | 760.72 | 755.19 | 760.96 | 777.25 | 10 |
| 3 | A | 775.77 | 789.61 | 773.08 | 782.01 | 764.63 | 4 |
| 4 | A | 798.74 | 782.55 | 801.64 | 802.54 | 782.00 | 1 |
| 5 | A | 747.77 | 744.19 | 748.71 | 761.21 | 744.50 | 2 |
| 6 | B | 751.77 | 755.71 | 753.10 | 761.37 | 853.00 | 1 |
| 7 | B | 830.43 | 831.15 | 829.76 | 817.60 | 828.00 | 1 |
| 8 | B | 717.07 | 736.31 | 757.79 | 776.59 | 776.00 | 1 |
| 9 | B | 722.88 | 732.77 | 758.34 | 739.57 | 759.25 | 2 |
| 10 | B | 829.56 | 812.69 | 812.64 | 816.56 | 822.50 | 1 |
| 11 | B | 857.58 | 798.44 | 777.63 | 751.77 | 857.50 | 1 |
| 12 | C | 776.31 | 779.12 | 769.30 | 787.15 | 776.00 | 4 |
| 13 | C | 774.33 | 784.69 | 774.12 | 793.54 | 761.75 | 2 |
| 14 | C | 806.48 | 801.56 | 794.99 | 762.08 | 809.00 | 1 |
| 15 | C | 806.99 | 800.70 | 802.52 | 791.53 | 825.50 | 1 |
| 16 | C | 758.81 | 749.88 | 764.59 | 775.18 | 761.50 | 1 |
| 17 | C | 831.05 | 832.03 | 831.13 | 832.60 | 869.00 | 1 |
| 18 | D | 712.46 | 739.62 | 705.22 | 766.86 | 677.25 | 2 |
| 19 | D | 764.83 | 769.08 | 779.13 | 773.53 | 765.00 | 2 |
| 20 | D | 780.08 | 792.09 | 788.76 | 782.39 | 750.25 | 4 |
| 21 | D | 800.53 | 788.31 | 800.05 | 799.56 | 763.83 | 3 |
| 22 | D | 766.50 | 790.07 | 765.53 | 771.08 | 783.00 | 2 |
| 23 | D | 742.93 | 745.64 | 752.20 | 773.71 | 751.50 | 2 |
| 24 | D | 807.70 | 799.45 | 794.66 | 818.98 | 744.25 | 2 |

Table 45. Least square means for Sires when predicting live value at each ultrasound scan session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 1013.64 | 1005.58 | 1014.62 | 1021.01 | 1054.37 | 12 |
| 2 | A | 1011.27 | 1022.68 | 1014.36 | 1023.10 | 1045.52 | 10 |
| 3 | A | 1025.06 | 1049.42 | 1032.38 | 1043.94 | 1010.39 | 4 |
| 4 | A | 1055.09 | 1037.40 | 1072.39 | 1075.53 | 1033.35 | 1 |
| 5 | A | 988.78 | 985.84 | 988.46 | 1014.54 | 983.80 | 2 |
| 6 | B | 1058.67 | 1055.48 | 1045.68 | 1054.72 | 1196.90 | 1 |
| 7 | B | 1098.06 | 1093.04 | 1082.06 | 1064.47 | 1094.14 | 1 |
| 8 | B | 944.96 | 968.97 | 990.54 | 1031.31 | 1025.42 | 1 |
| 9 | B | 984.68 | 998.50 | 1028.42 | 1008.91 | 1034.90 | 2 |
| 10 | B | 987.17 | 989.66 | 982.64 | 984.87 | 1086.87 | 1 |
| 11 | B | 1203.93 | 1110.36 | 1054.27 | 1021.47 | 1203.21 | 1 |
| 12 | C | 1027.05 | 1030.97 | 1010.07 | 1044.11 | 1025.42 | 4 |
| 13 | C | 1024.82 | 1043.33 | 1031.97 | 1062.19 | 1006.59 | 2 |
| 14 | C | 1065.58 | 1060.15 | 1051.25 | 998.88 | 1069.03 | 1 |
| 15 | C | 1064.44 | 1057.50 | 1068.28 | 1044.97 | 1090.83 | 1 |
| 16 | C | 1003.63 | 992.03 | 1016.25 | 1033.84 | 1006.26 | 1 |
| 17 | C | 1097.55 | 1096.70 | 1110.40 | 1095.86 | 1148.32 | 1 |
| 18 | D | 943.30 | 985.10 | 926.20 | 1033.11 | 894.93 | 2 |
| 19 | D | 1041.15 | 1049.51 | 1066.39 | 1059.29 | 1041.40 | 2 |
| 20 | D | 1032.96 | 1051.70 | 1048.51 | 1038.37 | 991.40 | 4 |
| 21 | D | 1060.56 | 1042.86 | 1054.93 | 1059.35 | 1009.35 | 3 |
| 22 | D | 1012.45 | 1043.28 | 999.21 | 1010.78 | 1034.67 | 2 |
| 23 | D | 982.40 | 987.31 | 997.90 | 1032.63 | 993.05 | 2 |
| 24 | D | 1071.24 | 1059.55 | 1058.83 | 1090.70 | 983.47 | 2 |

