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Understanding and Improving Beef Cattle Carcass Quality

DANIEL J. DRAKE is Farm Advisor, University of California Cooperative Extension, Siskiyou County.

UNIVERSITY OF CALIFORNIA
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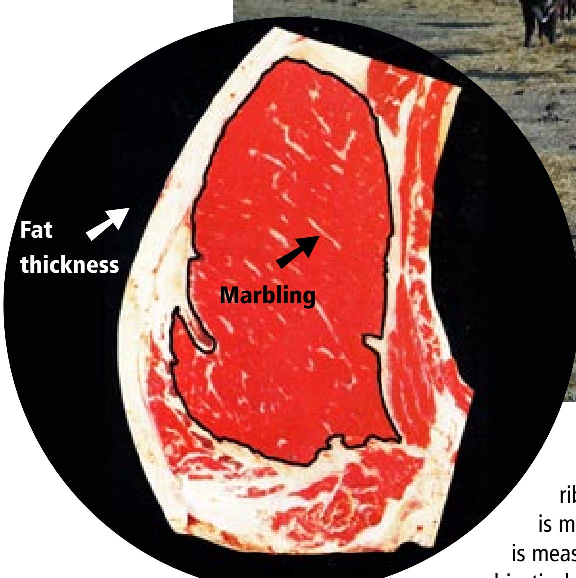
Interest and questions about the quality of beef are on the rise due to heightened awareness about the marketing of beef, from procurement and processing to consumer acceptance. Belatedly, producers are now beginning to receive information about the quality of the beef they produce. Consolidations among beef marketers have resulted in better communication between marketers and producers on carcass quality. Other changes have resulted in monetary incentives for improving beef quality. New marketing structures such as vertical integration and value-based marketing provide direct financial rewards to cow-calf producers who offer more desirable carcasses. With more emphasis on the beef product and carcass information more readily available, carcass attributes are figuring more and more into the cow-calf manager's decision-making process and yielding financial rewards. The goals of this publication are to help producers understand carcass information: what it means and how producers can use it to improve beef quality.



Herd genetics and management can be manipulated to produce higher-grade beef carcasses. The surface of the ribeye between the 12th and 13th ribs is used for obtaining carcass data (see cross-section at left). Fat thickness is measured as indicated (white arrow). The area of the ribeye (outlined in black) is measured in square inches. Flecks of fat, known as marbling (black arrow), are subjectively evaluated and assigned a marbling grade (in this case "modest"), which is categorized here as Choice quality grade.

Part I: Understanding Carcass Data

SOURCES OF CARCASS DATA

The processing facility

Producers involved in vertical integration receive a huge amount of carcass data from the cooperating processing plant. Producers retaining ownership or selling on a carcass basis can request carcass data from the processing plant. Selling on the basis of a grid (see Table 4) will generate a more limited (but still valuable) amount of carcass data. An additional source of carcass data is from futurities that assemble small lots of four to five weaned calves that are shipped, fed, and processed together. The producer receives group feedlot data and individual carcass data. Data on a random selection of four to five calves can help show the expected performance of the entire herd.

Ultrasound

Carcass data can also be obtained by using ultrasound technology to scan and predict carcass traits in live animals, either breeding or finished cattle. This type of information is particularly handy for breeding animals that will not go to slaughter. Ultrasound is usually conducted at about one year of age on breeding animals. Ultrasound technology is complicated and all breed associations require that it be carried out by trained and certified technicians to ensure the quality of measurements.

Ultrasound measurements of breeding animals are closely related to carcass values, but they really are not the same as the direct carcass data collected on finished slaughter cattle. Breeding animals have not been fed in the same way as cattle that are being prepared for processing, they are of a different age, and they are bulls instead of steers. Ultrasound data on breeding animals are most useful for breed associations when they calculate expected progeny differences (EPDs) based on carcasses.

Ultrasound may also be used to obtain carcass data on finished cattle, typically at the feedlot, as a substitute for actually measuring the carcass. For finished cattle, the correlation of ultrasound fat thickness and ribeye area measurements to actual carcass data is greater than 0.80, which is acceptable for most uses. Ribeye area must be measured to within about 1 square inch of actual carcass data and fat thickness to within 0.10 inch for certification. Similar accuracies are obtained for quality grade.

