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Kansas State University

ROUNDUP 1999

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Report of Progress 833

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Statement of Purpose

Roundup is the major beef cattle educational event sponsored by the Agricultural Research Center–Hays. The 1999 program is the 86th 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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KAES Contribution No. 99-378-S

Tracking the Development of Marbling in Steers on Full Feed

John R. Brethour
Beef Cattle Scientist

Summary

Marbling in feedlot cattle increases slowly but appears to follow a defined pattern in which the increase is very slow at low levels but speeds up as marbling score becomes higher. In the modified power function model that best fit the data, progressing from low Select to low Choice, low Choice to average Choice, and average Choice to Prime took 114, 70, and 96 days, respectively. This model explains why some cattle seem to have very little increase in marbling during the feeding period, while others reach Choice and higher in a relatively short time. The model correctly tracked the increase in marbling of Wagyu X Charolais steers that attained high Prime after a long feeding period.

Introduction

Marbling is a critical factor in determining the USDA quality grade of cattle. Because the price for Choice carcasses usually exceeds that of lower grades (usually about $50 per animal), increasing the proportion of Choice among a pen of cattle is important to most cattle feeders. Ultrasound allows an estimate of marbling on the live animal upstream in the production process and also enables tracking marbling development during the finishing phase. Predicting the time to reach a quality grade target (such as Choice) from an ultrasound estimate made early in the finishing phase would be most useful.

We reported on preliminary efforts to assess the development of marbling in 1995 (KAES Report of Progress 731) and indicated that the progression was slow, averaging about .01 marbling units per day (100 days to progress from low Select to low Choice). In that study using serial ultrasound estimates throughout the feeding period, the increase in marbling appeared to be linear. However, that does not explain why some cattle quickly reach Choice and progress upward to higher grades in a short period of time, whereas others seem to show little change over a long period. Two extensive trials were conducted to investigate the development of marbling more thoroughly.

Methods

Two sets of cattle were used in this study. The first group included 292 Angus and Angus X Hereford steers that averaged 12 months old and 858 lb at the start of the study. Ultrasound estimates were made soon after they arrived and again after they had been on feed for 81 days (average of 59 days before slaughter).

The second group included 137 steers that were primarily continental breed crossbreds that averaged 836 lb and were approximately 14 months old when the study began. Marbling estimates were made with ultrasound four times: at arrival and at days 37, 76, and 123. Their average time on feed was 166 days but ranged from 99 to 215 days.

Cattle within each group were marketed in four outcome sets when they approached either 0.5 inch (group 1) or 0.4 inch (group 2) backfat. Days fed averaged 148 and ranged from 99 to 215. Both sets of cattle were fed a high energy finishing diet during the experiment.

The data analysis focused on determining the mathematical function that best described the increase in marbling. Linear and exponential models were compared for goodness of least squares fit, a power function also was evaluated. The power function was a special equation where both time and marbling score were converted to logarithmic equivalents for plotting. We used a modification of this equation that included an intercept parameter. The resulting equation sloped upward very slowly at first but then escalated at an increasing rate. These analyses were performed on a Lotus 1-2-3 spreadsheet with parameters of the models manually iterated to find the best fit.

The serial measures were portrayed by fitting the exponential mean of each animal at its corresponding location on an arbitrary time line. From that location, the actual measures were plotted at those points in time that represented deviations from the mean days for the scans. The models for marbling score included carcass values. Marbling scores were coded so that 4.0 = slight ^{00} (low Select) and 5.0 = small ^{00} (low Choice).

Results and Discussion

Plots of the fits for the two sets of cattle are shown in Figures 1 and 2. The time line shown is relative and does not enumerate actual days on feed. The power function equation provided a better fit than either a linear or exponential function, especially among cattle in Group 1, where more serial evaluations were made. The closeness of the fit can be best evaluated visually by observing the relation of the individual points to the solid curve in the scattergrams. In group 1 (Figure 1), r^2 values were .802, .823, and .852 for the linear, exponential, and power function models, respectively. For the group 2 cattle (Figure 2), less difference occurred among linear, exponential, and power functions (r^2 = .763, .765, and .776, respectively) when they were compared for fitting the serial ultrasound marbling scores. In both groups, the power function provided a significantly better fit because of the large number of observations in each data set

Intuitively, the power function, which is more concave than the exponential function, seems to describe the change in marbling score best, because it coincides with observations that cattle with low initial marbling do not reach Choice, even when fed as long as 200 days. It also explains why other cattle can quickly surpass average Choice and even grade Prime. The progression is slow early in the feeding period (about .01 marbling score unit per day) and then starts to increase faster after reaching low Choice. But animals that start with low traces amount of marbling usually fail to become Choice within conventional feeding periods (<200 days).

The power function equations for the change in marbling score in groups 1 and 2, respectively, were $Y = 3.39 + .00000000123632 * T^{3.42}$ and $Y = 3.10 + .000214 * T^{1.55}$, where Y = marbling score and T = days. The two equations produce similar values, even though the parameters appear to vary substantially. Because more measures were made and more variation occurred among the cattle, the formula for the group 1 cattle seems more desirable.