Table 46. Least square means for Sires when predicting carcass value at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 1015.29 | 1006.49 | 1005.81 | 1021.64 | 1054.93 | 12 |
| 2 | A | 1010.16 | 1021.04 | 1003.61 | 1021.08 | 1043.84 | 10 |
| 3 | A | 1016.48 | 1043.62 | 1018.19 | 1038.34 | 1004.30 | 4 |
| 4 | A | 1047.67 | 1033.80 | 1054.67 | 1072.84 | 1026.84 | 1 |
| 5 | A | 982.25 | 980.79 | 980.36 | 1009.91 | 977.60 | 2 |
| 6 | B | 1066.12 | 1057.16 | 1042.86 | 1054.92 | 1199.92 | 1 |
| 7 | B | 1091.81 | 1082.86 | 1088.38 | 1052.60 | 1087.25 | 1 |
| 8 | B | 940.53 | 961.99 | 9991.43 | 1024.86 | 1018.97 | 1 |
| 9 | B | 984.38 | 997.87 | 1035.35 | 1008.14 | 1033.17 | 2 |
| 10 | B | 989.46 | 1004.24 | 1054.49 | 1062.36 | 1080.02 | 1 |
| 11 | B | 1207.73 | 1109.22 | 1046.27 | 1016.63 | 1206.25 | 1 |
| 12 | C | 1022.14 | 1025.98 | 1006.65 | 1039.01 | 1018.97 | 4 |
| 13 | C | 1018.81 | 1039.59 | 1033.26 | 1058.98 | 1000.25 | 2 |
| 14 | C | 1057.66 | 1053.36 | 1041.48 | 990.71 | 1062.30 | 1 |
| 15 | C | 1058.67 | 1053.17 | 1058.42 | 1040.24 | 1083.96 | 1 |
| 16 | C | 998.49 | 987.79 | 1018.30 | 1030.10 | 999.93 | 1 |
| 17 | C | 1093.53 | 1091.21 | 1115.53 | 1089.70 | 1141.08 | 1 |
| 18 | D | 935.38 | 978.72 | 927.31 | 1027.85 | 889.30 | 2 |
| 19 | D | 1024.17 | 1033.61 | 1064.38 | 1071.41 | 1028.81 | 2 |
| 20 | D | 1031.34 | 1050.93 | 1055.84 | 1037.27 | 990.56 | 4 |
| 21 | D | 1053.78 | 1036.13 | 1059.40 | 1052.42 | 1002.99 | 3 |
| 22 | D | 1006.59 | 1035.23 | 1006.36 | 1001.55 | 1028.16 | 2 |
| 23 | D | 977.68 | 983.24 | 1012.27 | 1029.20 | 986.79 | 2 |
| 24 | D | 1063.39 | 1051.93 | 1056.26 | 1083.23 | 977.27 | 2 |