Genetic tests

While not actually carcass data, new technology using the principles of DNA analysis is identifying genes that may be important in controlling carcass traits. For example, this technology will not measure the degree of marbling or the corresponding quality grade, but instead it might determine the presence or absence of genes that control marbling. Cattle with marbling genes would be genetically inclined to produce more marbling. This area is still in its infancy but rapidly advancing. Currently, two genetic tests are available on a commercial basis. One test evaluates the genetic condition for thyroglobulin, a precursor molecule to thyroid hormone. Initial testing suggests that this gene has sufficient impact on marbling to be of value in increasing the quality grade of long-fed cattle. Most researchers believe this is only one of several genes that might be useful in improving quality through marbling. A second commercially available genetic test is for tenderness. It measures variants in the gene for calpastatin—one associated with tenderness and the other with increased toughness. This test illustrates that some improvements in carcass quality may not reap easy monetary rewards under the current marketing system.

A number of other genetic tests are being researched. Some of these include the potential to modify fat composition, which may be important to human health and so have marketing value. Again, these tests and the cattle that result from selection on the basis of genetic tests may not yield quick, direct financial rewards, but they will yield better beef and so a better market in the long run.

TYPES OF CARCASS INFORMATION

Actual measurements or physical descriptions of carcasses, whether obtained from carcasses or by ultrasound, are usually restricted to five factors:

- quality grade (or the corresponding marbling score or numerical score, or percentage intramuscular fat, or a combination of all of these)
- yield grade (or the components of yield grade: carcass weight, fat thickness, percentage kidney, pelvic, and heart fat [%KPH fat], and ribeye area)
- carcass weight
- ribeye area
- fat thickness or backfat thickness

Quality grade

The quality grade of a carcass is mostly determined by the amount of marbling on the cut surface of the ribeye between the 12th and 13th ribs. *Marbling* is the flecks of fat in the ribeye muscle. Increased marbling results in higher quality grades (Table 1). The amount of marbling required for each quality grade varies slightly with the maturity of the cattle, but most cattle in typical production systems are younger than 30 months old at slaughter and therefore fall under maturity class A.

Marbling grades, not quality grades, are determined through visual observation of the carcass. Then, based on the marbling grade, a quality grade is assigned. Marbling grades may be reported to the nearest one-third by using the + or – sign, such as "Small –." Marbling scores may also have a more detailed value using fractions of 100. An example is "Small 20," which means 20 percent of the way toward "Modest," the next marbling grade above "Small" (Table 1). A marbling grade may also be converted to or reported as a numerical decimal equivalent. In the system used by the American Angus Association, a "Small –" marbling grade would be a numerical marbling score of 5.0 (Table 1). A similar alternative scoring system also in use assigns numerically higher values for each marbling grade (Table 1). Conversion of marbling grades to numerical scores can be laborious, but it is essential for evaluating quality grades. Marbling EPDs are based on a numerical marbling score like that used by the American Angus Association (Table 1).

Ultrasound measurements of marbling are reported as percentage intramuscular fat (%IMF) in the ribeye muscle. Ultrasound values for finished cattle can be converted to a marbling grade and score (Table 1). For breeding cattle, %IMF is not converted to a marbling grade since these are not finished cattle. EPD values for %IMF are not converted either, and should not be compared to marbling EPDs.

Yield grade

Yield grade (YG) estimates the amount of closely trimmed retail cuts of meat that a carcass is likely to yield. Yield grades range from 1 to 5, with 1 the highest yielding and 5 the lowest yielding. Typical USDA reporting gives only whole numbers for yield grade, but carcass data are often expressed in decimal fractions of yield grade. Carcass data should use yield grade to the closest one-tenth (e.g., 2.3 yield grade) rather than whole numbers.

Yield grade is calculated on the basis of the amount of external fat cover or fat thickness, the percentage of fat in the kidney, pelvic, and heart areas, the ribeye size, and carcass weight. This formula uses those factors to estimate the yield grade:

$$\text{YG} = 2.5 + [2.5 \times \text{fat thickness (in.)}] + [0.0038 \times \text{carcass weight (lb.)}] + (0.20 \times \text{\%KPH fat}) - [0.32 \times \text{ribeye area (sq. in.)}]$$

Table 1. Marbling score, abbreviation, and numerical equivalents plus the quality grade associated with each marbling grade (for maturity class A cattle, less than 30 months of age). Listed in order of decreasing amounts of marbling.

