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Abstract

Roundup is the major beef cattle education and outreach event sponsored by the Agricultural Research Center-Hays. The purpose is to communicate timely, applicable research information to producers and extension personnel. The research program of the Agricultural Research Southeast Agricultural Research Center Center-Hays is dedicated to serving the people of Kansas by developing new knowledge and technology to stabilize and sustain long-term production of food and fiber in a manner consistent with conservation of natural resources, protection of the environment, and assurance of food safety. Primary emphasis is on production efficiency through optimization of inputs in order to increase profit margins for producers in the long term. Roundup 1997 was held at the Agricultural Research Southeast Agricultural Research Center Center--Hays, KS, April 3, 1997

Keywords

Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 784; Kansas Agricultural Experiment Station contribution; no. 97-335-S Kansas; Beef cattle production

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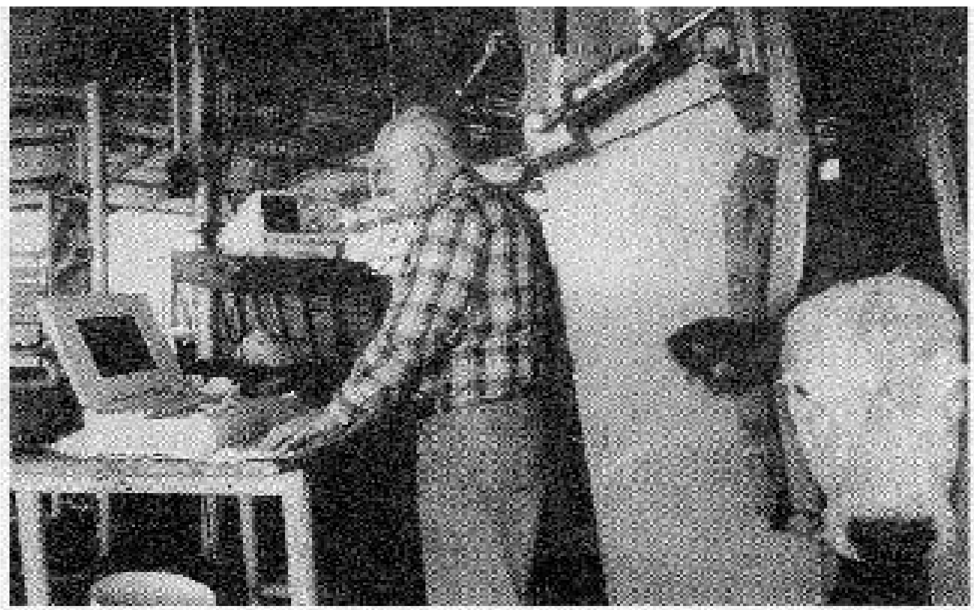

Agricultural Research Center, Hays

Report of Progress 784 • Agricultural Experiment Station, Kansas State University, Manhattan
Marc A. Johnson, Director

ROUNDUP 1997

KAES Report of Progress 784

April 1997

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KAES Contribution No. 97-335-S

Statement of Purpose

Roundup is the major beef cattle educational event sponsored by the Agricultural Research Center–Hays. The 1997 program is the 84th staging of Roundup. The purpose is to communicate timely research information to producers and extension personnel.

The research program of the Agricultural Research Center–Hays is dedicated to serving the people of Kansas by developing new knowledge and technology to stabilize and sustain long-term production of food and fiber in a manner consistent with conservation of natural resources, protection of the environment, and assurance of food safety. Primary emphasis is on production efficiency through optimization of inputs in order to increase profit margins for producers in the long term.

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Ultrasonic Sorting in a Program to Produce High Quality Beef

John R. Brethour

Beef Cattle Scientist

Summary

Clustering feedlot cattle into outcome groups with ultrasound was an effective way to increase the proportion that attained sufficient marbling for Certified Angus Beef (CAB), while reducing the proportion that became too fat. This study showed the accuracy of ultrasound for projecting future marbling and backfat thickness in a field application. The method substantially reduced the variability of carcass backfat thickness and allowed targeting of specific endpoints. A simulation of the change in proportion of CAB and Yield Grade #4 carcasses as a function of days fed showed that the progression is slow, and extending days on feed to obtain more CAB carcasses may not be profitable unless premiums for CAB cattle are substantial, especially without ultrasonic sorting. Another way to increase the proportion of CAB carcasses is to enhance genetics for the marbling trait, which appears to be a superior strategy.

Introduction

Producers of cattle with superior marbling genetics have considerable interest in pricing formulas that provide premiums for carcasses that grade average Choice or higher. The best known example is the Certified Angus Beef (CAB) program. Attaining that objective requires a combination of cattle with the genetic ability to add sufficient marbling during the finishing phase and careful control of the number of days on feed to allow maximum marbling development without producing over-fat carcasses. (Carcasses that are Yield Grade #4 (YG#4) and fatter are not eligible for CAB certification.)

For several years, a “Value Discovery Program" has been offered that attracts consigners of Angus cattle from across the country who wish to evaluate the performance and carcass merit of their cattle when fed out in a common environment. It was conducted in 1995-96 at the T Bone Feeders, Inc. in Goodland, Kansas. Such programs attract a diversity of cattle that make it difficult to schedule marketing, especially at a common date. That results in early maturing cattle being held too long and becoming too fat. Others are sold too soon, before they realize their potential to accumulate sufficient marbling and qualify for price premiums. Visually sorting cattle or using weight to provide uniform marketing groups is often ineffective.

K-State research has resulted in an ultrasonic cattle-sorting procedure that evaluates each animal at reimplanting time and estimates the number of days of extended feeding that will maximize profitability and/or maximize carcass value according to the price matrix concomitant with the marketing program. This procedure was used in clustering the cattle in the Value Discovery Project with emphasis on maximizing the proportion that would meet CAB specifications. This report summarizes results of that project.

Methods

Complete ultrasound and carcass data were obtained on 485 steers, which were presumed to be predominately Angus, in November and December at T Bone Feeders. Cattle were sorted by weight into two sets, the heavy and light sets were evaluated at reimplanting time (February 12 and March 12; average weight 979 and 998 lbs., respectively) with the ultrasound technology, and each set was clustered into three groups. Projected marketing dates for those groups were 37, 75, and 114 days after scanning. However, it was not feasible to adhere exactly to that schedule; also, a few cattle were sold in other than their designated group. Where necessary, appropriate adjustments were applied in this analysis.

Marbling Prediction

The accuracy of ultrasound for projecting future carcass merit is of great interest. In our previous studies, ultrasound measures were obtained in a research rather than a field situation, several images per animal were collected, and higher quality data were expected. In this project, cattle were insonated quickly (about 50 per hour), and multiple readings were not feasible. Figures 1 and 2 present the projected marbling scores for the two scanning sessions. In creating these graphs, some retrospective analysis was performed because the system seemed to underestimate future marbling. (That analysis involved iterating for the best fit of an adjustment equation that estimated slope and intercept parameters.) Most of the original underestimation may have been caused by differences in grading at different packing plants. The system had been calibrated with cattle slaughtered at a packing plant with limited cooling capacity where carcasses are held for only 24 hours before marbling scores are assigned. The cattle in this study appeared to benefit from more favorable grading conditions (better chilled carcasses grade better), because marbling scores appeared to be about 12 percent higher than projected. Another factor in projecting future marbling is the selection of the rate of increase from time of insonation until slaughter. Retrospectively, the least squares iteration that we used indicated that the rate was .0098 marbling units per day, essentially the same as the estimate of 0.01 units per day reported in earlier research.

The average errors in projected marbling were .59 and .55 marbling units for the two evaluation sessions. Variations in marbling calls averaging 0.4 units among graders have been experienced. The allowable average error for Beef Improvement Federation certification of animal sonographers (for evaluating purebred cattle) is 0.8 units. The latter does not involve projecting future marbling, because cattle are slaughtered for validation during the certification procedure. The greatest difficulty was predicting the 6% that eventually graded Prime (marbling score 8.0 and higher). Choice or better was attained by 82% of the steers. This constrained the range of the data, which might have reduced the correlation coefficient.

Prediction accuracy diminished as time from evaluation to slaughter became longer (Figures 3 and 4). The average prediction error for cattle marketed 37 or 56 days after evaluation was only .42 marbling units. Discrimination of cattle that would or would not meet CAB marbling specifications had an accuracy of 84%. The projections were less accurate for the deferred cattle fed for over 100 days after evaluation (Figure 4), although significantly better than random allotment.

In order to obtain a high proportion of cattle that met CAB specifications, they were fed longer than might be customary. The technology might be accurate enough to cull those animals with little likelihood of ever being CAB before they are committed to extra feeding. However, the price premium for Choice over Select is often substantial enough for producers to extend the feeding period for those culls hoping that they will at least reach Choice. Twelve cattle were cattle predicted to grade less than High Select, and only two of those graded Choice. In a group of mixed cattle, the ability to identify those unlikely to attain Choice might be more important than it was in this set.

Yield Grade Prediction

In this system, back fat thickness is used to project future yield grade because it can be measured quickly and accurately with ultrasound, and usable models to predict future backfat thickness have been developed. Figure 5 shows the association of carcass backfat thickness and the frequency of YG#4 carcasses (calculated using the USDA yield grade equation and measurements of its components - carcass backfat; rib eye area; carcass weight; and percent kidney, heart, and pelvic fat - on each carcass). The graph shows that YG#4 carcasses can be kept low by ensuring that carcass backfat does not exceed 15mm (0.6 inch) and that the average minimum backfat thickness for YG#4 carcasses was 18 mm (0.7 inch). Substantial discrepancies often occur between yield grades assigned by graders and those that are calculated from the yield equation that would shift this curve to the right and also make it steeper. Furthermore, we have reported that feed efficiency can decline rapidly after cattle reach 12mm (0.5 inch) backfat.

Low correlations of projected backfat thickness and actual carcass values would be expected, because the clustering procedure is programmed to make that characteristic more uniform, (Correlation coefficients usually will be less when the variability of the item being correlated is reduced.) That is shown in Figure 6, where the distribution and variability of clustered cattle are compared to a simulation in which all are marketed at the same time. Clustering reduced the standard deviation of backfat thickness by 33%. In this project, a component of the strategy was to assign cattle to the marketing group that would allow the longest feeding period without risking YG#4 carcasses. Consequently, the correlation of predicted and actual backfat was nil in the first set of cattle scanned and low in the second set (Figures 7 and 8). A better evaluation of the ability of ultrasound to predict future backfat thickness is obtained by adjusting carcass backfat thickness to a common marketing date (Figure 9). In preparing this graph the carcass backfat thickness was adjusted to the average 86-day postevaluation interval with the formula:

$$Y = X \times E^{(.0088 \times (86 - T))}$$

Where:

Y = Carcass backfat adjusted to 86 days after insonation

X = Carcass backfat at actual slaughter date

T = Actual days in interval from insonation to slaughter

(The constant of .0088 was obtained retrospectively as providing the best fit for this set of cattle.)

After this adjustment, the correlation of ultrasound backfat and carcass backfat 86 days later was 0.73 (Figure 9).

Relationship of CAB and YG#4 to Days on Feed

Increasing days on feed increases both the quality grade and fatness of the cattle, and there is an exchange of premiums between more cattle that have sufficient marbling to grade average Choice or better and price penalties for cattle that become YG#4. This data set provided an opportunity to model the progression of both CAB and YG#4 in a simulation of clustering with ultrasound or marketing the entire group at one time (Figure 10). These attributes appeared to increase linearly up to about 84 days after evaluation. After that time, the proportion of YG#4 carcasses started to escalate at an increasing rate, whereas the proportion of CAB carcasses seemed to plateau. If cattle had been marketed at one time (batch system), each additional feeding day would have increased the proportion of CAB carcasses by 0.44% and the proportion of YG#4 carcasses by 0.20%, a ratio of 2.2. Because the penalty for YG#4 carcasses is about 4 or 5 times the premium for CAB carcasses, extended feeding in a batch marketing system probably would not have been feasible with these cattle.