Solution of the power function equation that models marbling enables the prediction of future marbling as a function of time from an estimate of present marbling:

$$Y = k * [((A - I)/k)^{(1/m)} + T]^{m} + I$$

Y = Future marbling after T days
k = 0.00000000123642
A = Present marbling
I = Intercept: 3.39 (if A < I, then A = I)
m = 3.42
T = days

A companion equation to predict the days to increase marbling from one level to another is:

$$T = [(A_2 - I)/k]^{(1/m)} - [(A_1 - I)/k]^{(1/m)}.$$

T = days to reach a marbling target
A_1 = beginning marbling score

A2 = target marbling score
Other variables are as cited above.

Solutions of the equations indicated that an average of 114 days is required to progress from low Select to low Choice. Likewise, the time to increase from low Choice to average Choice (Certified Angus or equivalent) is 70 days, and moving up from that level to Prime takes 96 more days.

A validation of the model is shown in Figure 3. The data points are ultrasound estimates taken on six Wagyu X Charolais steers that were scanned frequently during a 256-day feeding period. These steers all graded Prime when slaughtered. The solid line in Figure 3 is the above formula superimposed on the data. It nearly mimics a line that averages the values.

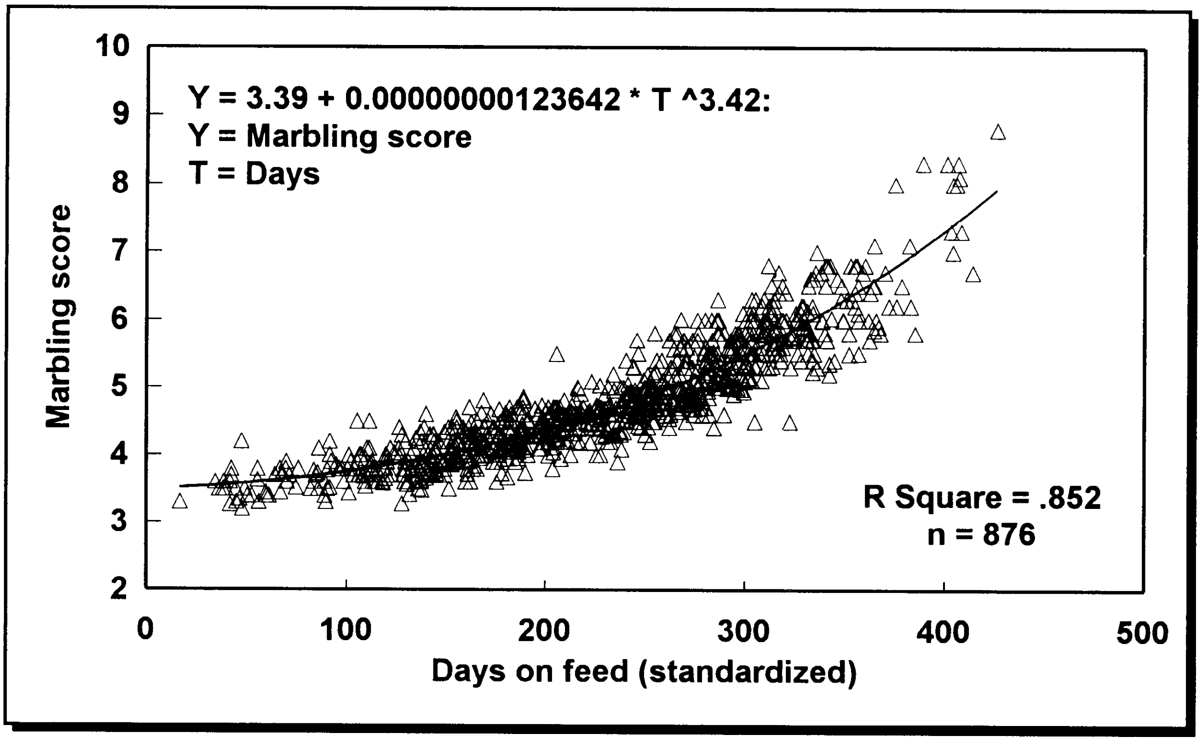

Figure 1. Fit of serial ultrasound marbling measures as a function of days on feed The exponential mean of the marbling measures was fit to the corresponding location on the time line, and the actual measures were plotted from that point (Group 1).