Marbling grade	Marbling abbreviation	Numerical marbling score (American Angus Assoc.)	Quality grade	Actual percentage intramuscular fat* (%IMF)	Alternative scoring system*
Abundant+	AB+	10.67 – 10.99			1,567 – 1,590
Abundant	AB	10.33			1,533
Abundant–	AB–	10.0	Prime+	>12.21	1,500
Moderately abundant+	MAB+	9.67			1,467
Moderately abundant	MAB+	9.33			1,433
Moderately abundant–	MAB–	9.0	Prime	10.33 – 12.21	1,400
Slightly abundant+	SLAB+	8.67			1,367
Slightly abundant	SLAB	8.33			1,333
Slightly abundant–	SLAB–	8.0	Prime–	8.56 – 10.32	1,300
Moderate+	MD+	7.67			1,267
Moderate	MD	7.33			1,233
Moderate–	MD–	7.0	Choice+	6.89 – 8.55	1,200
Modest+	MT+	6.67			1,167
Modest	MT	6.33			1,133
Modest–	MT–	6.0	Choice	5.34 – 6.88	1,100
Small+	SM+	5.67			1,067
Small	SM	5.33			1,033
Small–	SM–	5.0	Choice–	3.91 – 5.33	1,000
Slight+	SL+	4.5	Select+		967
Slight	SL	4.25			933
Slight–	SL–	4.0	Select–	2.59 – 3.90	900
Traces+	TR+	3.67			867
Traces	TR	3.33			833
Traces–	TR–	3.0	Standard+	1.38 – 2.58	800
Practically devoid+	PD+	2.67			767
Practically devoid	PD	2.33			733
Practically devoid–	PD–	2.0	Standard–	0.28 – 1.37	700
Devoid+	D+	1.67			
Devoid	D	1.33			
Devoid–	D–	1.0	Utility	NA	NA

NA = not applicable
* Provided by Doyle Wilson, Iowa State University, and slightly adapted to fit table categories.

Fat thickness is the most influential factor affecting yield grade. As the external fat covering increases, the numerical yield grade increases, which is reflected in fatter and fewer closely trimmed retail cuts of meat. This is sometimes referred to as "reduced cutability."

A carcass may also receive a Preliminary Yield Grade (PYG). This is a first approximation of the eventual yield grade and is based solely on the amount of external fat thickness at the 12th and 13th ribs. A carcass with no fat opposite the ribeye would have a PYG of 2.0. For each 0.2 inch of fat thickness, the PYG increases by 0.5 (Table 2). When the PYG is provided and the yield grade is not, the PYG must be converted into fat thickness, which is then used in the yield grade equation to calculate yield grade. To convert PYG to fat thickness, multiply PYG by 0.4 and then subtract 0.8. Then use this value along with carcass weight, percentage kidney, pelvic, and heart fat, and ribeye area to calculate the yield grade to one decimal.

Table 2. Relationship between fat thickness opposite the ribeye at the 12th and 13th ribs and preliminary yield grade (PYG).*

Fat opposite ribeye (in inches)	Preliminary yield grade (PYG)
0	2.0
0.2	2.5
0.4	3.0
0.6	3.5
0.8	4.0
1.0	4.5

* PYG can also be converted to fat thickness using the equation
Fat thickness (in.) = (PYG × 0.4) – 0.8

Yield grade can be converted to a percentage representing the same cuts. To convert yield grade to USDA percentage retail product use this formula:

$$56.9 - (2.3 \times YG)$$

This value is not used in most breed association calculations of EPD percentage retail cuts. For instance, the American Angus Association uses a formula that predicts the percentage of the carcass that is made up of boneless muscle systems (subprimals) that have been trimmed free of removable surface fat, plus ground beef. This equation uses the same factors as the yield grade equation. To calculate the percentage of retail cuts by this method use this equation:

$$\% \text{ retail cuts} = 65.69 - [9.93 \times \text{fat thickness (in.)}] + [1.226 \times \text{ribeye area (sq. in.)}] - [0.01317 \times \text{carcass weight (lb.)}] - (1.29 \times \%\text{KPH fat})$$

Carcass weight

Carcass weight is recorded just before the carcass enters the chilling room during the processing of finished cattle. Consequently, it is sometimes referred to as the *hot carcass weight*. The (hot) carcass weight is used when calculating yield grade. It also reflects the approximate size of the cuts of meat that can be expected from further processing of the carcass: heavier carcasses produce larger ribeyes. Larger carcasses are more efficient in processing time and labor. Many markets have minimum and maximum sizes of specific cuts, however, so there is a range of acceptable carcass weights. During the 1970s the industry was converting to boxed beef so the carcass had to fit the box. The industry is even more specific today: beef needs to fit the plate.