However, some strains of cattle have the genetics to reach CAB quality without becoming too fat. That is apparent in Figure 11, which shows that little correlation occurred between carcass backfat and marbling score. A strategy of selecting cattle with the ability to attain higher quality grades without accumulating excessive backfat combined with ultrasound technology to objectively define the optimal length of time to feed animals appears appropriate in a system to produce high quality beef.

The rates of change appeared substantially different when sorting was imposed to stratify marketing times. In this case the increase in CAB was 0.82% per day and the increase in YG#4 was 0.11% per day, a ratio of over 7:1. Although that offsets the premium:discount relationship, no information was obtained in this study that could be used to assess marginal changes in feed efficiency on either a live weight gain or carcass gain basis.

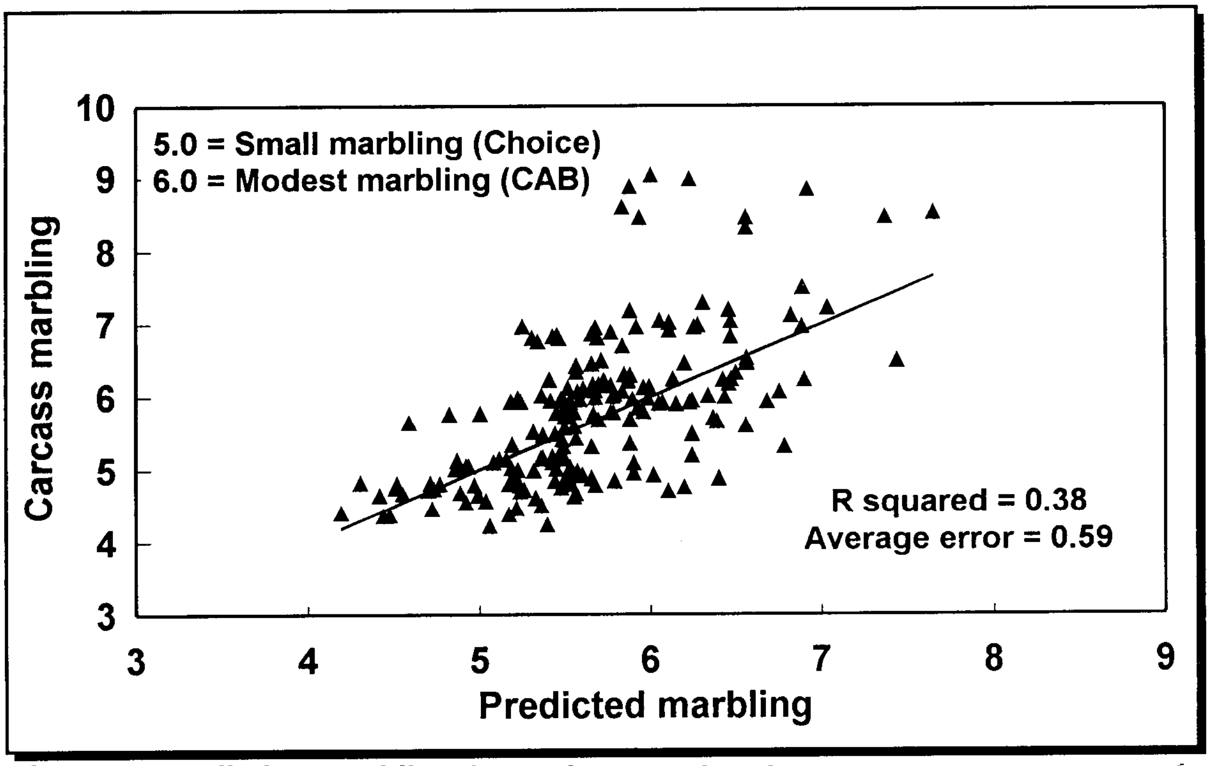


Figure 1. Predicting marbling from ultrasound estimates; 193 steers scanned on February 12th; average 89 days before slaughter.

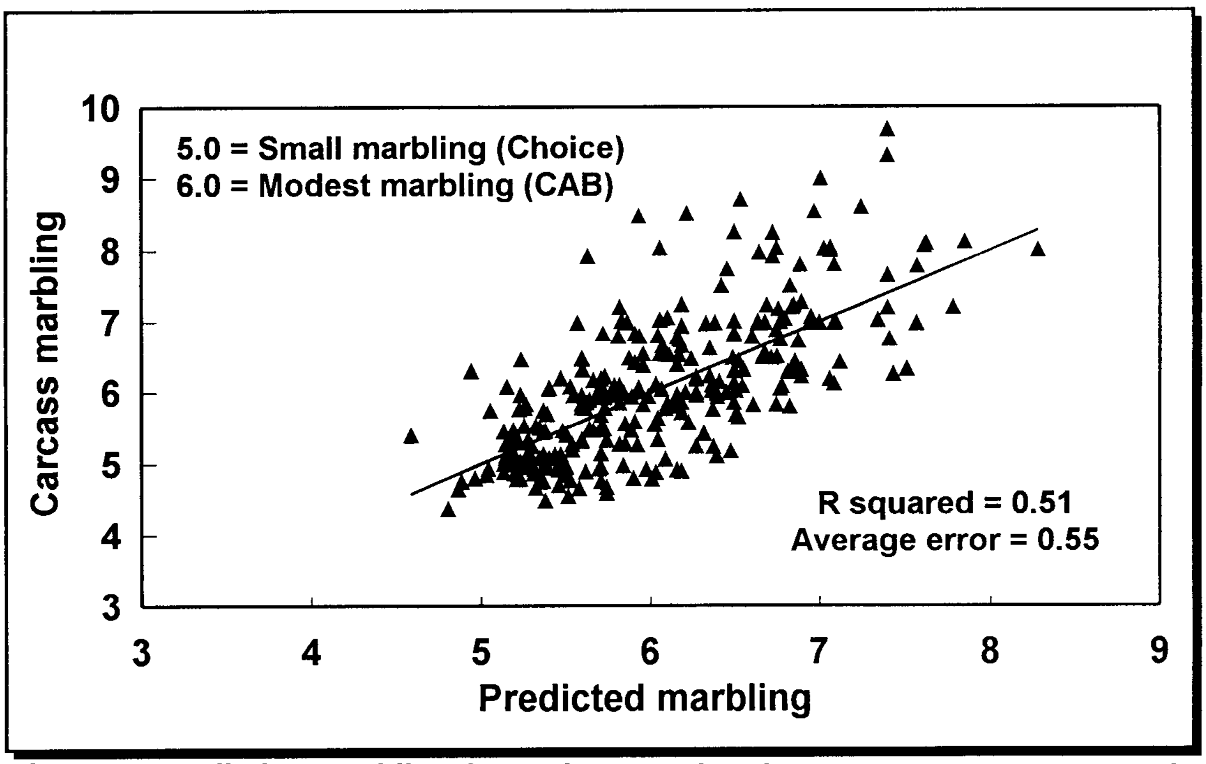


Figure 2. Predicting marbling from ultrasound estimates; 290 steers scanned on March 12th; average 85 days before slaughter.

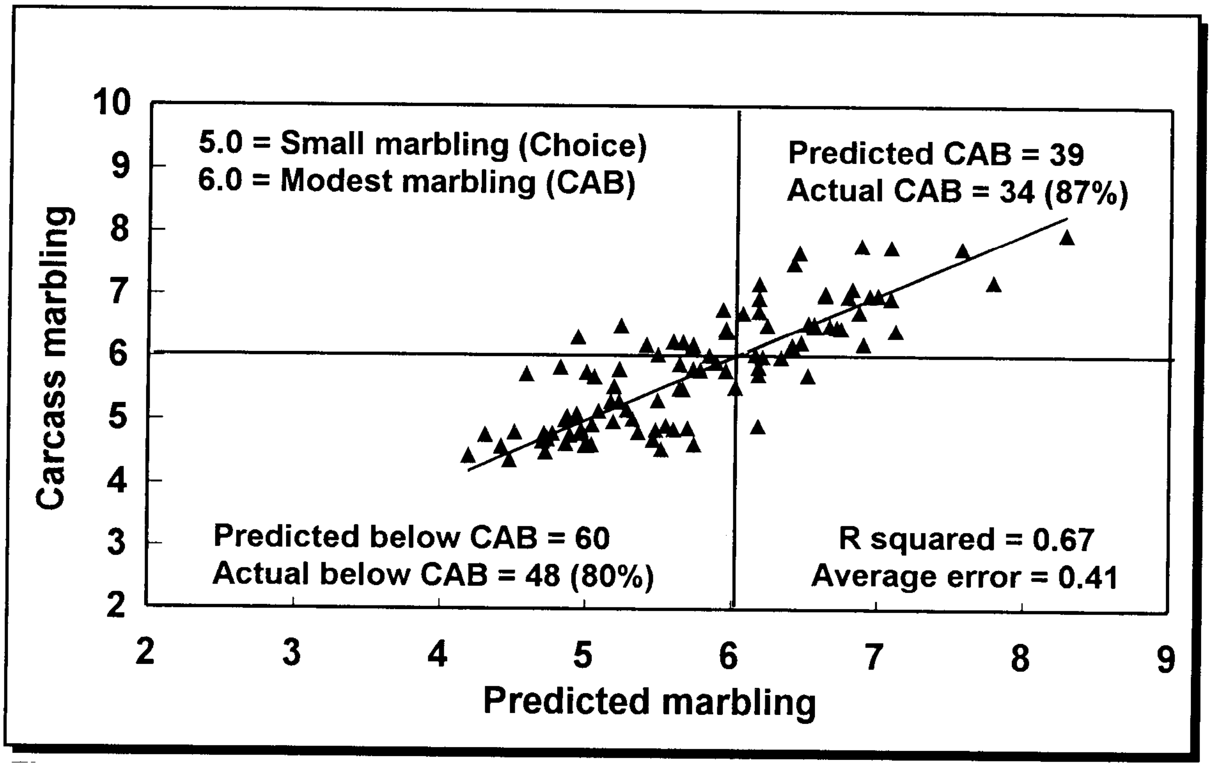


Figure 3. Predicting marbling from ultrasound estimates; 99 steers slaughtered 37 and 56 days after evaluation.