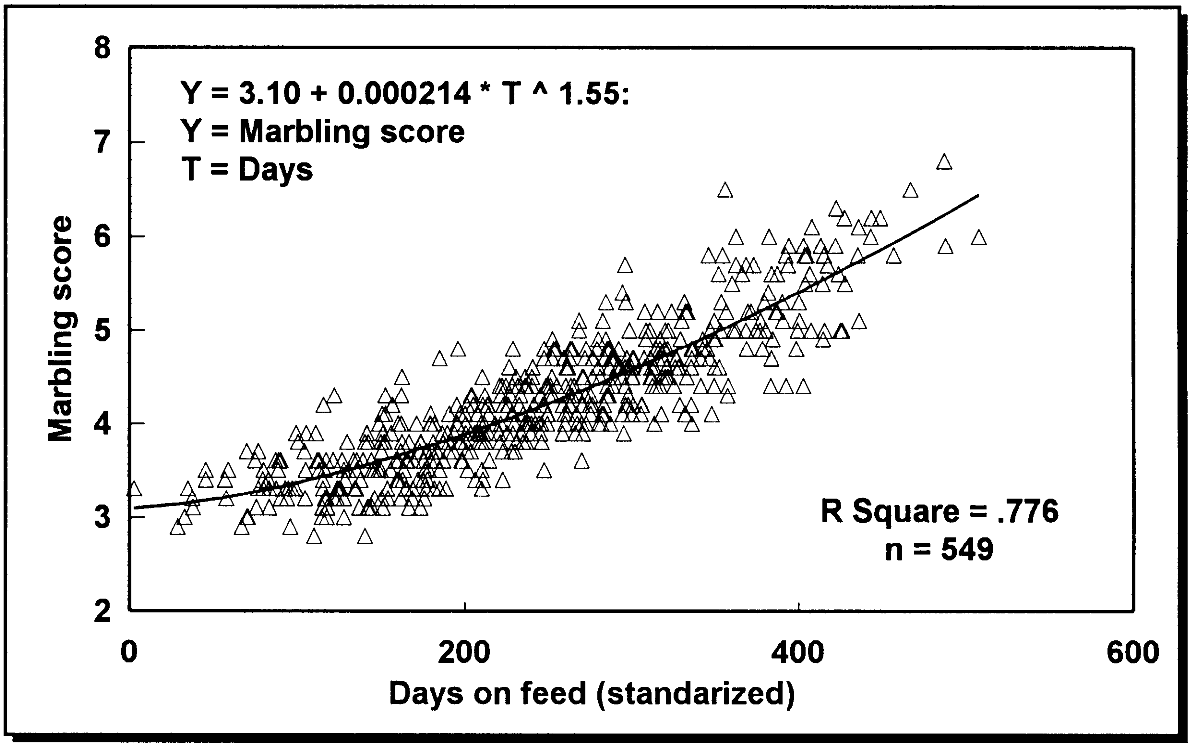

Figure 2. Fit of serial ultrasound marbling measures as a function of days on feed The exponential mean of the marbling measures was fit to the corresponding location on the time line, and the actual measures were plotted from that point (Group 2).

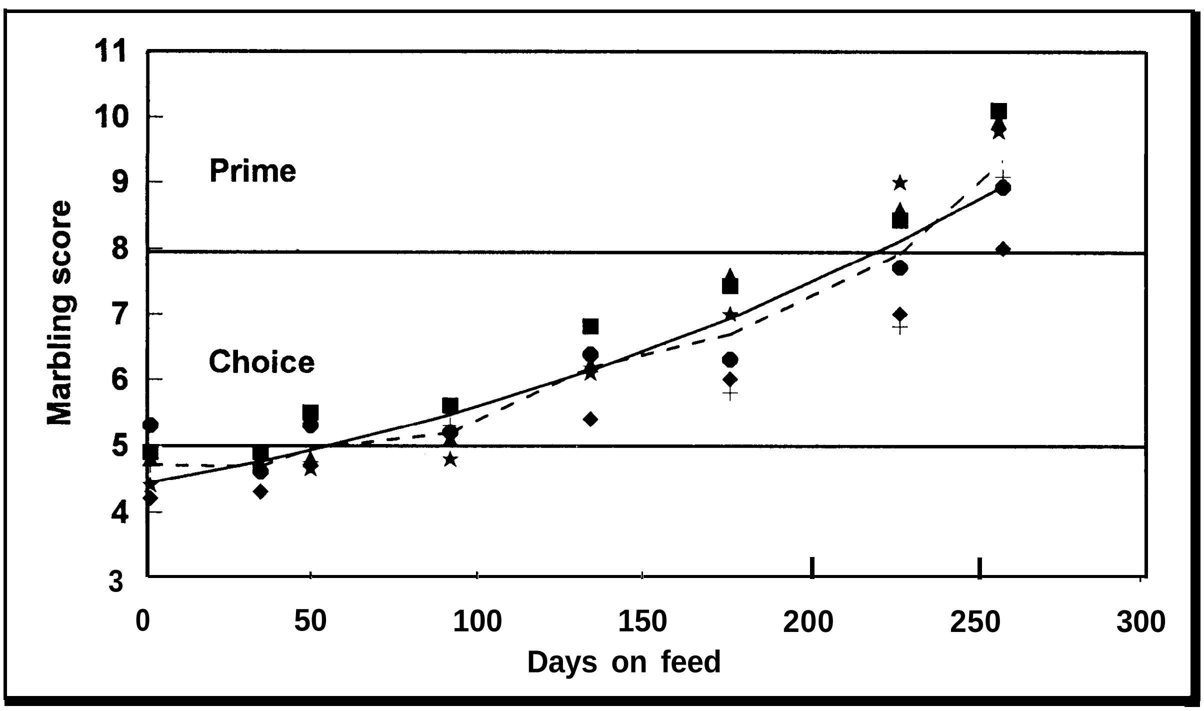

Figure 3. Increase in marbling score of Wagyu X Charolais steers during 256 days on feed. Different symbols represent individual animals. Solid line represents the marbling increase model from Figure 1 (discussed in the text). Dashed line shows average of six animals at each session.

Accuracy in Predicting Future Grade from Ultrasound Estimates on Calves

John R. Brethour
Beef Cattle Scientist

Summary

Ultrasound marbling estimates on calves were over 70 percent accurate in predicting whether they would grade Choice or not when finished 7 or 8 months later. This paper introduces a procedure called Receiver Operating Characteristic analysis, which analyzes the error rate and enables a user to determine if evaluation of calves is sufficiently accurate to meet expectations and needs.