Ribeye area

Closely related to the carcass weight is the area of the ribeye. This is measured as the surface area on the cut surface of the ribeye muscle between the 12th and 13th ribs, the same location used to determine the marbling grade. Higher-priced steaks are processed from this area of the carcass. For satisfactory cooking and eating, steaks need to have at least a minimum thickness; 12 to 15 square inches is the recommended area if the ribeye is to yield 8- to 12-ounce steaks 1 inch thick (Dunn et al. 2000). If the ribeye area is too large, steaks cut to the desired thickness will be too large and too expensive, and steaks cut to the desired weight will be too thin.

Ribeye area is used in calculation of the yield grade. Ribeye size will increase with larger carcasses. To compare the ribeye size of different carcasses, one must first convert them to a common carcass weight by dividing the ribeye area by the actual carcass weight and then multiplying by 100 (e.g., [13.5 sq. in. ribeye area ÷ 750 lb. carcass] × 100 lb. = 1.8 sq. in.).

Fat thickness

Fat thickness (backfat thickness) is measured as the amount of fat opposite the ribeye at the cut surface between the 12th and 13th ribs. Fat thickness is used when calculating the yield grade. As the fat thickness increases, yield grade becomes less desirable (the yield grade number increases). External fat generally is considered to be a waste product, but the presence of at least some external fat is important in that it protects the meat from chilling too quickly in the cooler, protects the meat from drying, and enhances the aging (tenderization) process.

Other factors related to carcass characteristics

A number of other factors relate to or influence carcass characteristics. In order to judge improvements in carcass quality over time, it is important that a producer maintain a record of these factors along with other information on the cattle and their carcass data. Factors (adapted from BIF 2002) that may apply include

- general information:
  - ▸ calf breed
  - ▸ breed of dam
  - ▸ breed of sire
  - ▸ carcass's sex

- pre-weaning:
  - weaning weight, date, and price
  - approximate age at weaning
  - growth-promoting implants
  - creep feed or supplementation
  - average daily gain
- post-weaning (stocker phase):
  - number of days
  - average daily gain
  - growth-promoting implants
  - type of feed
  - supplements
- feedlot:
  - days on feed
  - in-weight
  - date on feed
  - harvest date
  - feedlot name and location
  - feedlot ration description
  - feedlot average daily gain for the individual animal

Of these factors, the most important are days on feed, in-weight, and breed.

INTERPRETING CARCASS DATA

Carcass traits

How carcass quality is evaluated depends on the specific intended market for the carcass and its products. The most important and most common carcass traits are quality grade, yield grade, and carcass weight. Producers that are vertically integrated may have well-defined standards or carcass goals that have been set by the cooperating partners. Industry organizations have developed standards or recommendations that are most suitable for higher-quality (Choice) beef markets and probably are appropriate for the majority of producers (Table 3). These could be used as criteria or standards for comparison. Producers who retain ownership and sell their beef on a grid will have a specific monetary value for each carcass based on their grid. A sample grid is provided in Table 4. Grids vary; some emphasize quality and others are oriented more toward yield or commodity.

Table 3. Suggested standards or goals for carcass traits.

Carcass trait	Suggested goal
Carcass weight	650–850 lb.
Quality grade	
Prime	7%
Choice	24%
Choice –	40%
Select +	29%
Standard	0%
Yield grade	1 and 2
Ribeye area	11 to 15 sq. in.
Fat thickness	0.2 to 0.4 in.

Carcass data from individual cattle or groups (pens) of cattle can be compared to the appropriate standard. A bar graph is a good tool for evaluating the values and their distribution for a specific carcass trait with regard to a group of cattle (Figure 1). When recommended standards are used for comparison, the graph shows the percentage of carcasses within and outside of the standards. An average value can then be estimated visually along with a general sense for uniformity. A tight cluster of tall bars represents a very uniform group with small variation. This is a desirable characteristic for the carcass data of a group of cattle.

Graphs would typically be developed for the five major carcass traits previously identified: quality grade, yield grade, carcass weight, ribeye area, and fat thickness. It is also helpful to include ancillary information describing the cattle (Figure 1) with the graph. This can include any or all of the factors previously discussed.