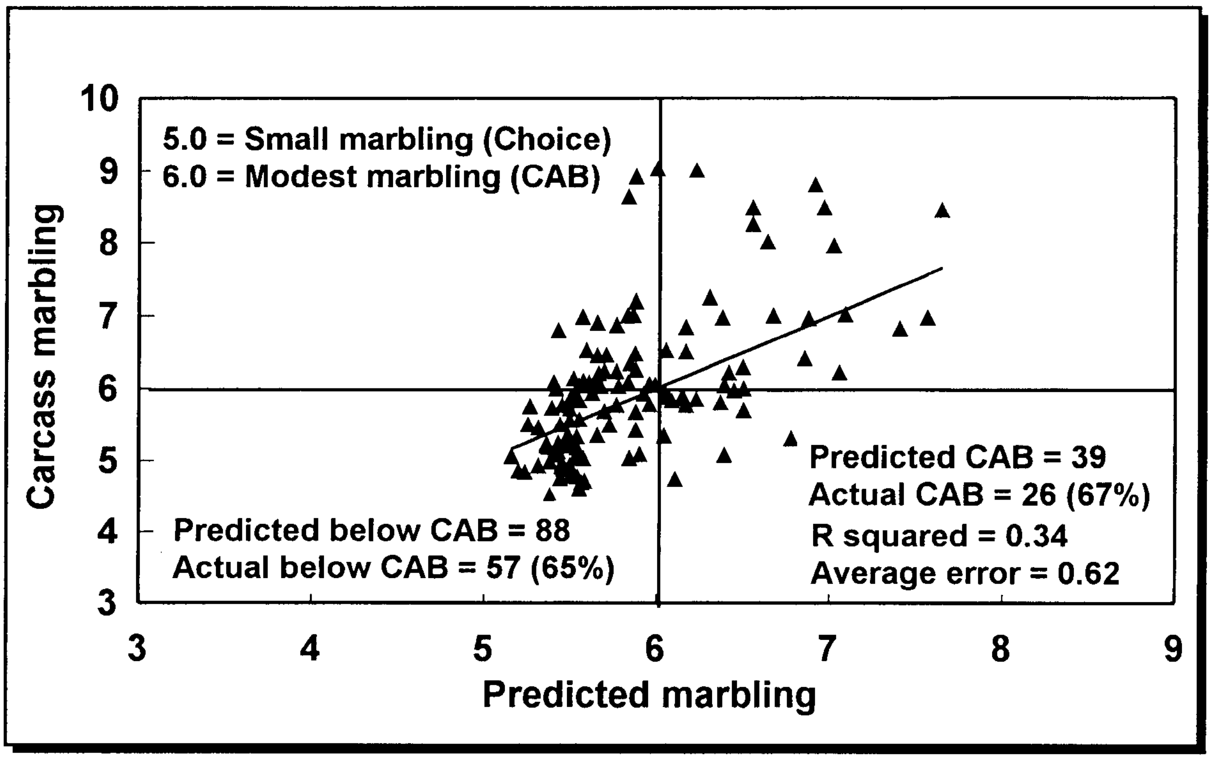


Figure 4. Predicting marbling from ultrasound estimates; 127 steers slaughtered 112 and 117 days after evaluation.

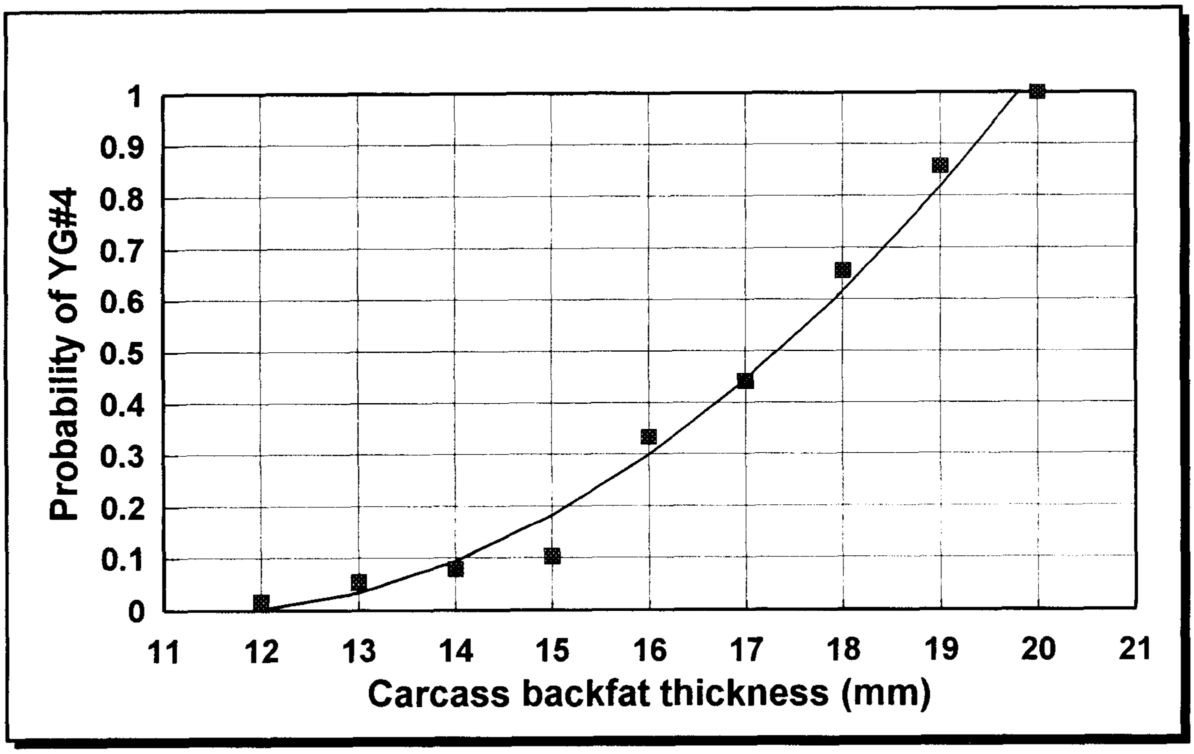


Figure 5. Carcass backfat thickness and frequency of Yield Grade #4.

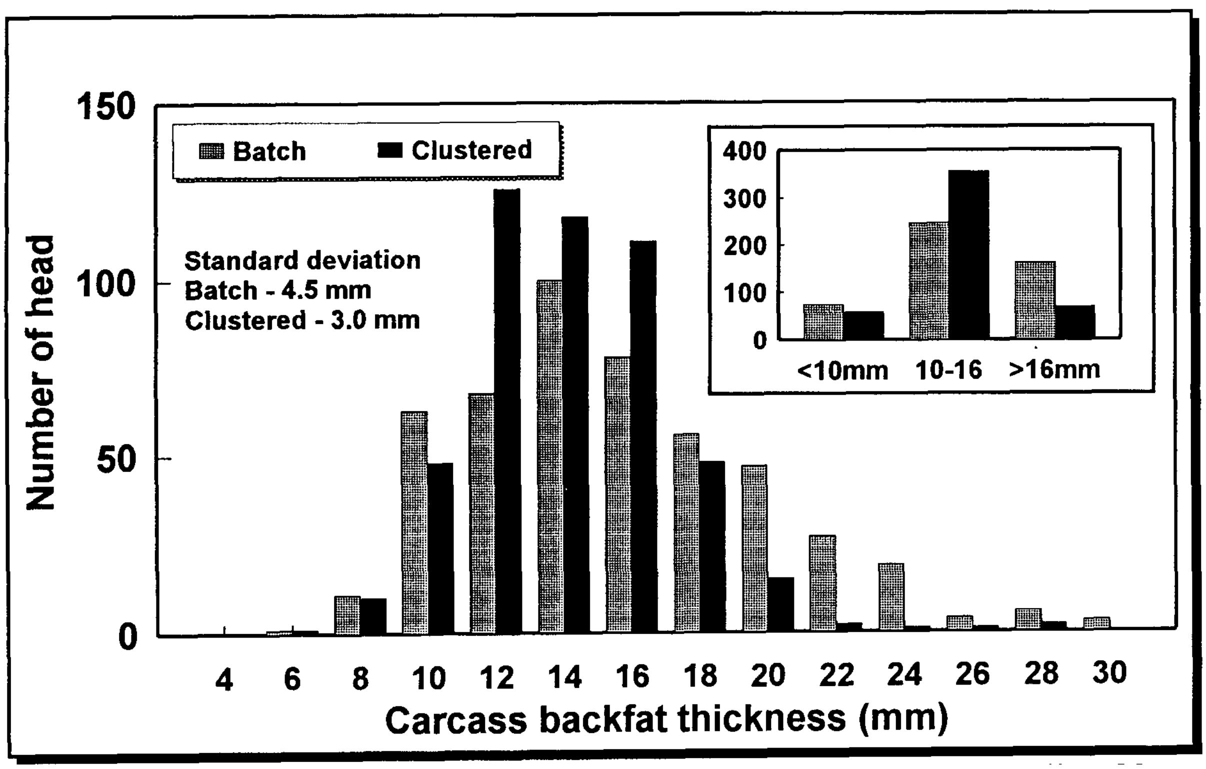


Figure 6. Effect of clustering cattle into three groups or marketing all at 86 days on uniformity of carcass backfat measurements.

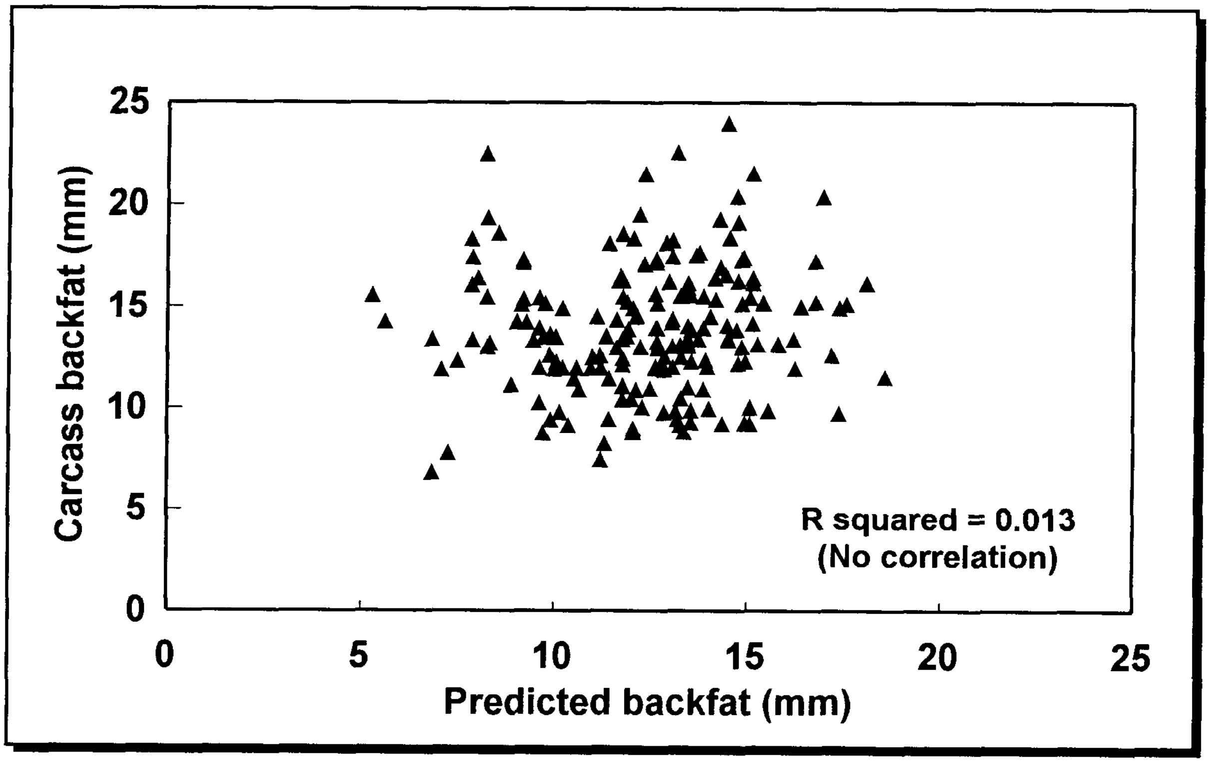


Figure 7. Predicting carcass backfat from ultrasound estimates; 193 steers scanned on February 12th; average 89 days before slaughter.