Introduction

Producers have considerable interest in using ultrasound to evaluate calves shortly after weaning to predict the carcass quality grade that they will attain when eventually fed out and harvested. That would enable those who practice retained ownership to select a contingent of the herd that has a greater likelihood of meeting desired carcass expectations. Or it might enable clustering calves for management for different carcass grids.

Estimating carcass potential of calves with ultrasound is not an exact science. Many components of error exist in the process, including:

* Error in the capture and automated interpretation of the ultrasound image.
* Error in ascertaining the rate of marbling increase over time.
* Biological variability among animals in carcass development.
* Subjectivity in assigning carcass marbling score after slaughter.

Scientists often report correlation coefficients as a measure of accuracy from their research. However, correlation coefficients are often worthless in determining whether a procedure has sufficient merit for application.

In many disciplines such as engineering and medicine, a mathematical procedure called the Receiver Operating Characteristic (ROC) is used to measure diagnostic accuracy. This procedure calculates probabilities of correct and false predictions across the range of initial values. The ROC analysis probably has never been used in agriculture but appears appropriate for the task of evaluating ultrasound measurements on calves.

Methods

Two sets of steer calves were used in this study. The 143 calves in Group 1 (from the ARCH cow herd) were evaluated for marbling with ultrasound in October, 1997, which was soon after weaning. They were harvested after an average of 249 days on feed. The other 185 calves (Group 2) where weaned in November, but ultrasound evaluation was postponed until early January, because an October storm had stressed the calves and may have affected accuracy of ultrasound readings for several weeks afterwards. The interval between evaluation and slaughter for Group 2 calves averaged 222 days. Marbling scores were coded so that 4.0 = slight ^{00} (low Select) and 5.0 = small ^{00} (low Choice).

The computer software for the ROC analysis was provided by Charles Metz, from the University of Chicago but is also available from sources on the Internet.

Results and Discussion

The raw data for Groups 1 and 2 are shown in Figures 1 and 2, respectively. The coefficients of determination of .30 and .29 (which correspond to correlation coefficients of .55 and .54) are statistically highly significant. However, one can see in the scatter plots that considerable error occurred and assessing whether the accuracy is good enough for application is difficult.

The ROC analysis indicated that ultrasound estimates were 70 and 72 percent accurate in predicting whether individual calves in groups 1 and 2, respectively, would grade Choice or not. The accuracy in predicting whether an individual calf would reach premium Choice (average Choice and higher – equivalent to Certified Angus Beef) was slightly higher, 79 and 76 percent, respectively.

Figure 3 was generated from the ROC analysis. It can be used to select the threshold marbling score for picking a segment of calves that will result in an expected proportion of Choice. However, to use the information in Figure 3, the proportion of Choice in the total calf crop must be estimated. For example, a group of calves might have graded 60 percent Choice in previous years, but one might wish to retain only a proportion that would grade 80 percent Choice. The arrow in Figure 3 indicates the intersection of 80 percent Choice with the 60 percent total Choice line. Reading down to the marbling score threshold at meaning indicates using a level of 3.85 (traces ^{85}) for a decision to retain.

Figure 4 is an important complement to Figure 3. It shows the proportion of the total group that will be expected to meet or exceed the threshold requirements. In the example, a marbling score threshold was established at 3.85. Reading up from that value in Figure 4 to the 60 percent line (estimated percent Choice in the entire group), the intersection corresponds to 35 percent on the left axis. Choosing a group that will be expected to grade 80 percent Choice will result in taking only 35 percent of the herd.

The ROC calculations account for the errors in predicting future quality grade with ultrasound and provide a guide for expectations that are achievable or not. Another situation might involve a set of poorer grading calves that has a history of only 30 percent Choice. Figures 3 and 4 indicate that sorting off a set expected to grade 60 percent Choice might be possible but that set would include only 15 percent of the crop.

Figures 5 and 6 could be used to upgrade sets of high-grading calves to increase proportions that meet requirements for premium Choice (average Choice). Similar charts could be constructed for distinguishing between Standard and Select or between Choice and Prime. If technology for predicting future quality grade among young cattle can be improved, then the ROC analyses will show how much more exact it is in grouping animals.