Table 47. Least square means for Sires when predicting carcass ribeye area at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 11.93 | 11.68 | 12.10 | 12.32 | 12.47 | 12 |
| 2 | A | 12.73 | 12.40 | 12.51 | 12.69 | 13.01 | 10 |
| 3 | A | 12.62 | 12.60 | 12.57 | 12.47 | 13.05 | 4 |
| 4 | A | 12.45 | 13.37 | 13.34 | 12.25 | 13.40 | 1 |
| 5 | A | 11.94 | 12.56 | 12.68 | 13.24 | 12.65 | 2 |
| 6 | B | 12.50 | 10.97 | 11.33 | | 12.97 | 1 |
| 7 | B | 12.87 | 13.03 | 12.52 | 13.01 | 12.00 | 1 |
| 8 | B | 12.36 | 12.51 | | 12.15 | 13.00 | 1 |
| 9 | B | 11.56 | 11.98 | 12.34 | 12.33 | 11.90 | 2 |
| 10 | B | 12.02 | 12.04 | 12.52 | 12.66 | 12.70 | 1 |
| 11 | B | 14.30 | 14.76 | 13.23 | 12.87 | 13.40 | 1 |
| 12 | C | 13.38 | 13.25 | 13.69 | 12.23 | 13.90 | 4 |
| 13 | C | 12.53 | 10.80 | 14.08 | 12.99 | 13.30 | 2 |
| 14 | C | 12.89 | 12.51 | 13.10 | 12.06 | 13.50 | 1 |
| 15 | C | 11.78 | 11.95 | 11.58 | 11.40 | 12.10 | 1 |
| 16 | C | 13.23 | 13.03 | 13.65 | 12.57 | 14.20 | 1 |
| 17 | C | 12.46 | 11.83 | 11.55 | 11.33 | 13.40 | 1 |
| 18 | D | 9.74 | 9.92 | 10.43 | 11.56 | 9.45 | 2 |
| 19 | D | 10.02 | 10.42 | 10.28 | 10.31 | 10.60 | 2 |
| 20 | D | 11.36 | 11.58 | 11.48 | 11.89 | 11.27 | 4 |
| 21 | D | 12.19 | 12.15 | 12.58 | 12.69 | 11.93 | 3 |
| 22 | D | 10.51 | 10.26 | 10.14 | 10.83 | 10.25 | 2 |
| 23 | D | 8.89 | 8.61 | 8.21 | 10.35 | 9.75 | 2 |
| 24 | D | 12.84 | 12.75 | 12.80 | 12.69 | 12.05 | 2 |

Table 48. Least square means for Sires when predicting carcass 12th rib fat thickness at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 0.25 | 0.25 | 0.24 | 0.24 | 0.31 | 12 |
| 2 | A | 0.32 | 0.32 | 0.33 | 0.33 | 0.32 | 10 |
| 3 | A | 0.33 | 0.43 | 0.39 | 0.42 | 0.35 | 4 |
| 4 | A | 0.32 | 0.21 | 0.29 | 0.26 | 0.15 | 1 |
| 5 | A | 0.34 | 0.28 | 0.32 | 0.34 | 0.30 | 2 |
| 6 | B | 0.33 | 0.23 | 0.19 | | 0.33 | 1 |
| 7 | B | 0.59 | 0.59 | 0.49 | 0.42 | 0.50 | 1 |
| 8 | B | 0.30 | 0.29 | 0.35 | 0.31 | 0.15 | 1 |
| 9 | B | 0.21 | 0.25 | 0.27 | 0.27 | 0.20 | 2 |
| 10 | B | 0.43 | 0.46 | 0.49 | 0.54 | 0.55 | 1 |
| 11 | B | 0.33 | 0.32 | 0.29 | 0.33 | 0.35 | 1 |
| 12 | C | 0.27 | 0.24 | 0.31 | 0.31 | 0.28 | 4 |
| 13 | C | 0.27 | 0.38 | 0.31 | 0.36 | 0.38 | 2 |
| 14 | C | 0.37 | 0.45 | 0.34 | 0.38 | 0.35 | 1 |
| 15 | C | 0.33 | 0.34 | 0.39 | 0.42 | 0.50 | 1 |
| 16 | C | 0.13 | 0.09 | 0.14 | 0.28 | 0.20 | 1 |
| 17 | C | 0.41 | 0.38 | 0.38 | 0.40 | 0.50 | 1 |
| 18 | D | 0.41 | 0.46 | 0.44 | 0.46 | 0.38 | 2 |
| 19 | D | 0.33 | 0.33 | 0.42 | 0.42 | 0.30 | 2 |
| 20 | D | 0.23 | 0.36 | 0.31 | 0.33 | 0.34 | 4 |
| 21 | D | 0.28 | 0.22 | 0.24 | 0.28 | 0.20 | 3 |
| 22 | D | 0.46 | 0.49 | 0.45 | 0.47 | 0.40 | 2 |
| 23 | D | 0.30 | 0.36 | 0.32 | 0.33 | 0.33 | 2 |
| 24 | D | 0.30 | 0.32 | 0.57 | 0.40 | 0.35 | 2 |