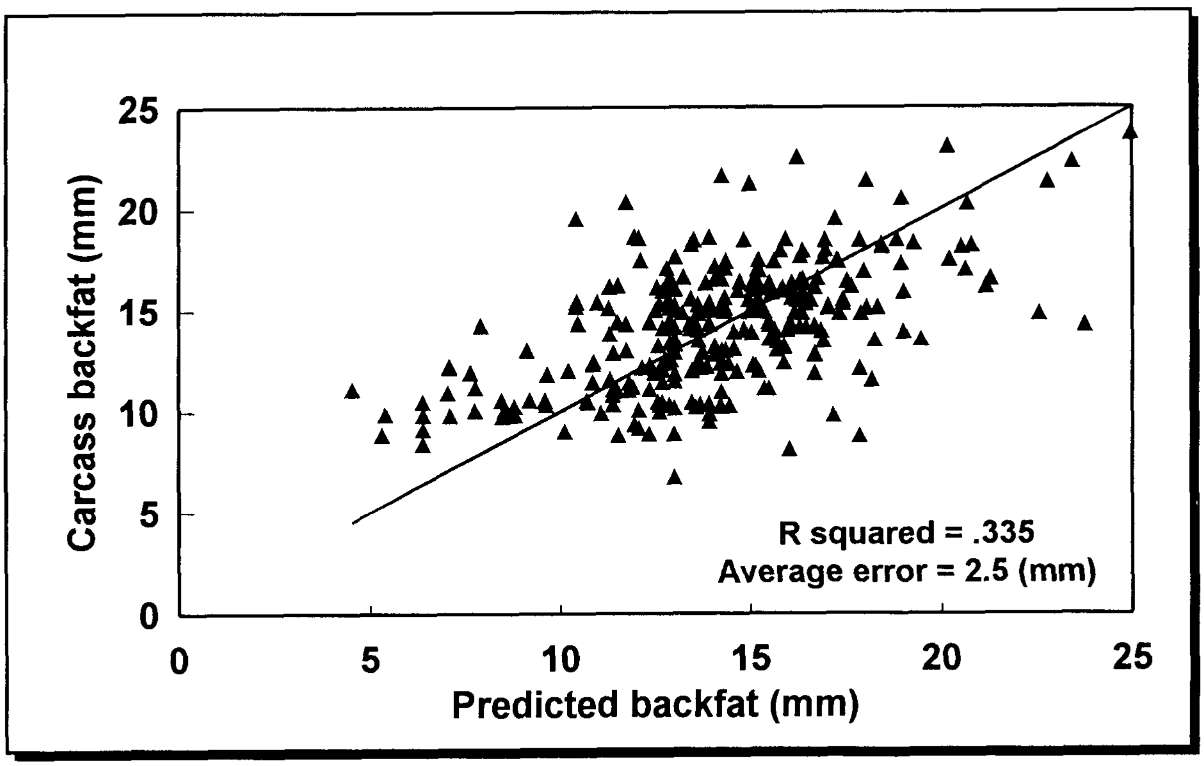


Figure 8. Predicting carcass backfat from ultrasound estimates; 290 steers scanned on March 12th; average 85 days before slaughter.

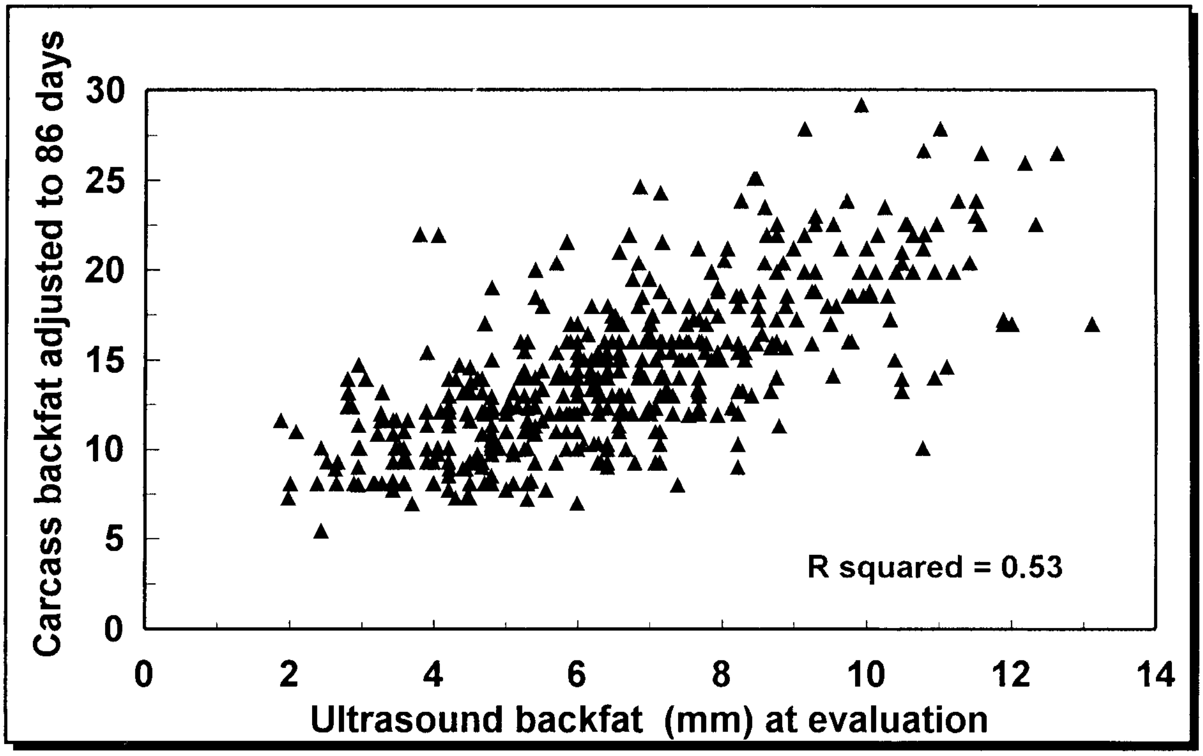


Figure 9. Relationship of ultrasound backfat and carcass backfat adjusted to a constant slaughter date (86 days after evaluation).

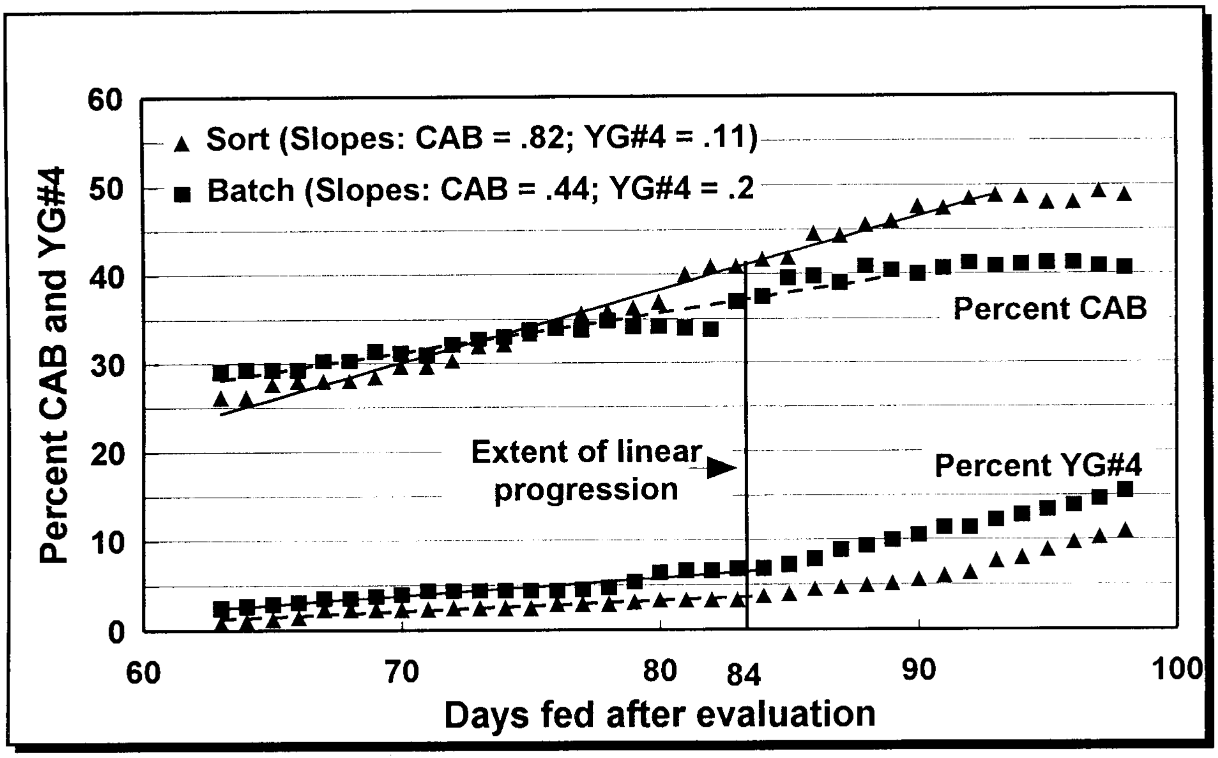


Figure 10. Simulation of days on feed and percent CAB and YG#4 with batch and sort systems.

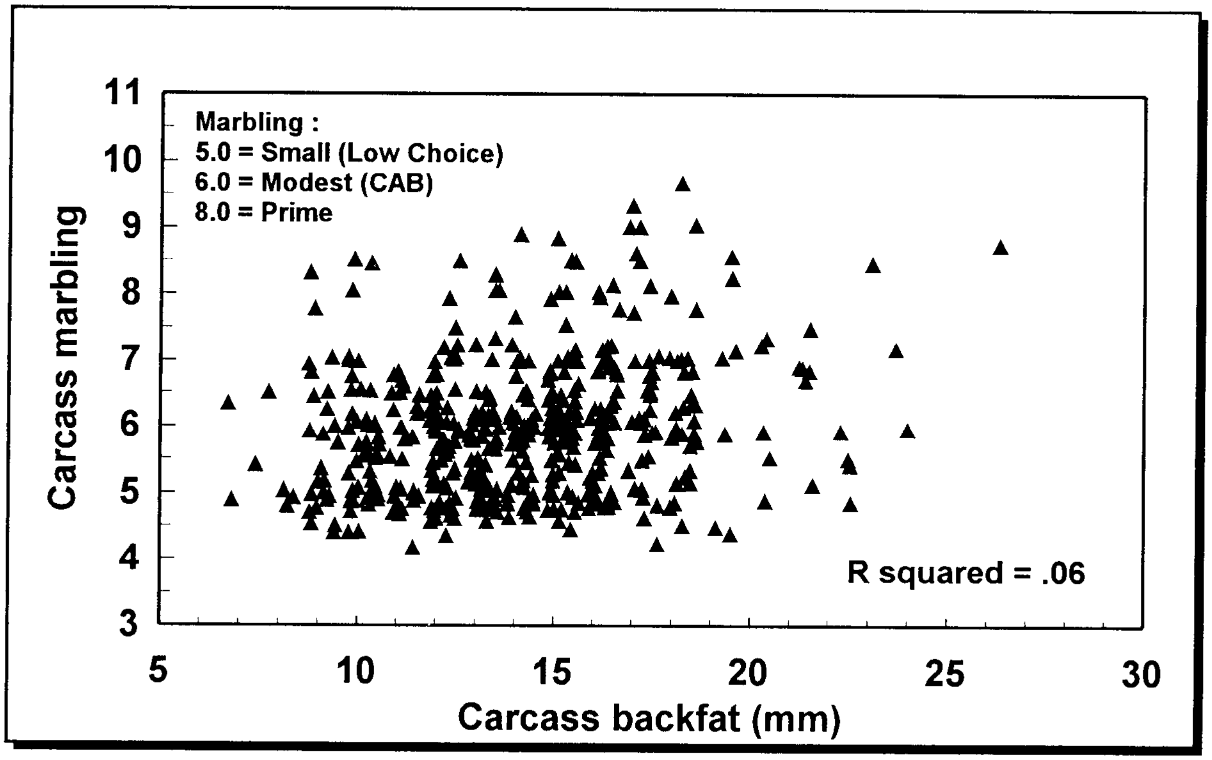
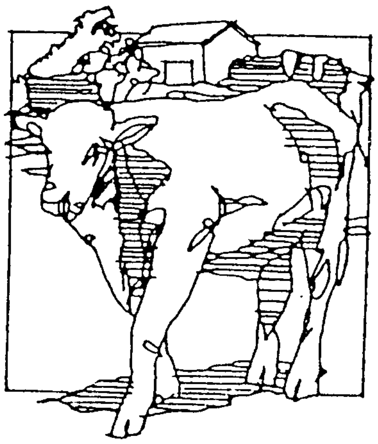


Figure 11. Relationship between carcass marbling and carcass backfat.