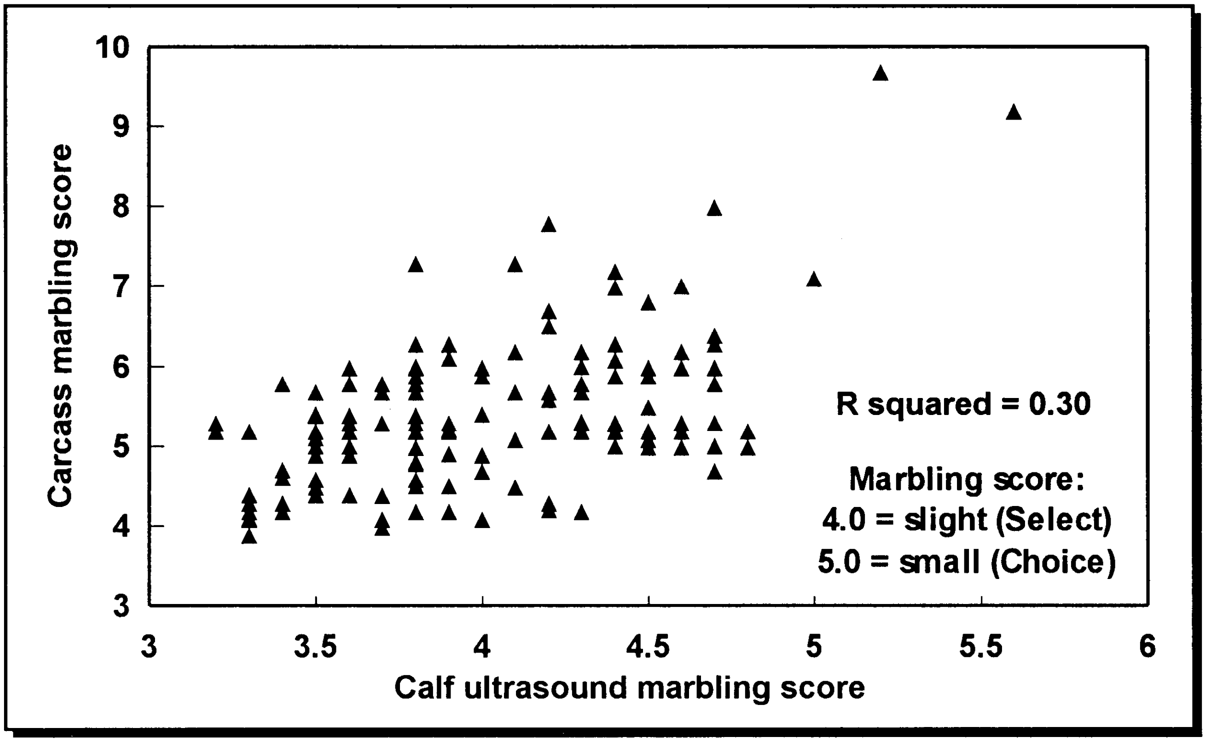

Figure 1. Relationship of calf ultrasound score and carcass grade 8 months later (Group 1 - 143 calves).

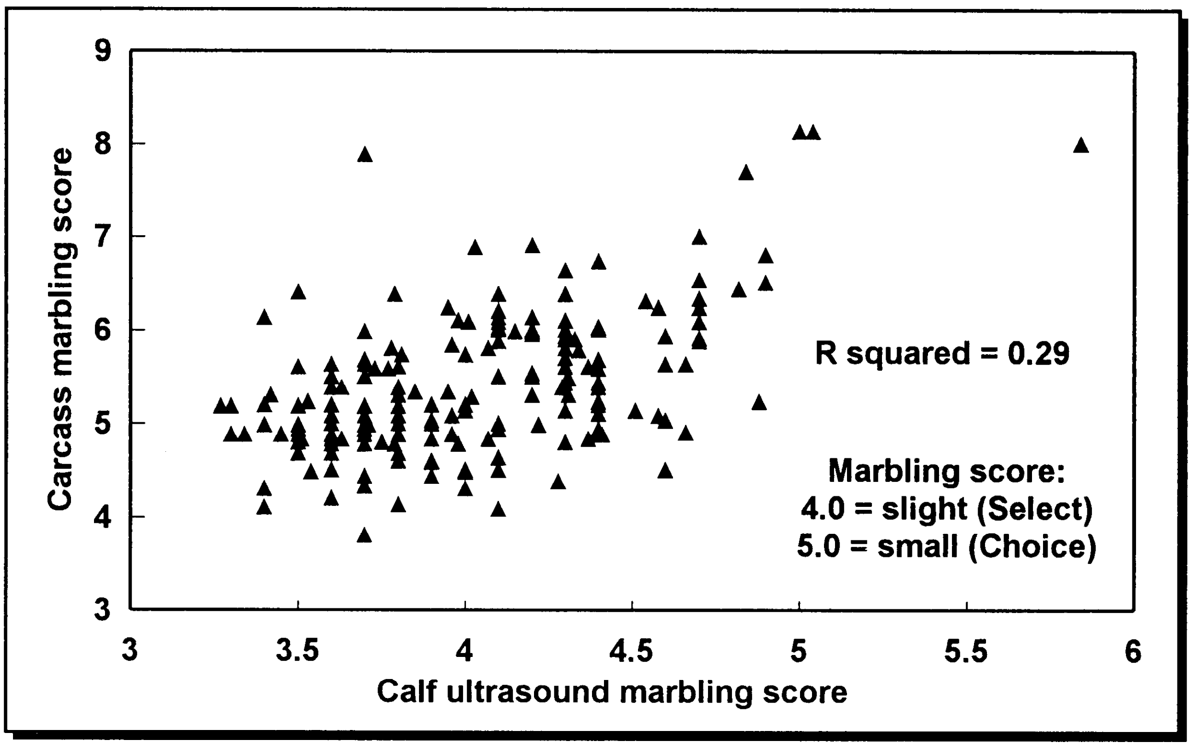

Figure 2. Relationship of calf ultrasound score and carcass grade 7 months later (Group 2 - 185 calves).