Table 4. Sample grid for valuing carcasses.*

	Yield grade (YG) number (assumes a Choice-Select spread of $9/cwt)				
Quality grade	YG 1	YG 2	YG 3	YG 4	YG 5
	$/cwt of carcass				
Prime	$8.00	$7.00	$6.00	–$9.00	–$14.00
Choice +	$3.00	$2.00	$1.00	–$13.00	–$18.00
Choice & Choice –	$2.00	$1.00	($/cwt carcass base value)†	–$15.00	–$20.00
Select +	–$5.00	–$6.00	–$7.00	–$20.00	–$25.00
Select	–$6.00	–$7.00	–$8.00	–$22.00	–$27.00
Select –	–$7.00	–$8.00	–$9.00	–$24.00	–$29.00
Standard	–$16.00	–$17.00	–$18.00	–$33.00	–$38.00
Carcass weights			Other		
<550 lbs. (–$19.00/cwt)			Dark cutters (–$25.00/cwt)		
550 – 749 lbs. (base)			Bullocks/stags (–$25.00/cwt)		
750 – 950 lbs. (–$4.00/cwt)					
>950 lbs. (–$19.00/cwt)					

**From Nevada Market Steer Carcass of Merit Program, Ron Torell, Area Livestock Extension Specialist.*
†Dollar values in this table are relative to this carcass base value. For instance, when the price per cwt for Choice and Choice – YG 3 carcasses is $80, the price per cwt for Prime YG 1 carcasses is the base value plus $8.00 ($80 + $8 = $88).

Other calculated terms that help to describe carcass quality include the percentage of cattle with yield grades of 1 or 2, the percentage with yield grades of 1 and 2 combined, the percentage grading Choice– or better, and the percent grading Select+ or better. An example of this type of summary is provided in the Appendix.

Uniformity

Uniformity is a valuable quality in carcasses. Increased automation of processing and portion control place greater importance on uniformity. Bar graphs that compare carcass values to standards help identify carcasses that are outside of desired ranges. Averages for carcass traits help describe an overall group of carcasses. These are the most common carcass data summaries. A common statistical parameter, the *standard deviation,* can be estimated to illustrate the degree of variation within the group. Standard deviation is a difficult value for many people to understand, however, and it may be hard to calculate without using a computer.

The percentage of the carcasses that meet all of the suggested standards (carcass weight, quality grade, yield grade, ribeye area, and fat thickness) or the primary three (carcass weight, quality grade, and yield grade) is a single figure that also expresses variation, insofar as it implies that the remaining percentage of carcasses do not meet all of the standards. It can be used in conjunction with averages to help describe the cattle. The group averages may be the only figures that fall within acceptable ranges, as few individual steers satisfy all of the criteria. Carcass data from five ranches in northern California show that, based on averages, most of the cattle were within suggested standards for five carcass factors (Table 5). The number of steers that satisfied all of the factors, however, was highly variable. These cattle were at least half Angus, most were Angus-and-Hereford crosses or pure Angus,

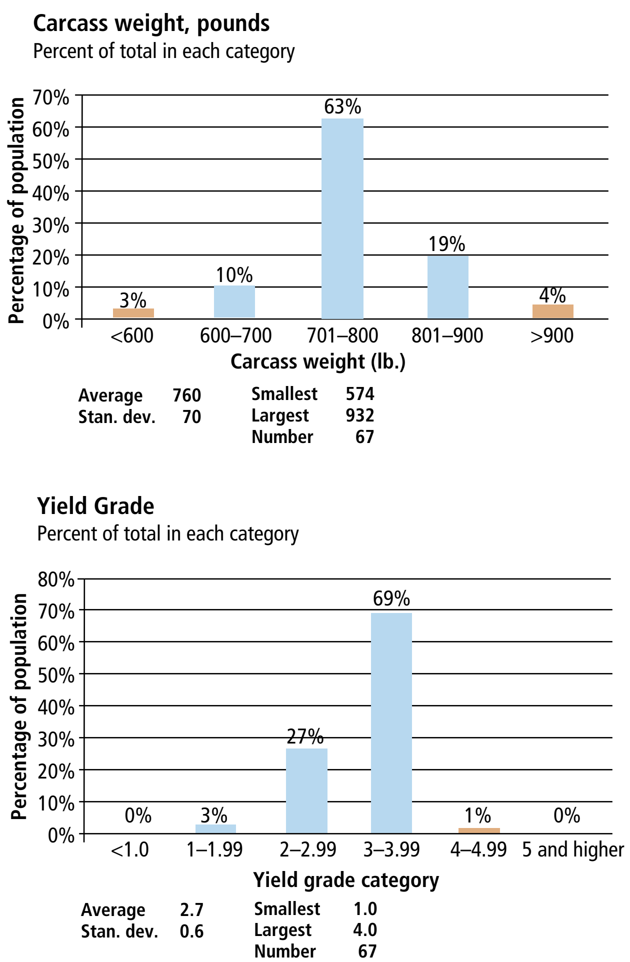


Figure 1. The bar graph is a useful tool for displaying data on cattle from specific pens and then comparing those values to generally accepted standards. (Because of rounding, percentages do not always total 100.)