Use of Ultrasonic Backfat Measures to Estimate Carcass Composition

John R. Brethour
Beef Cattle Scientist

Summary

This study showed that backfat is much more important than rib eye area in predicting carcass composition (percent fat or percent lean). Also ultrasonic measurements of backfat over the rib and rump on live animals were nearly as accurate in predicting carcass composition as elements of the USDA yield grade equation (backfat; rib eye area; percent kidney, heart, and pelvic fat; and carcass weight). This is especially important in the application of ultrasound technology, because backfat estimates can be obtained in near real time with low cost instruments, whereas rib eye area measurements may require more expensive ultrasound equipment and are difficult to do rapidly chuteside.

Introduction

Body composition is of interest to the cattle feeder because USDA yield grade, an estimate of body composition, is a dimension of the price matrix for formula pricing. In addition, feed efficiency is related to composition of gain, and feed conversion declines after an animal transfers from a growing to a fattening mode.

Ultrasound technology may provide a very usable tool to estimate body composition, which is valuable information for both cattle producers and animal scientists. Particular advantages are that this method is noninvasive and can be used on the live animal at any stage of growth. Both backfat thickness and rib eye area are estimated with ultrasound on live animals. It is difficult to measure rib eye area quickly enough to use that estimate in many field applications. However, backfat thickness can be measured rapidly, especially when interfaced with computer image analysis techniques for automated measurement, so that readings are obtained in near real time. The purpose of this study was to evaluate the accuracy of using only backfat thickness to estimate carcass composition

Methods

A data set that evaluated the utility of ultrasonic backfat measurements was collected on 214 steers at the USDA Meat Animal Research Center (MARC) at Clay Center, Nebraska. Live animal estimates of subcutaneous fat between the 12th and 13th rib and also over the rump were obtained within a week of slaughter. Eleven diverse sire breeds were represented in this Cycle IV of the MARC germplasm program. Components of USDA yield grade were obtained after a 24-hour chill in a commercial packing plant. The right side of each carcass was transported to the MARC meats laboratory and fabricated into boneless retail cuts trimmed free of fat. Chemical analysis was not performed but should coincide with the percents fat, lean, and bone that were reported.

Figure 1 presents the correspondence of ultrasound backfat thickness and that measured on the carcass. The correlation coefficient is high (R squared = 0.78) but may have been exaggerated by the extreme diversity of the sample. A better measure of accuracy is the average error, which was 2.27 mm (0.09 inch). The solid line in this figure is the isopleth (one:one) line, and the error is calculated as the average distance from this line.

Predicting Percent Trimmable Fat

Figure 2 shows a comparison of models to predict the proportion of trimmed fat on each carcass from elements of the yield grade equation or the ultrasound measures. When the individual attributes (backfat thickness; rib eye area; percent kidney, heart, and pelvic fat; and carcass weight) of the USDA yield grade equation were evaluated, little improvement occurred in model efficiency from adding indicators other than backfat. A model that combined backfat and rib eye area increased the R squared (correlation coefficient) only from 0.601 to 0.613, and the full model with all four components had an R-squared value of .678.

Predictions of percent trimmable fat from ultrasound rib fat were slightly less accurate than those from carcass backfat but accounted for 83% as much variation as the model containing all the yield grade elements. Adding an ultrasound rump fat measurement to ultrasound rib fat significantly improved prediction accuracy to 96% of the full carcass equation.

Predicting Percent Fat-Free Boneless Lean

Prediction models for proportions of trimmed, boneless lean (Figure 3) had R-squared values similar to those for fat. Adding carcass rib eye area to a model containing only carcass backfat improved it only slightly, and the model with only carcass backfat thickness was 85% as accurate as the model that contained all four elements of yield grade. Models developed from ultrasonic rib fat or rib fat plus rump fat were 79% and 91%, respectively, as accurate as the model with all four carcass measures. The relative ability of fat measures alone to predict carcass composition differs from the perception that rib eye area is also an important predictive measure. That may result from a failure to appreciate that the carcass has only three components - fat, lean, and bone. Because percent bone is relatively constant, percent lean is merely the complement of percent fat, and the autocorrelation between fat and lean was -0.975. The rib eye area variable averaged only 11.9 square inches among these cattle, with a standard deviation of 1.15 square inches (10 carcasses had less than 10 square inches rib eye area and seven had more than 14 square inches). Perhaps rib eye area would have been more useful in the models if it had shown greater variability. Carcasses with large rib eye areas tend toward more desirable yield grades but may be discriminated against by beef purveyors, who complain that muscles from those carcasses are too large for traditional fabrication.

Figures 4 and 5 shows individual animal projections in scatter graphs so that the reader can quickly grasp the amount of error in the estimates. The parameters of the models used in generating these graphs are shown on the figures. However, readers should consider that these models are fitted to this data set and need to be validated on other cattle.

Discussion

Predicting percent carcass lean and fat rather than total poiunds lean and fat seems more important. As expected, weight was the most important measure to predict either total pounds lean or pounds fat, because it is a spurious variable that is comprised by the predicted item. However, carcass fat thickness was more important than ribeye area to improve a prediction equation after variations in carcass weight were considered. The R-squared correlations for predicting total pounds of lean for models that included carcass weight, carcass weight and backfat, and those two variables plus rib eye area were 0.77, 0.87, and 0.89. The respective correlations for predicting pounds trimmed fat were 0.57, 0.78, and 0.81.

It is serendipitous that the single measure of subcutaneous fat over the longissimus between the 12th and 13th rib on either the live animal or the carcass provides an excellent estimate of the fat:lean ratio in cattle. Fat thickness is the attribute that is measured most accurately with ultrasound and affected least by variation among different sonographers. The ultrasound measurement of fat on the live animal is probably much more accurate than that obtained on the carcass in the packing plant because of various disturbances that occur in the slaughtering process - especially in commercial facilities (trimming, mutilation by mechanical hide pullers, glacier-like flow of fat from the thicker deposits over the loin and rump on the hanging carcass during chilling, and expansion of fat after hide removal).

In conclusion, the correlations between ultrasonic backfat measures and carcass composition appear high enough to favor exploiting this technology. Where a high number and frequency of estimates are needed and low cost is an important consideration, ultrasound may be the most feasible method. Ultrasound could be especially cost effective in those commercial applications where knowledge of present and future carcass compositions of the live animal is important.

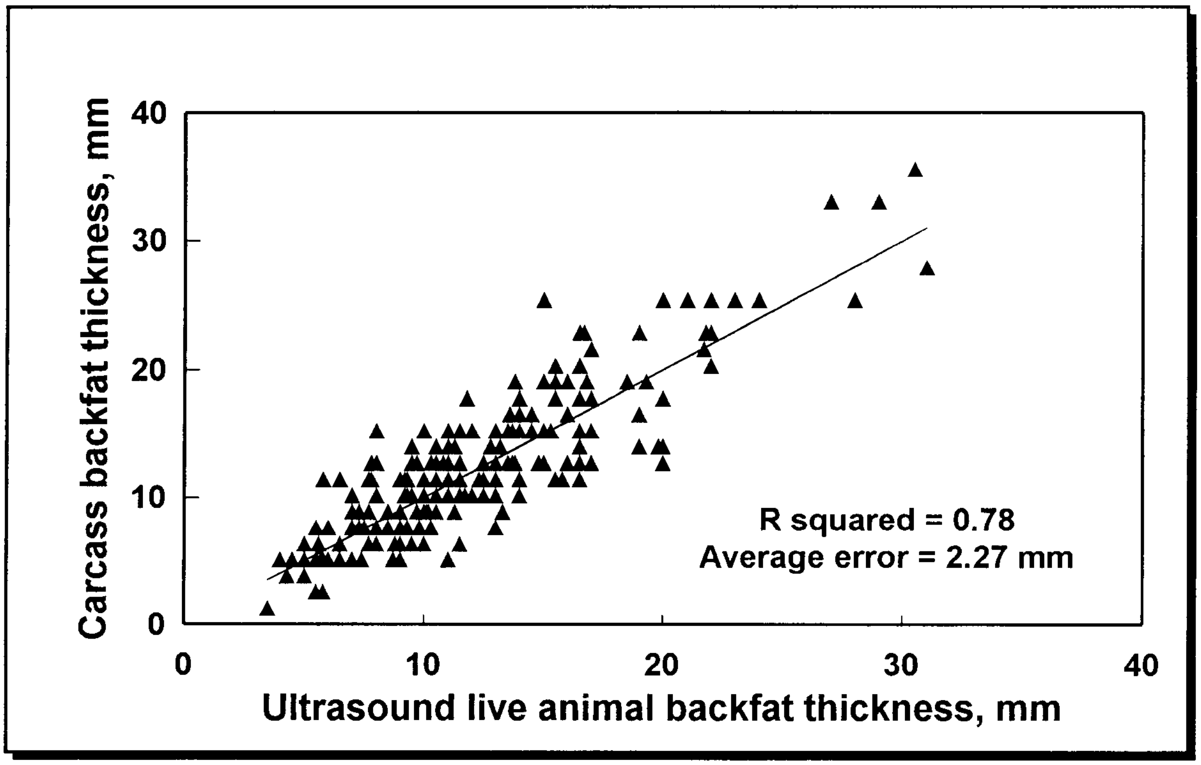


Figure 1. Accuracy of predicting carcass backfat with ultrasound.

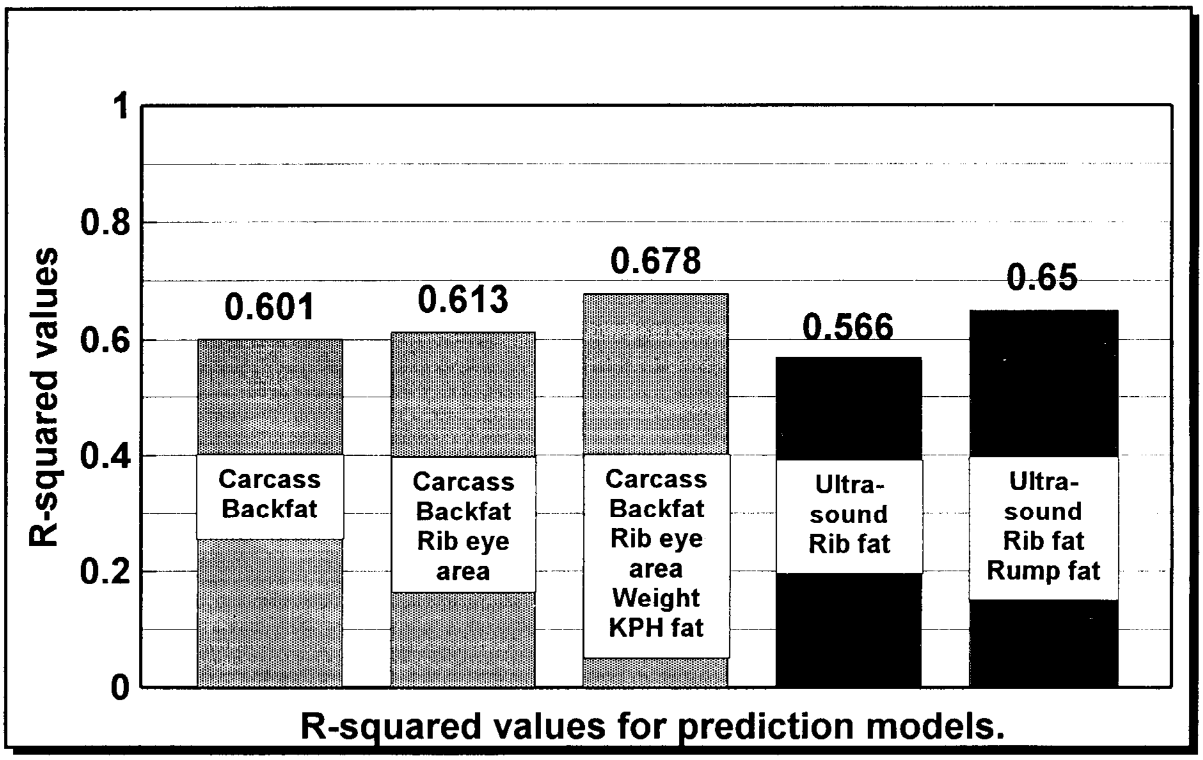


Figure 2. Different models for predicting percent trimmable carcass fat from carcass or ultrasound measurements.