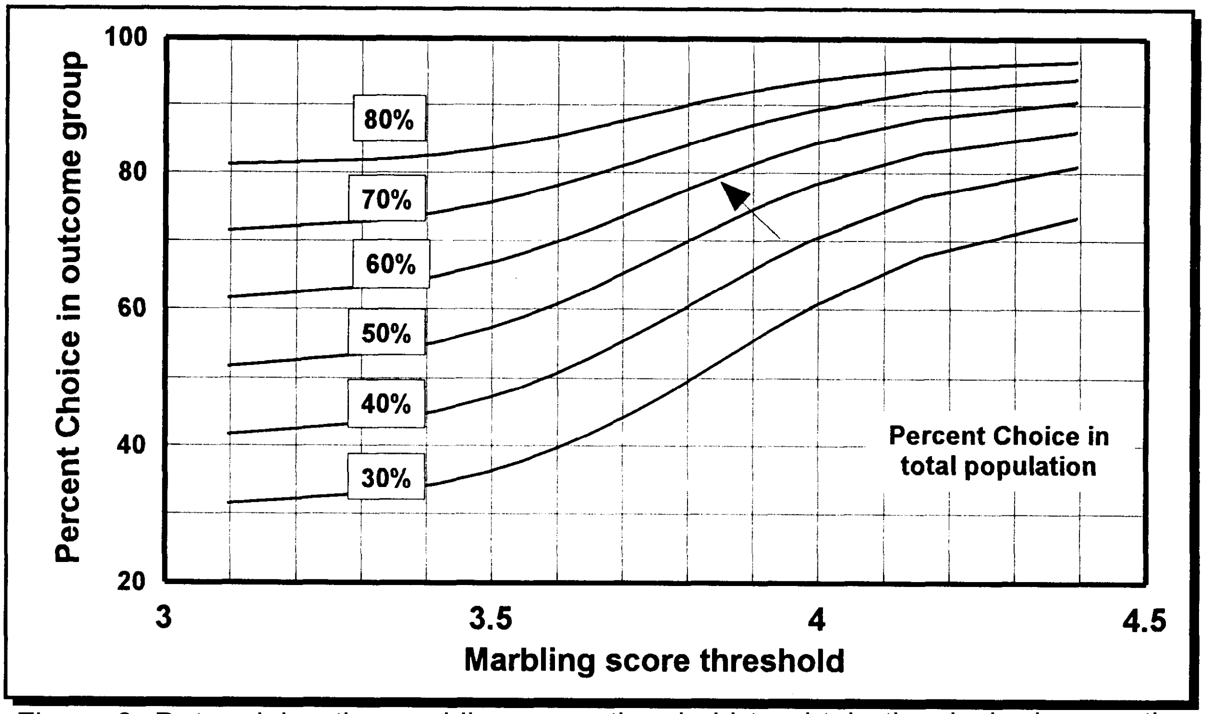

Figure 3. Determining the marbling score threshold to obtain the desired proportion of Choice in a selected group (this depends on the estimate of percent Choice in the total set). For example, in a herd of calves that have graded 60% Choice in the past, the marbling score threshold would be set at 3.85 to select a group that would grade 80% Choice.

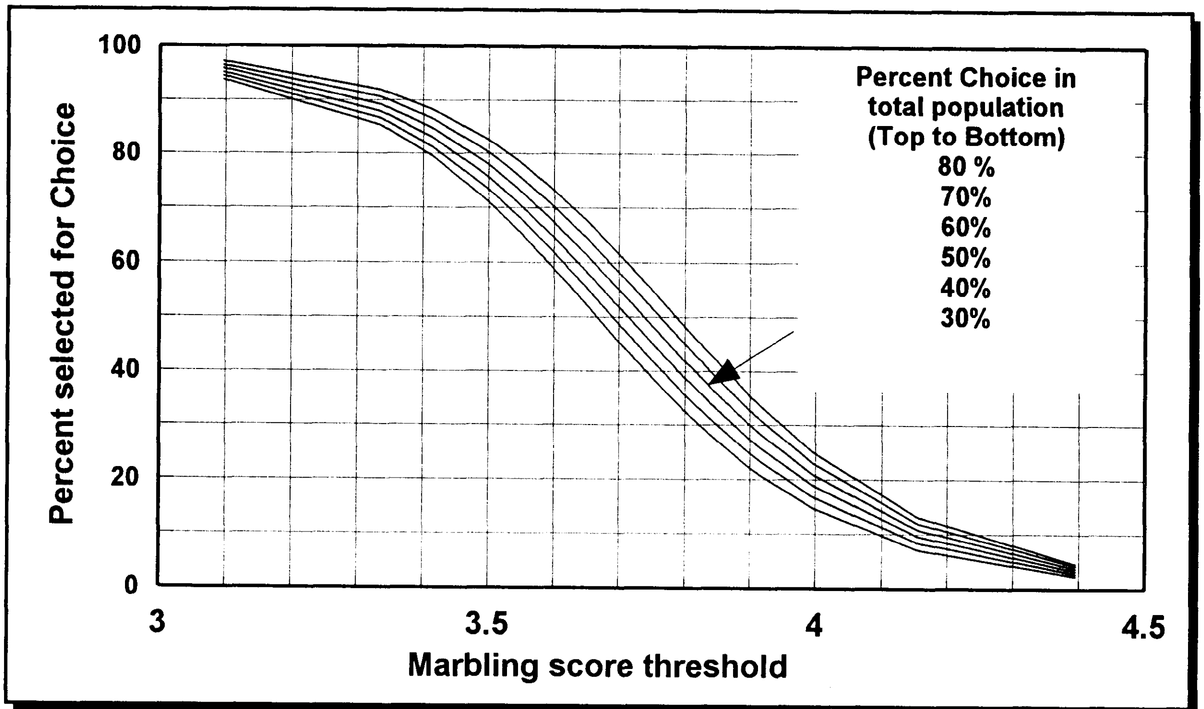

Figure 4. percent of total population selected to obtain a targeted percent Choice. If the marbling score threshold is set at 3.85 (to obtain a set that grades 80% Choice) and all are expected to grade 60% Choice, then about 35% will be selected.