Table 49. Least square means for sires when predicting GridA value at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 971.72 | 942.81 | 951.20 | 960.16 | 1016.42 | 12 |
| 2 | A | 1029.16 | 1023.71 | 1010.62 | 1012.62 | 1057.91 | 10 |
| 3 | A | 1039.72 | 1045.39 | 1040.28 | 1051.17 | 1041.98 | 4 |
| 4 | A | 1083.53 | 1076.30 | 1086.88 | 1077.94 | 1094.80 | 1 |
| 5 | A | 1010.07 | 999.75 | 1010.33 | 1035.10 | 1024.00 | 2 |
| 6 | B | 1076.71 | 1056.79 | 1017.48 | 1036.65 | 1151.55 | 1 |
| 7 | B | 1131.65 | 1155.37 | 1178.04 | 1113.15 | 1092.96 | 1 |
| 8 | B | 989.97 | 1022.00 | 1028.92 | 1076.34 | 1047.60 | 1 |
| 9 | B | 966.95 | 976.96 | 1014.12 | 1012.19 | 1013.81 | 2 |
| 10 | B | 987.55 | 998.37 | 1034.26 | 1055.27 | 1085.70 | 1 |
| 11 | B | 1168.70 | 1067.04 | 1012.15 | 996.62 | 1131.90 | 1 |
| 12 | C | 1024.43 | 1023.23 | 989.15 | 1034.48 | 1034.80 | 4 |
| 13 | C | 1016.00 | 1043.67 | 1040.95 | 1056.33 | 1028.36 | 2 |
| 14 | C | 1079.48 | 1062.99 | 1067.00 | 1033.27 | 1092.15 | 1 |
| 15 | C | 1091.37 | 1069.34 | 1090.10 | 1052.91 | 1130.94 | 1 |
| 16 | C | 1003.40 | 1019.03 | 1029.93 | 1055.27 | 1028.03 | 1 |
| 17 | C | 1094.17 | 1094.31 | 1118.77 | 1117.82 | 1147.08 | 1 |
| 18 | D | 935.27 | 995.42 | 938.65 | 1037.20 | 893.97 | 2 |
| 19 | D | 1010.22 | 1017.25 | 1045.53 | 1054.06 | 1021.00 | 2 |
| 20 | D | 1015.52 | 1042.64 | 1043.82 | 1022.70 | 984.44 | 4 |
| 21 | D | 1066.09 | 1064.44 | 1080.23 | 1086.51 | 1023.58 | 3 |
| 22 | D | 990.52 | 1037.06 | 995.95 | 1005.00 | 990.71 | 2 |
| 23 | D | 962.64 | 984.46 | 1013.35 | 1014.66 | 991.98 | 2 |
| 24 | D | 1083.29 | 1095.20 | 1078.84 | 1113.96 | 1001.55 | 2 |

Table 50. Least square means for Sires when predicting GridB value at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 906.49 | 879.92 | 886.84 | 893.69 | 959.26 | 12 |
| 2 | A | 986.46 | 979.63 | 961.04 | 953.45 | 1011.41 | 10 |
| 3 | A | 971.99 | 989.37 | 986.39 | 992.81 | 984.98 | 4 |
| 4 | A | 977.62 | 1067.09 | 1062.56 | 1032.30 | 1094.80 | 1 |
| 5 | A | 964.91 | 952.42 | 967.09 | 991.74 | 987.40 | 2 |
| 6 | B | 1023.07 | 995.84 | 940.16 | 971.96 | 1066.25 | 1 |
| 7 | B | 1116.64 | 1108.12 | 1077.50 | 1073.00 | 1010.16 | 1 |
| 8 | B | 968.02 | 969.83 | 974.62 | 1038.10 | 970.00 | 1 |
| 9 | B | 918.90 | 905.81 | 952.62 | 967.78 | 937.89 | 2 |
| 10 | B | 922.57 | 948.98 | 966.34 | 998.65 | 1003.45 | 1 |
| 11 | B | 1105.22 | 989.98 | 930.91 | 930.14 | 1046.15 | 1 |
| 12 | C | 935.35 | 946.15 | 897.82 | 956.44 | 977.18 | 4 |
| 13 | C | 888.58 | 951.48 | 954.80 | 960.81 | 952.19 | 2 |
| 14 | C | 1001.81 | 984.49 | 994.40 | 970.43 | 1011.25 | 1 |
| 15 | C | 1077.89 | 1053.84 | 1079.67 | 1021.56 | 1130.94 | 1 |
| 16 | C | 906.63 | 936.61 | 945.50 | 982.59 | 951.88 | 1 |
| 17 | C | 1010.53 | 994.48 | 1031.02 | 1046.70 | 1060.18 | 1 |
| 18 | D | 894.49 | 949.44 | 891.59 | 999.85 | 826.25 | 2 |
| 19 | D | 936.17 | 949.09 | 986.93 | 1011.03 | 944.50 | 2 |
| 20 | D | 957.07 | 987.89 | 993.86 | 963.66 | 928.53 | 4 |
| 21 | D | 995.66 | 986.28 | 1009.58 | 1022.69 | 947.19 | 3 |
| 22 | D | 960.36 | 987.49 | 950.58 | 967.91 | 912.41 | 2 |
| 23 | D | 881.89 | 900.03 | 946.95 | 928.47 | 916.83 | 2 |
| 24 | D | 1052.05 | 1066.00 | 1042.56 | 1087.00 | 965.40 | 2 |