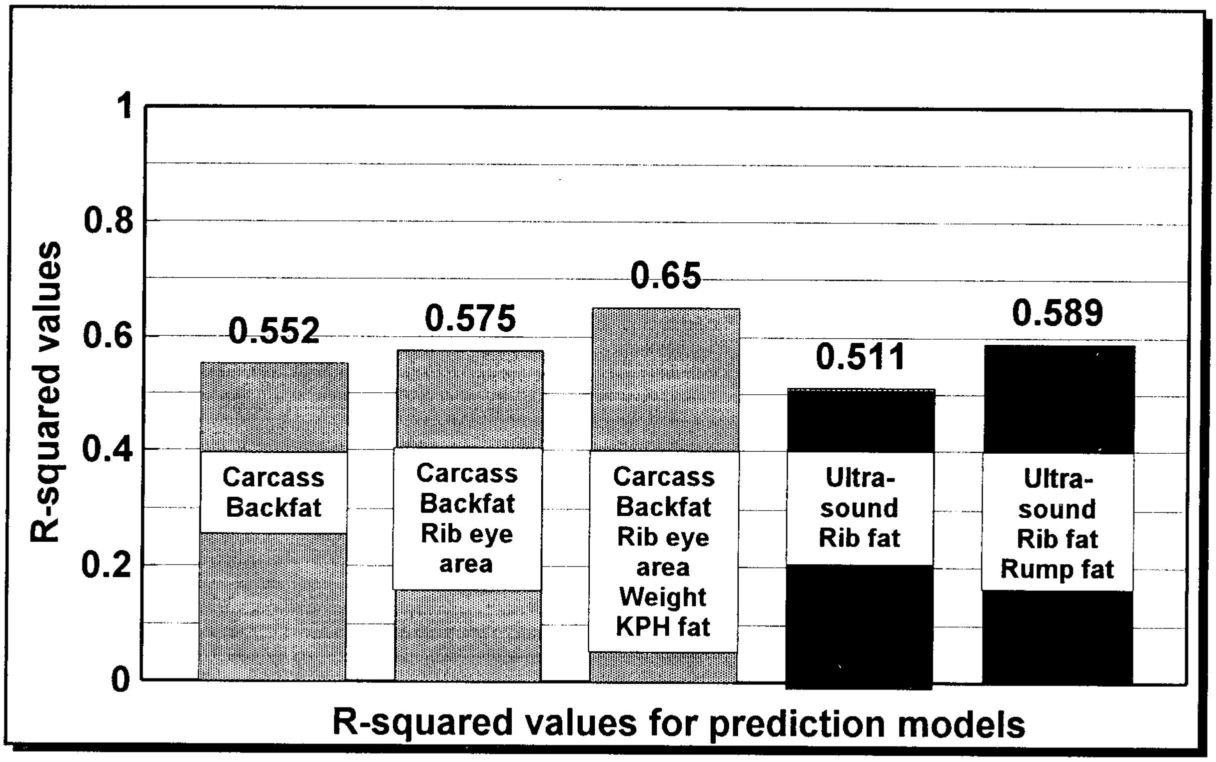


Figure 3. Different models for predicting percent fat-free boneless lean from carcass or ultrasound measurements.

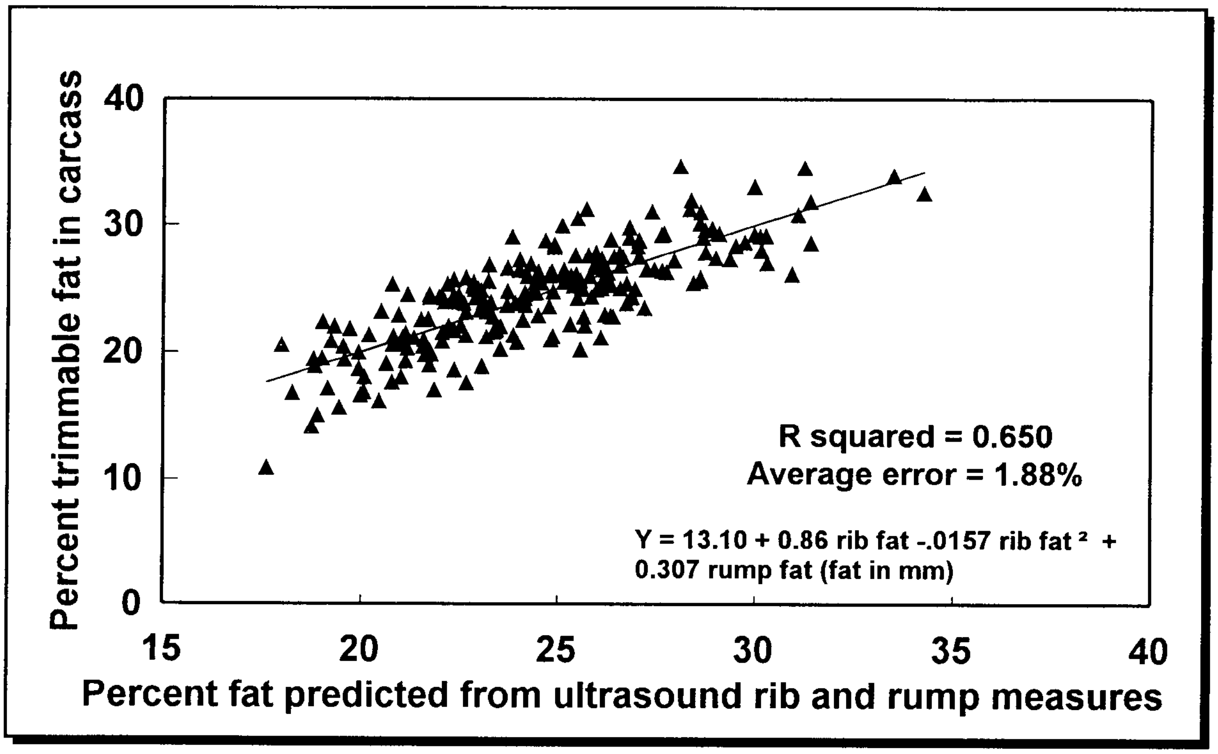


Figure 4. Accuracy of a model for predicting percent trimmable carcass fat from ultrasound live-animal measurements.

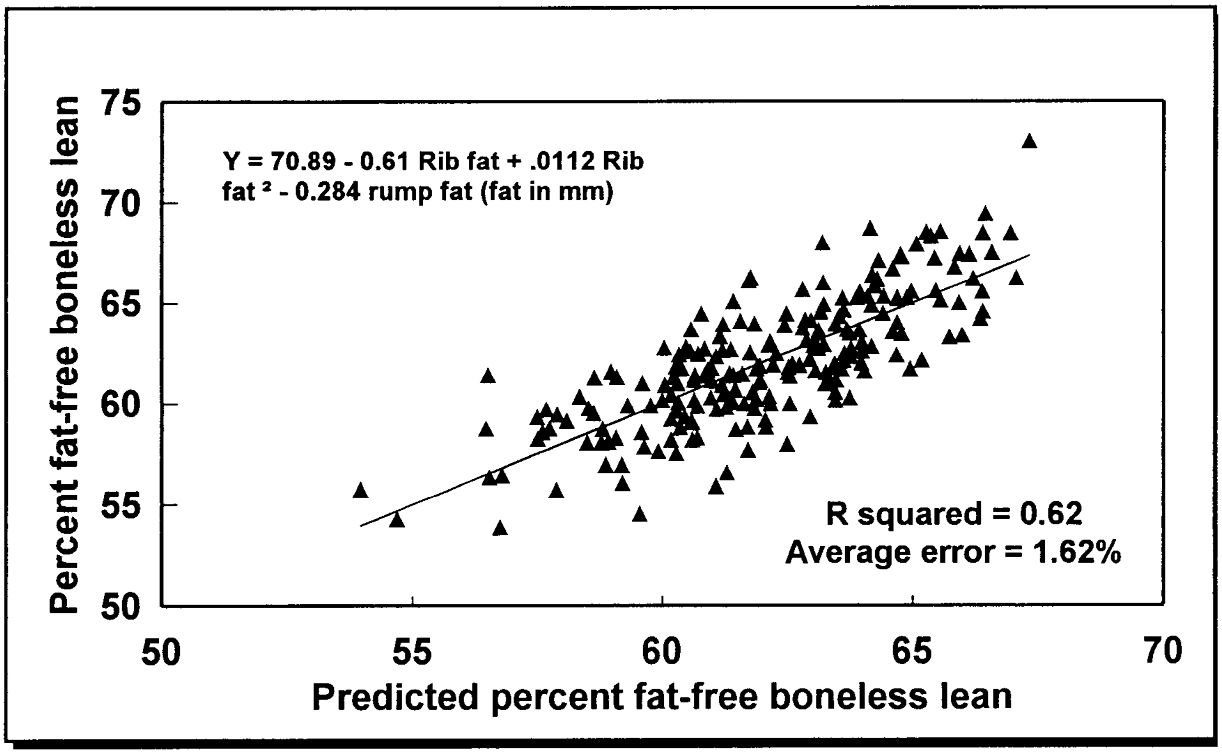
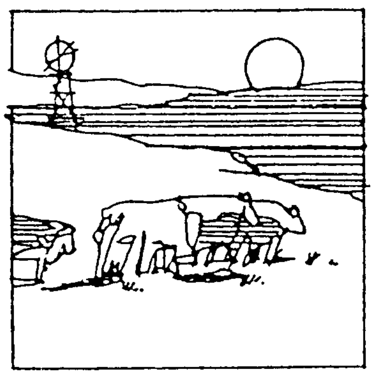


Figure 5. Accuracy of a model for predicting percent fat-free boneless lean from ultrasound live-animal measurements.



Nutrient Values of Range Grasses Collected in Clark County, Kansas

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Summary

Knowing the nutrient value of range grasses can aid managers of cattle operations in their decisions. Our data indicate that it is imperative for producers to sample their own range sites regularly. In common with other studies involving taller grasses, our results show that Clark County producers should consider supplementing protein to cattle grazing in the later half of the summer season. Tall grass research indicates that feeding 1 lb of a high protein supplement (> 36%, all-natural crude protein) can increase stocker cattle gains by .4 lb/day when ample amounts of low-quality forage are available. Whether the same results can be experienced in Clark County has not been determined. The time to commence and the amount of nutrient to supplement certainly will vary from year to year. Clark County producers may want to fortify or supply trace minerals to ensure that recommended levels of copper, manganese, and (or) zinc are consumed.