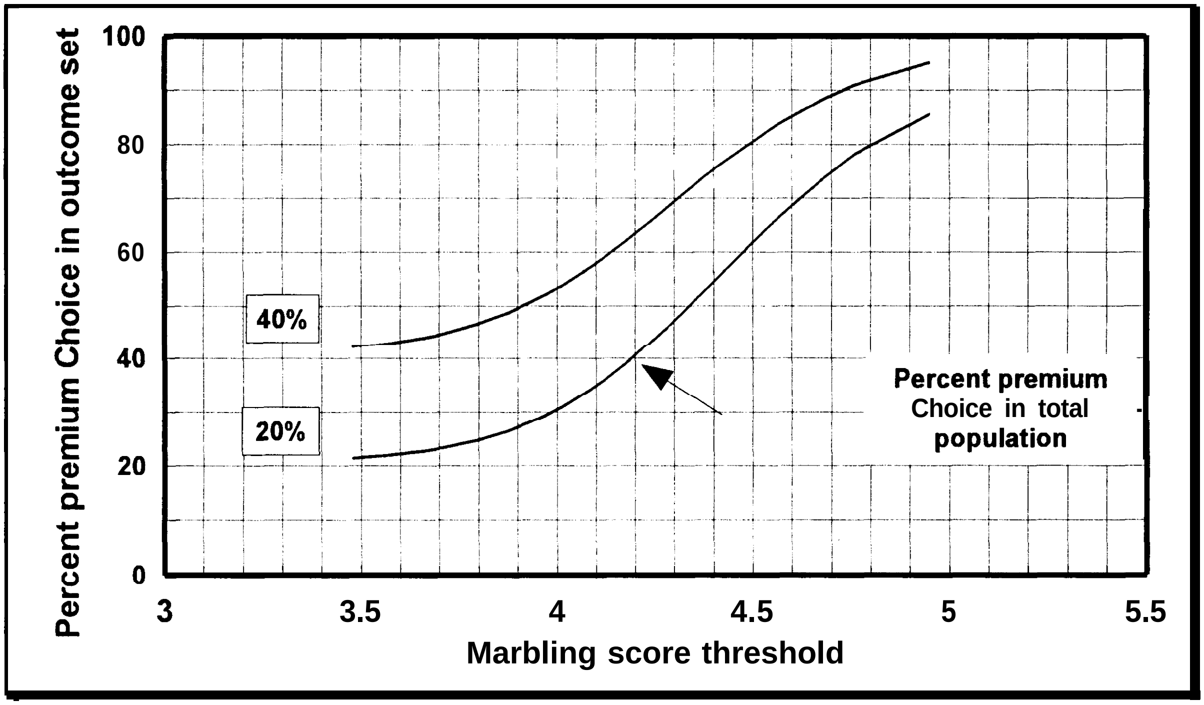

Figure 5. Determining the marbling score threshold to obtain the desired proportion of "premium Choice" in a selected group (this depends on the estimate of percent premium Choice in the total set). For example, in a herd of calves that have graded 20% premium Choice in the past, the marbling score threshold would be set at 4.20 to select a group that would grade 40% premium Choice.