Table 5. Average carcass values for five ranches in northern California were within the range for suggested standards (outliers are in bold italic). However, the percentage of carcasses within the suggested range for all five carcass categories varied from 8 to 31% for steers and 28 to 58% for heifers (Drake and Forero 2001).

	Suggested standards		Actual average ranch values				
	Lower	Upper	A	B	C	D	E
Steers							
Number			129	130	243	107	55
Carcass weight (lb.)	600	800	754	765	798	***871***	756
Yield grade	1.5	3.5	3.05	3	3.37	3.45	3.06
Ribeye area (sq. in.)	11	15	12.9	14.0	13.1	14.1	13.5
Backfat thickness (in.)	0.1	0.6	0.43	0.44	0.55	0.56	0.44
Marbling score	4.7		4.6	4.6	4.8	5.0	4.6
Percentage			26	26	16	8	31
Heifers							
Number			76	123	211	76	56
Carcass weight (lb.)	600	800	692	681	686	730	650
Yield grade	1.5	3.5	3.21	3.23	3.49	***3.58***	3.46
Ribeye area (sq. in.)	11	15	12.3	12.4	12.5	12.7	11.6
Backfat thickness (in.)	0.1	0.6	0.51	0.48	0.59	0.57	0.50
Marbling score	4.7		4.9	5.2	4.9	5.2	5.0
Percentage			58	54	32	28	34

and all were fed at the same feedlot, yet there was considerable ranch-to-ranch variation. Averages are useful for describing these carcasses, but there really is no "average" steer. What is important is how many individuals satisfy all of the important criteria. Another advantage with this percentage figure is that it can easily be compared from year to year, measuring changes over time.

Carcass value and grids

In some cases the monetary value of the carcass is available, especially when the producer retains ownership. Otherwise, producers can use carcass data and a grid to establish a value for individual carcasses. A typical grid (Table 4) uses quality grade, yield grade and carcass weight to determine premiums or discounts for carcasses. There is no standard or universal grid, so the "value" based on the grid depends on which grid is used. Averages of grid discounts and premiums are reported weekly by USDA Market News Service, on the Worldwide Web: http://www.ams.usda.gov/mnreports/lm_ct155.txt

While the carcass value or grid value is a practical and realistic measure of the quality of a carcass, it is not very helpful in determining why a carcass has more or less value. In addition, because the value is linked to a market, the absolute values can be highly variable. In contrast, for example, the yield grade or ribeye area is a consistent measure that one can compare over time.

Monitoring and evaluating carcass quality change

Carcass data provides a snapshot of quality at one point in time for one group of cattle, but for many producers an equally important feature is the ability to monitor change in carcass quality over time. Comparisons may be made between two pens of cattle in a single year or from year to year. Accurate and correct comparisons are hard to make, and the reasons or causes of differences are even more difficult to determine. Obviously, drawing incorrect conclusions from carcass data and then incorporating those incorrect conclusions into breeding or management decisions can cause problems rather than solve them.

The largest and most easily recognized factors contributing to variations in carcass data are days on feed, in-weight, and breed, and these particularly influence the quality grade, yield grade, and carcass weight. These factors must be accounted for when comparing carcass data between pens of cattle or between years. These three factors tend to interact with one another, influencing feedlot management and carcass characteristics. Most feedlots, and certainly those striving to produce USDA Choice grade cattle, will continue to feed cattle (increasing days on feed) until the cattle have sufficient fat cover and sufficient marbling (intramuscular fat) for the Choice grade. Marbling and quality grade both tend to increase with more days on feed. As cattle are fed longer (eating diets high in grain) they gain weight, increasingly depositing fat and increasing their carcass weight. It would be easy to attain sufficient marbling and quality grade merely by lengthening the days on feed, but that could easily lead to too large a carcass size, too much external fat cover, and an increased, less desirable yield grade. Excessive weights bring with them price discounts and excessive external fat is of little value, so feedlots will process cattle despite inadequate fat cover (and quality grade) in order to avoid suffering discounts.

Cattle with the same fat thickness are best for comparing differences in carcass characteristics. Improvements in feedlot techniques, such as ultrasound for objective measurement of fat thickness and more frequent sorting, will help to present more uniform cattle for processing and subsequent carcass data comparisons.