Introduction

Stockmen need to know the nutrient values of range sites. This knowledge allows them to predict animal performance, develop supplemental programs, and increase profits. They often have relied upon “book values” that are averages of divergent range sites to make their decisions. This may lead to poor management decisions and reduced profits. Therefore, supplementation programs should be based on data that are more like conditions on their own range sites. This study was planned with the intent of offering range site information that may be more applicable to southwestern Kansas producers.

Methods

Grass samples were harvested from various range sites located throughout Clark County, Kansas. Samples were collected monthly (May through October) in 1994, 1995, and 1996 during the growing season, except no samples were collected in May, 1994. Range sites were included in a cooperating agreement with several ranchers. Four sites (cooperators) were used in 1994, and seven and nine sites (cooperators) were used in 1995 and 1996, respectively. Collection areas were platted randomly from available cooperators’ pastures. Then each area was enclosed so that no grazing took place during the particular grazing season. Samples were collected randomly within the enclosures during the third week of the corresponding month. Collection areas were reassigned within a range site in subsequent years, so that previous years’ forage growth was minimized. Forage samples were collected by hand trimming all standing forage within a randomly placed quadrant. Samples contained mostly mixtures of buffalo grass, sideoats grama, and little bluestem. Samples were placed immediately into plastic bags, sealed, and sent to a commercial laboratory for wet chemistry analysis. Least square means are reported and represent the average nutrient values by month within a specific year.

Results and Discussion

Because of the significant differences in nutrient values between years and months, means values are reported by month within each year of the study (Table 1). Readers should remember that the samples were taken within areas protected from grazing; therefore, the samples reflect the nutrient values of stockpiled forages and may not be true representations of masticate samples.

In the study's first year, 1994, forage quality was determined to be significantly less than in other years. Notably, crude protein levels were less and acid detergent fiber ADF content was greater (p< .01). These two nutrients indicate that crude protein and energy both could have been limiting animal performance for cow/calf and stocker operations in 1994. If 1995 and 1996 are more typical years, than protein supplementation programs would be most appropriate during the later half of the summer grazing season.

In 1994, crude protein percentages were lower (p< .01), yet more constant, during the grazing period in than other years. In contrast, 1995 and 1996 crude protein levels began the grazing season nearly a third higher than in 1994 and declined through the duration of the summer, much like we would expect range grasses to respond. Past recommendations have been for stocker producers to consider feeding supplemental protein starting in July or August. Supplementing protein can cause an increase in low-quality forage intake. Responses to increased forage intake are often increases in digestible dry matter intake (energy) and animal performance. This appears to be a good supplementation strategy in the later 2 years of the study. In 1994, some sort of protein/energy supplementation throughout the entire grazing period might have been advisable. Because forage availability (quantity) was not measured, determining which supplementation program would be optimal is difficult.

The ADF values increased as the grazing season advanced in 1995 and 1996, reflecting the maturity of the grasses in the platted areas. Acid detergent fiber is inversely correlated to energy content. August, September, and October of 1995 and 1996 had significantly greater ADF percentages than earlier months. We could conclude from the ADF and crude protein data that cattle grazing in Clark County would need supplementation during the later half of the grazing season to maintain body weight gains and(or) body condition scores. Increases in ADF values corresponded with increasing dry matter contents and declining crude protein percentages.

Cattle producers often are concerned with meeting the trace mineral requirements of cattle. Our data indicated that trace mineral contents of plants change from year to year and month to month, with the exception of Molybdenum. High levels of molybdenum (> 5 ppm) have been shown to reduce the availability of copper. Our data indicate that molybdenum levels are independent of time and are mostly site specific. Three important trace minerals are copper, manganese, and zinc. Copper levels of our samples varied widely among both years and months. For example, July 1995 levels were nearly 3 times the cattle requirement, and 1 month later, the level had dropped to about one third of the requirement (10 ppm, NRC, 1996). During all years, more than half the samples indicated a need for some level of copper supplementation. Manganese levels in all samples were greater than published requirements for growing and finishing cattle (20 ppm, NRC, 1996), but levels in about half of the months sampled were less than requirements for gestating and early lactating cows (40 ppm, NRC, 1996). Zinc levels were dependent on year, month, and year by month interactions (p < .01). The NRC (1996) recommends that cattle diets contain more than 30 ppm zinc. Our samples varied both above and below this value.

Table 1. Average nutrient values of grass samples from Clark County, Kansas.[ab]

Month:	May	June	July	August	September	October	SE
1994[cd]							
Crude protein, %		6.4	6.6	6.5	7.0	6.0	.5
ADF, %		46.0	47.2	46.2	46.3	48.5	1.3
Phosphorus, %		.10	.12	.13	.14	.17	.02
Copper, ppm		11.8	2.8	4.0	4.2	3.0	1.4
Iron, ppm		481	356	564	767	639	86
Manganese, ppm		33.0	35.0	42.0	43.5	43.5	6.2
Molybdenum, ppm		1.29	1.63	1.52	1.35	1.37	.32
Zinc, ppm		27.5	20.3	21.5	39.8	26.5	2.8
1995							
Dry matter, %	40.6	45.1	57.4	69.2	71.2	80.4	2.8
Crude protein, %	8.9	8.2	7.1	5.3	5.0	4.9	.4
ADF, %	40.9	37.0	38.1	42.9	44.9	45.9	1.0
Calcium, %	.89	.63	.70	.71	.63	.64	.10
Phosphorus, %	.22	.17	.17	.19	.14	.13	.02
Copper, ppm	16.0	16.5	36.8	3.6	3.3	3.9	1.0
Iron, ppm	822	415	311	183	148	303	65
Manganese, ppm	67.6	51.9	43.9	39.3	31.3	41.4	4.7
Molybdenum, ppm	1.23	1.49	1.31	1.54	1.63	1.23	.24
Zinc, ppm	44.0	41.0	39.6	23.0	19.7	25.1	2.1
1996							
Dry matter, %	60.4	49.7	57.8	50.0	49.0	68.3	2.6
Crude protein, %	9.4	9.6	8.3	7.3	6.8	5.1	.4
ADF, %	42.3	42.8	45.4	45.5	46.2	49.1	.9
Calcium, %	.58	.55	.46	.35	.39	.46	.09
Phosphorus, %	.21	.22	.21	.17	.17	.16	.02
Copper, ppm	7.1	6.9	13.2	16.2	15.0	3.9	1.0
Iron, ppm	421	337	367	344	265	121	61
Manganese, ppm	44.1	33.4	36.7	32.9	28.3	28.4	4.4
Molybdenum, ppm	1.25	1.72	1.80	1.74	1.08	1.54	.22
Zinc, ppm	29.8	26.1	36.0	37.0	31.5	31.0	2.0

[a] Dry matter concentrations reported on as-fed basis. All other consituents reported on a dry matter basis.
[b] Year and month effects signigican ($p < .01$) for all variables reported
[c] No samples were collected in May, 1994.
[d] Samples collected in 1994 were not analyzed for dry matter or calcium.

Influence of Type and Amount of Supplement on Intake and Utilization of Low-Quality Forage Sorghum Hay by Beef Steers

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Summary

With a protein-supplemented, low-quality, forage sorghum hay, increasing the level of a starch-based supplement (sorghum grain) from 3 to 9 lb per steer per day depressed digestibility of fiber and dry matter. Using supplements with less starch and larger quantities of digestible fiber (wheat middlings and soybean hulls) alleviated much of the depression in fiber digestion but did not result in improvements in apparent energy consumption by the steers because of rather large negative effects on forage intake. Thus, in situations where cows' requirements for energy exceed what we can supply with protein-supplemented, low- to moderate-quality forages, our supplementation options appear to be limited. Until the underlying mechanisms for the intake and digestibility depressions can be determined and overcome, the best option for improving the energy status of cows with high requirements is feeding high-quality forages.

Introduction

Research has indicated that protein is generally the first-limiting nutrient in low-quality forages fed to beef cattle. Furthermore, supplementing with ruminally degradable intake protein (DIP) has been shown to stimulate both the voluntary intake and digestibility of low-quality forages. However, using starch-based supplements (e.g., sorghum grain or corn) does not stimulate forage intake and often depresses forage digestion because of detrimental effects on fiber-digesting bacteria.

Forage sorghum hay varies considerably in quality because of varietal, environmental, and management factors. Often, the utilization of forage sorghum hay can be improved by supplementing with DIP. However, situations exist where the stimulation in energy intake as a result of DIP supplementation is insufficient to meet the animal's requirements, and supplemental energy sources are required. Because the negative effects of energy supplements on forage digestion generally are attributed to the presence of starch, fiber-based energy supplements, which generally do not inhibit ruminal fiber digestion, may be more economical.

The purpose of this experiment was to evaluate the effects of increasing amounts of starch-based vs. fiber-based energy supplements on the intake, digestion, and fermentation characteristics of cattle consuming low-quality forage sorghum hay and a protein supplement.

Methods

Nine ruminally cannulated, crossbred, beef steers (average weight = 1206 lb) were used in a replicated 3 x 3 Latin square design to evaluate three supplements, each fed at three different levels. Each of the three squares represented a different supplement type: 1) sorghum grain (10% NDF), 2) wheat middlings (40% NDF), and 3) soybean hulls (59% NDF). Each supplement type was offered at 3 (L), 6 (M), or 9 (H) lb/d. All steers received low-quality forage sorghum hay (5% CP; 56% NDF) at 130% of ad libitum intake, 3 lb/d soybean meal (calculated to meet or exceed DIP needs for all diets), and .22 lb/d of a mineral mixture. Steers were fed individually once daily in metabolism stalls and had free access to water. The Canex (Sharp Bros., Healy, KS) forage sorghum hay was fertilized with 30 lb N/ac, seeded at a rate of 22 lb/ac on June 16, swathed on September 18, and baled on October 9, 1995. The large round bales were stored outside with no cover until January, at which time the hay was ground through a tub grinder with a 2.5 in screen and stored outside under plastic. Supplements were fed once daily just before feeding hay. Refused feed was weighed back from feed bunks daily just before feeding and sampled for determination of chemical composition. Samples of feed, supplements, and feces were obtained daily and dried immediately at 122° F in a forced-air oven. Periods lasted 28 days. Steers were adapted to diets for 10 days, followed by 6 days of voluntary intake measurement. Steers were fitted with fecal collection bags for 6 days for total collection of feces. Following this, ruminal fermentation characteristics were measured just before feeding and at 3 h intervals for the next 12 h.

Results and Discussion

Supplement type and amount did not show significant interactions for any of the measured characteristics except for NDF digestibility. This suggests that, for most variables, the influence of supplement amount was independent of the type of supplement offered, and similarly, that the influence of supplement type was the same regardless of the amount of supplement offered. Forage and, therefore, total DM intakes were greater ($P \geq .08$) when sorghum grain was supplemented than when either soybean hulls or wheat middlings were used (Figure 1). The higher NDF concentrations in the fiber-based supplements likely caused the greater depression in forage intake with these diets. However, no difference in forage intake was noted between the soybean hulls and wheat middlings supplements, despite a 48% greater NDF content in the soybean hulls as compared with the wheat middlings. Forage intake was depressed linearly ($P < .01$) with increasing amount of supplements. The substitution ratio was .67:1, indicating that each lb of supplement consumed above 3 lb replaced 2/3 lb of forage. Thus, total DM intake increased (linear, $P = .08$) with increasing supplement but not in an additive manner.

Dry matter digestibility was greater for the high-NDF supplement (soybean hulls), second greatest with the moderate-NDF supplement (wheat middlings), and lowest with the sorghum grain ($P < .10$; Figure 2). Multiplying DM intake by DM digestibility gives us a measure of the intake of digestible DM (Figure 3). Because of depressions in digestibility with sorghum grain and depressions in intake with the fiber-based supplements, each of the three supplements resulted in similar ($P = .74$) intakes of digestible DM. Dry matter digestibility was not influenced significantly by the amount of energy supplement provided, but small depressions in digestibility with each increment of supplement combined with the effects on forage intake were sufficient to prevent increases in intake of digestible DM with increasing supplement amount ($P = .22$).