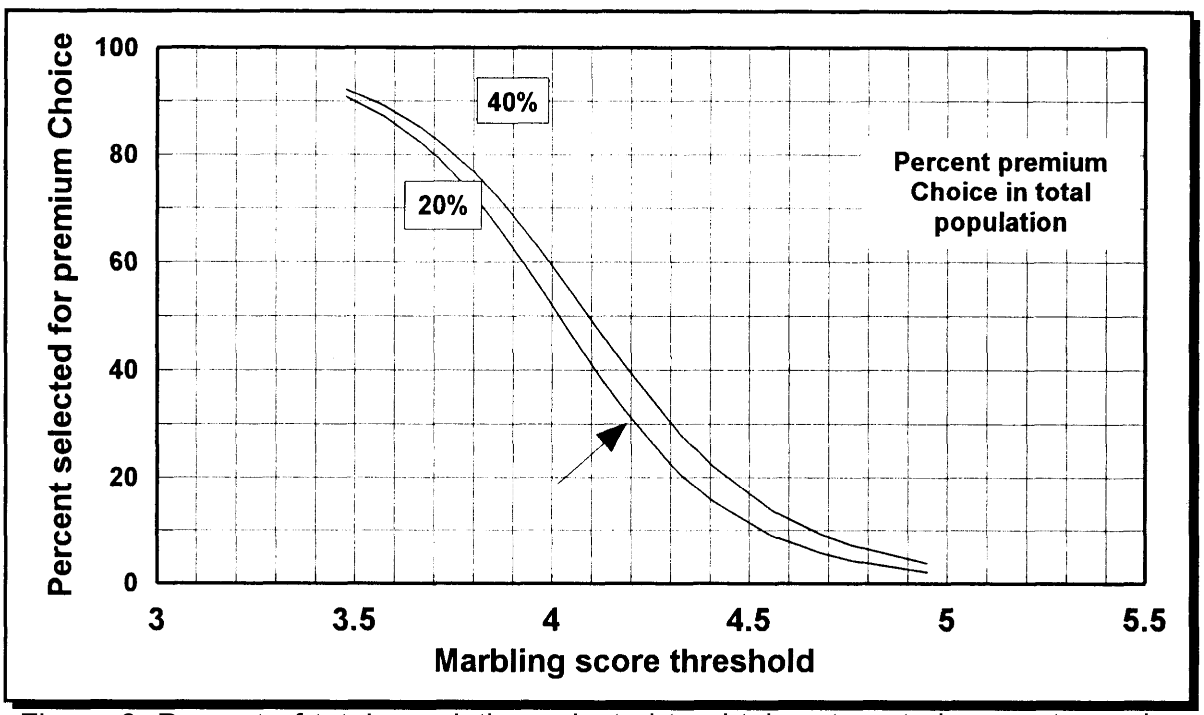

Figure 6. Percent of total population selected to obtain a targeted percent premium Choice. If the marbling score threshold is set at 4.20 (to obtain a set that grades 40% premium Choice) and calves are expected to grade 20% premium Choice without sorting, then about 30% will be selected.

Rumen-Protected Choline and Free Betaine in Steer Finishing Rations

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Summary

Little response was seen to feeding 4.5 g/hd/d rumen-protected choline, 20 g/hd/d free betaine, or the combination of those two treatments in steer finishing rations. Initial ultrasound estimates of backfat and marbling provided better research control to measure treatment effects on those traits. No differences occurred among treatments in marbling score or quality grade. However, choline and/or betaine tended to increase fattening rate, especially among cattle with higher initial levels of backfat.

Introduction

Both choline and betaine are involved in fat transport in the body, and earlier research has suggested that they may increase marbling score and improve carcass quality grade. Ultrasound provides an opportunity to obtain base values for both backfat thickness and marbling score at the beginning of an experiment. This should improve the statistical precision of feeding trials that need to evaluate treatment effects on those attributes. The ultrasound measures also enable blocking cattle into experimental blocks where the replications can be fed for an appropriate number of days within each block. Newer formulations of choline and betaine should allow rumen bypass and have greater biological activity.

Methods

A total of 290 yearling crossbred steers was used in this experiment, which was divided into three blocks. Blocking was done according to projected days on feed (DOF) based upon initial weight and ultrasound measurement. The three initial weight and ultrasound blocks of steers were fed for 99, 126, and 148 days, respectively. Each of these three DOF blocks were divided into four equal groups and assigned to one of four dietary treatments. Treatments included 4.5 g/hd/d rumen-protected choline (RPC), 20 g/hd/d free betaine (FB), the combination of 4.5 g/hd/d RPC plus 20 g/hd/d FB, or a control diet. Each treatment contained three pen replicates and each pen replicate contained 24 or 25 head. The basal diet consisted of rolled sorghum grain, sorghum silage, soybean meal, urea, and a monensin/tylosin plus vitamin-trace mineral premix.

Final weights were determined from carcass weights divided by a constant dressing percent. Feedlot performance measurements included average daily gain, dry matter intake, and gain/feed. Carcass measurements included ultrasound estimates of backfat thickness and marbling score. Performance and carcass data were analyzed by two-way analysis of variance after obtaining the best estimate of location within each pen with a statistical model that included initial weight, animal source, and the ultrasound estimates. Rate coefficients (k) for backfat accretion (k = (ln final - ln initial)/days) also were determined within each pen for steers with low versus high initial backfat thickness.

Results and Discussion

No significant differences occurred in the performance attributes (Table 1). Treatments did not affect marbling score or USDA quality grade. A tendency was seen for the experimental products to increase carcass backfat thickness. That trend was statistically significant among the half of the animals within each pen that had the higher levels of initial backfat.

The ultrasound procedures were effective in providing a covariant for the analysis of the carcass data and accounted for over 30 percent of the experimental variations in backfat thickness and marbling score.

Rate coefficients (k) for backfat accretion (k = (ln final - ln initial)/DOF) also were determined within each pen for steers with low versus high initial backfat thickness. Subsequent analysis of variance of these two backfat sub-groupings revealed that RPC, FB, and RPC + FB treatments significantly increased k values for steers with high initial backfat thickness but not for steers with low initial backfat thickness. These findings suggest that RPC, FB, and their combination can increase the rate of fattening in cattle with a greater backfat accretion propensity.

Table 1. Effects of rumen-protected choline and free betaine in steer finishing rations

	Treatment			
Item	Control	Choline	Betaine	Choline + Betaine
Dry matter intake, lb	26.02	26.69	26.00	26.02
Average daily gain, lb	3.10	3.18	3.07	3.11
Lb gain/100 lb DM	12.10	12.29	12.25	12.15
Backfat thickness, mm	9.50	9.93	9.88	10.07
Marbling score	5.02	5.00	5.03	5.11
Percent choice	60.08	58.17	64.17	68.13
Percent YG #1 and #2	75.08	68.52	71.07	64.07
Fattening rate (1)				
Low initial backfat	11.72	12.26	11.33	11.54
High initial backfat	9.53	10.59	10.45	10.41

(1) Fattening rate is rate coeffecient (times 1,000) for exponential increase of backfat thickness during the trial.

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