The relationships between days on feed, breed, and in-weight to carcass characteristics were described in a 1999 article by Short et al.(see Figures 2–7). In those data, in-weight was a function of on-feed age, which was 6, 12, or 18 months of age. The in-weights were larger for older cattle. Breed effects were estimated by high (Charolais) or moderate (Hereford) growth-potential sires bred to British crossbred cows. All of the major carcass characteristics increase with increasing days on feed, with variations in the speed of increase depending on breed and in-weight.

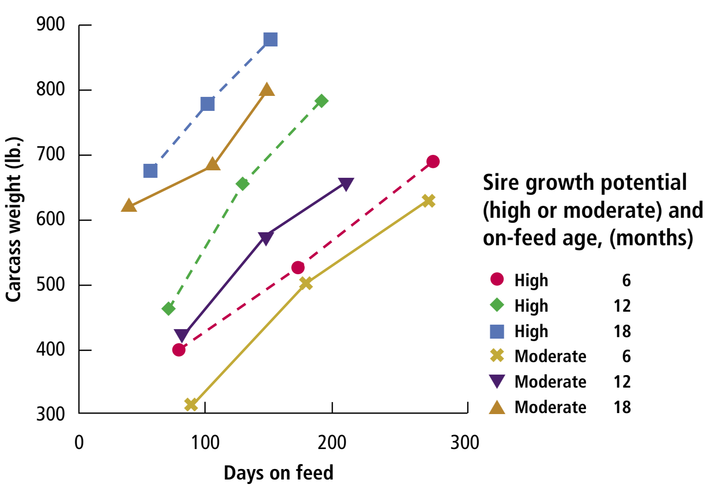


Figure 2. Carcass weights for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The carcass weight increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight)***.** Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

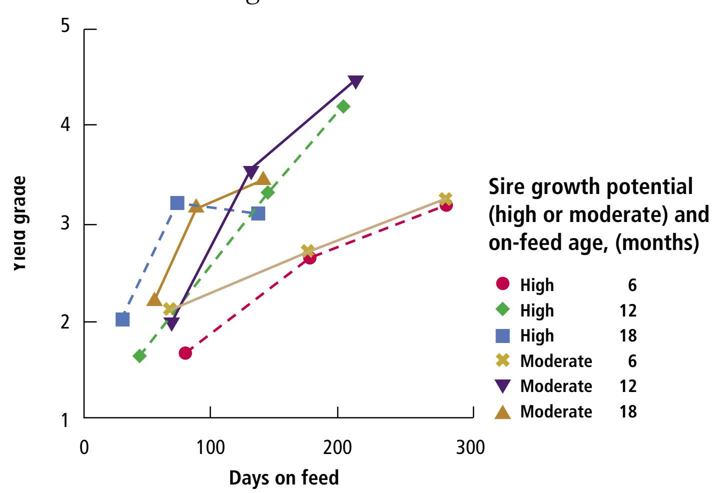


Figure 3. Yield grades for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The numerical yield grade *(YG)* increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight).* Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

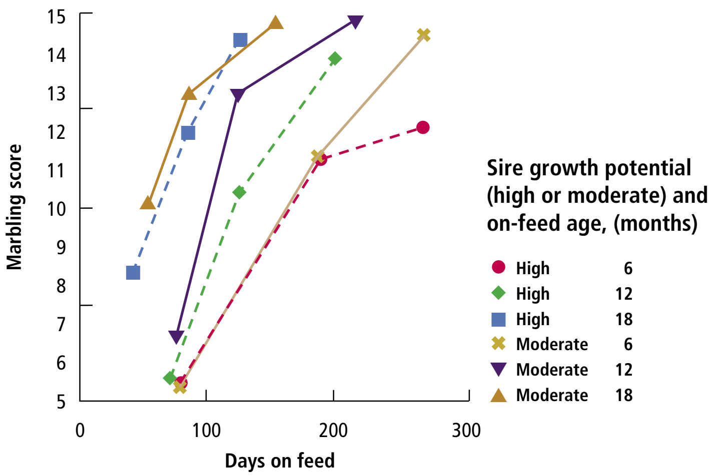


Figure 4. Marbling scores for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The marbling score increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight).* Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