The influence of the treatments on fiber (NDF) digestibility is shown in Figure 4. Increasing the amount of the high-fiber supplement (soybean hulls) did not significantly influence fiber digestibility. The small numerical increase in NDF digestibility with increasing soybean hulls was likely the result of the highly digestible fiber they contained. Increasing amounts of the moderate-fiber (wheat middlings) and low-fiber (sorghum grain) supplements depressed fiber digestibility (linear, $P < .10$). Other research has shown that starch can have a large negative effect on fiber digestibility within the rumen. The effects of the three supplements in this study on NDF digestion followed what we might expect based on the relative amounts of starch in each of the supplements.

Ruminal VFA concentrations were greatest and ruminal pH was lowest with wheat middlings ($P < .10$; Table 1) compared to the other two supplements. Generally, ruminal pH values below 6.2 are considered to depress ruminal fiber digestion. Ruminal pH fell below 6.2 only with 9 lb of wheat middlings and remained below 6.2 from 3 through 9 hours after feeding on this treatment (data not shown). Although the pH depressions were more severe with wheat middlings, ruminal fiber digestion was depressed to the greatest extent with sorghum grain supplementation, suggesting that some mechanism other than depressed pH was primarily responsible for the decrease in fiber digestion. Acetate:propionate ratios were slightly lower ($P < .10$) for sorghum grain than for the other two supplements and were unaffected by the amount of supplement fed (Table 2). The lower acetate:propionate ratio with the sorghum grain supplement is indicative of an increase in the importance of starch and a decrease in the importance of fiber as a substrate for the ruminal bacteria. Total VFA concentrations increased and ruminal pH decreased slightly with increasing amount of supplement, in agreement with the small numerical changes observed for digestible DM intake.

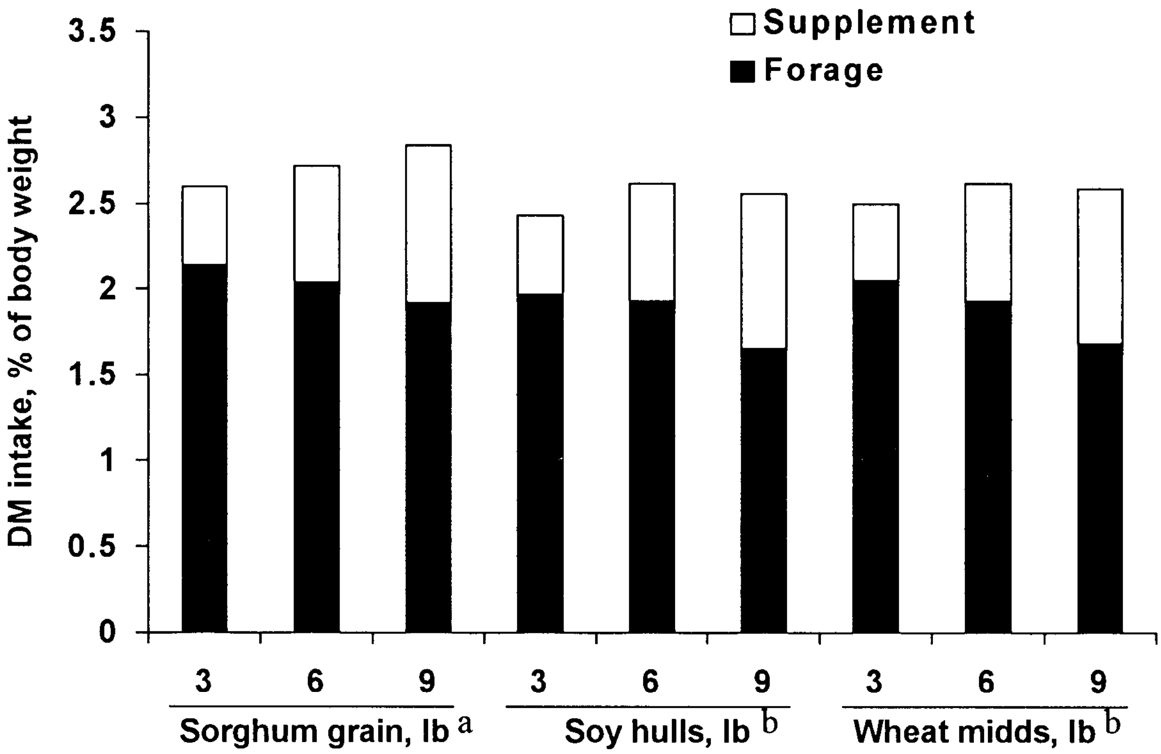

Figure 1. Influence of supplement type and amount on forage and total DM intake. Supplement type x amount interaction for forage DM intake (P = .88); for total DM intake (P = .85). Supplement types with different superscripts differed (P < .10) for both forage and total DM intake. Supplement amount had linear effects on both forage (P < .01) and total (P = .08) DM intake.

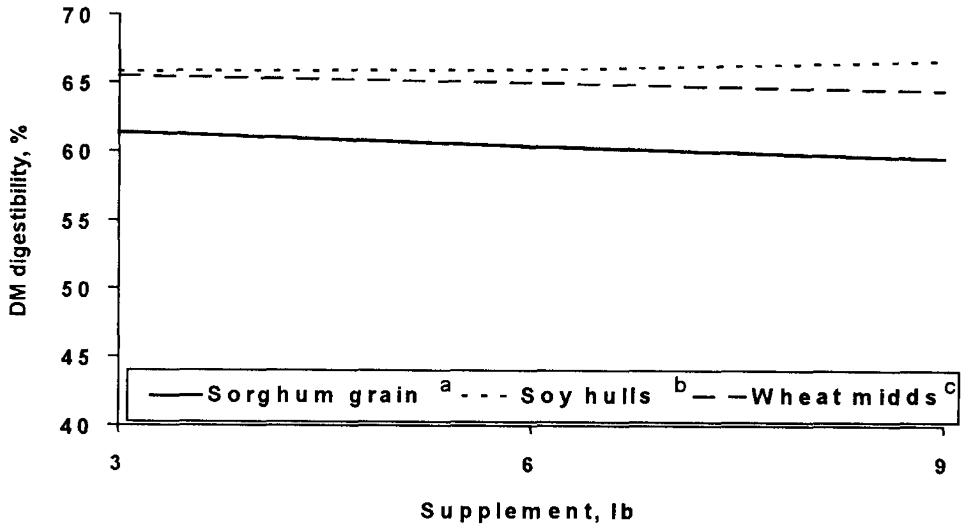

Figure 2. Influence of supplement type and amount on DM digestibility. Supplement type x amount interaction (P = .36). Supplement types with different superscripts differed (P < .10). Supplement amount did not affect (P = .44) DM digestibility.

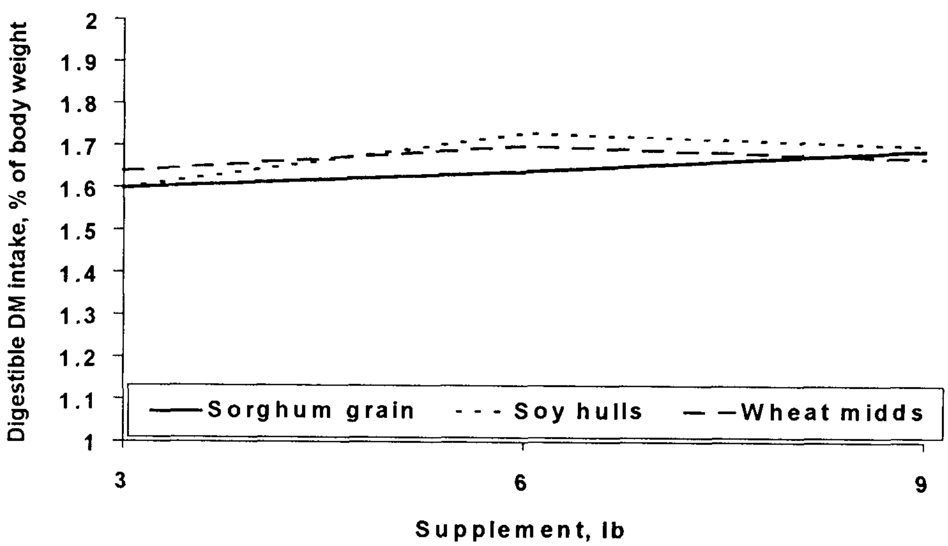

Figure 3. Influence of supplement type and amount on digestible DM intake. Supplement type x amount interaction (P = .88). Neither supplement type (P = .74) nor supplement amount (P = .22) affected digestible DM intake.

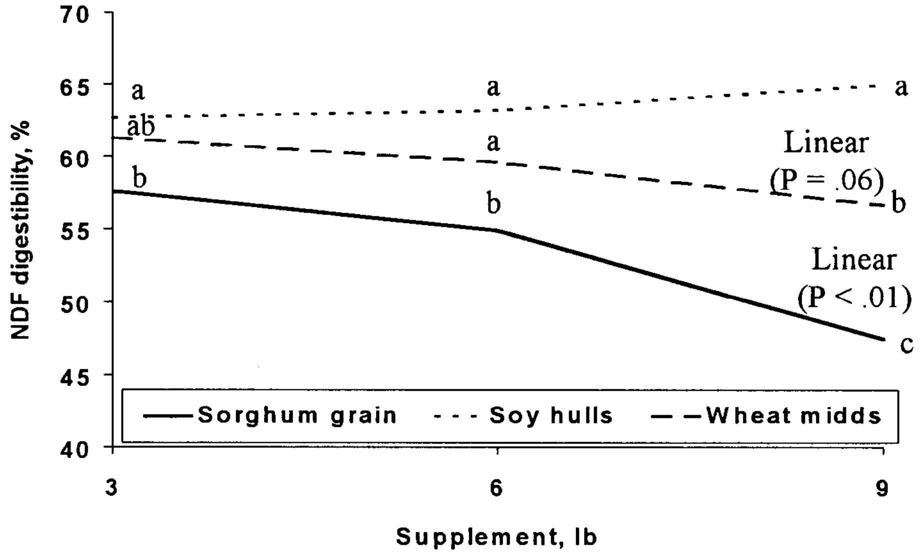

Figure 4. Influence of supplement type and amount on fiber (NDF) digestibility. Means within each level of supplement that have different letters assigned are different (P < .10).

Table 1. Influence of supplement type on ruminal fermentation characteristics.

Item	Supplement Type[a]			SEM[b]	P [c]
	SG	SH	WM		
Total VFA, mM	99.0[d]	103.1[d]	109.0[e]	1.64	<.01
pH	6.44[d]	6.46[d]	6.32[e]	.023	<.01
Acetate:Propionate	3.82[d]	4.06[e]	4.03[e]	.064	.06

[a] SG = sorghum grain; SH = soybean hulls; WM = wheat middlings.
[b] SEM = standard error of the mean.
[c] P = probability of a greater F-value.
[de] Means with different superscripts are different (P < .10).

Table 2. Influence of amount of supplement on ruminal fermentation characteristics.

Item	Amount of Supplement			SEM[a]	P [b]	
	3 lb	6 lb	9 lb		L	Q
Total VFA, mM	101.1	102.5	107.5	1.64	.02	.39
pH	6.44	6.43	6.35	.023	.02	.22
Acetate:Propionate	3.99	3.95	3.97	,064	.86	.74

[a] SEM = standard error of the mean.
[b] P = probability of a greater F-value; L = linear response to amount of supplement; Q = quadratic response to amount of supplement.

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