Table 51. Least square means for Sires when predicting GridC value at each ultrasound session.

| | | Scan Sessions | | | | | |
|---|---|---|---|---|---|---|---|
| Sire | Ranch | 1 | 2 | 3 | 4 | Actual | n |
| 1 | A | 858.36 | 822.89 | 844.59 | 842.53 | 904.88 | 12 |
| 2 | A | 949.57 | 936.90 | 907.48 | 895.50 | 964.91 | 10 |
| 3 | A | 925.03 | 937.19 | 905.92 | 926.34 | 927.98 | 4 |
| 4 | A | 946.54 | 1059.47 | 1021.44 | 972.23 | 1094.80 | 1 |
| 5 | A | 921.75 | 906.90 | 945.51 | 958.69 | 950.80 | 2 |
| 6 | B | 961.32 | 932.77 | 862.48 | 912.93 | 980.95 | 1 |
| 7 | B | 1047.49 | 1050.09 | 1030.80 | 1027.31 | 927.36 | 1 |
| 8 | B | 907.00 | 913.88 | 929.71 | 983.21 | 892.40 | 1 |
| 9 | B | 847.61 | 834.55 | 913.51 | 930.96 | 861.96 | 2 |
| 10 | B | 866.87 | 877.27 | 889.55 | 918.54 | 921.20 | 1 |
| 11 | B | 1034.70 | 910.17 | 882.94 | 863.32 | 960.40 | 1 |
| 12 | C | 859.15 | 868.01 | 820.71 | 873.31 | 919.55 | 4 |
| 13 | C | 790.59 | 858.08 | 864.84 | 866.35 | 876.01 | 2 |
| 14 | C | 929.86 | 908.50 | 924.72 | 899.95 | 930.35 | 1 |
| 15 | C | 1071.66 | 1041.88 | 1051.02 | 991.53 | 1130.94 | 1 |
| 16 | C | 810.30 | 850.44 | 859.28 | 890.65 | 875.73 | 1 |
| 17 | C | 908.46 | 892.97 | 894.26 | 955.87 | 973.28 | 1 |
| 18 | D | 832.65 | 898.12 | 868.56 | 966.09 | 758.52 | 2 |
| 19 | D | 868.27 | 881.70 | 911.80 | 964.15 | 868.00 | 2 |
| 20 | D | 902.71 | 938.35 | 952.96 | 918.08 | 881.57 | 4 |
| 21 | D | 906.82 | 903.22 | 952.68 | 945.88 | 870.81 | 3 |
| 22 | D | 895.66 | 930.96 | 909.22 | 933.81 | 834.11 | 2 |
| 23 | D | 787.10 | 812.68 | 884.26 | 853.81 | 841.68 | 2 |
| 24 | D | 1006.55 | 1029.42 | 970.39 | 1044.48 | 929.25 | 2 |

# APPENDIX B

**Producer Name:** 

**Ranch Name:** 

**Number of head supplied:** 

**Producer Address:** 

**City:** 

**State:** 

**Zip Code:** 

**Phone Number:** 

**FAX Number:** 

**Email Address:** 

## Herd Management

*For vaccines and implants, give name of product as well as dates administered.

**Vaccines***

**Implants***

**Creep fed (indicate yes or no; if yes, give length and type of feed**

**Producer:**

**Performance Data**

| Calf ID | | Birth Date | | Birth Wt. | | Weaning Date | | Weaning Wt. | | Castration date |
|---|---|---|---|---|---|---|---|---|---|---|
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**Producer Name:**

## Pedigree Information

| Calf ID | | Sire | | Dam |
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# VITA

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|---|---|
| Name: | Dustin Tyler Dean |
| Educational Background: | B.S. Animal Science<br>Texas Tech University<br>December 1999 |
| | M.S. Beef Cattle Breeding<br>Texas Tech University<br>August 2002 |
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