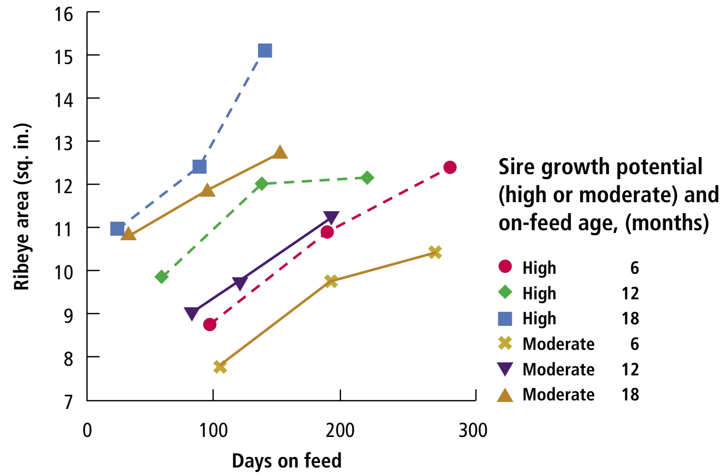


Figure 5. Ribeye area for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The ribeye area increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight).* Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

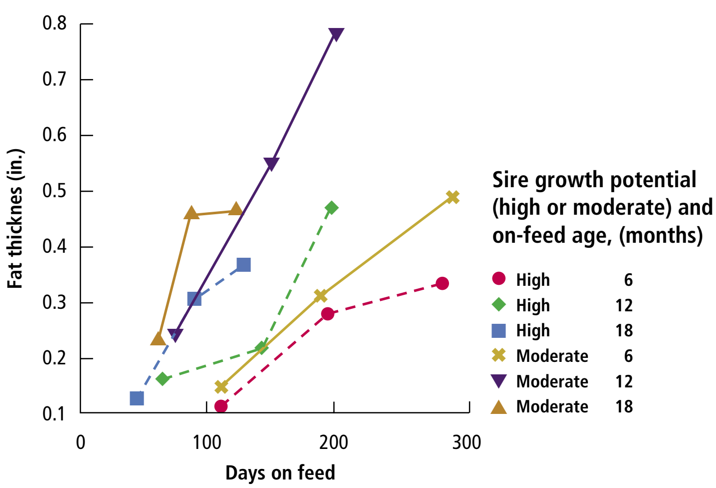


Figure 6. Fat thickness for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The fat thickness increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight).* Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

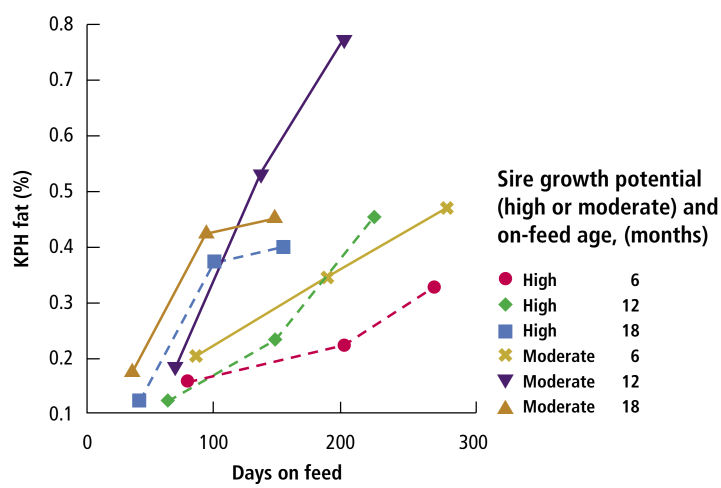


Figure 7. Kidney, pelvic, and heart fat (KPH) for cattle entering the feedlot at various ages (6, 12, and 18 months, and thus different initial weights) and having sires of different growth potential and various numbers of days on feed. The KPH fat increases with more days on feed. The rapidity of the increase (shown in the slope of the plot lines) varies based on the sire's growth potential and age *(initial weight).* Solid line data are for cattle with moderate growth-potential sires; broken line data are for cattle with high growth-potential sires. (Data from Short et al. 1999.)

Continental breed cattle and others entering the feedlot at higher weights (older ages) will have higher carcass weights. Fat thickness, marbling score, and yield grade, all measures of fat, will be higher in cattle with moderate-growth-rate sires and heavier calf entry weights. The ribeye area will be greater in cattle with high-growth-rate-potential sires and calves that enter the feedlot older and heavier.

There is no valid method for objectively adjusting or accounting for each of these factors using typical commercial cattle carcass data. One way to help interpret carcass data over time is to plot a carcass trait with days on feed and in-weight. This facilitates a mental weighting of each factor over time along with its potential impact on the carcass trait being evaluated (Figure 8).

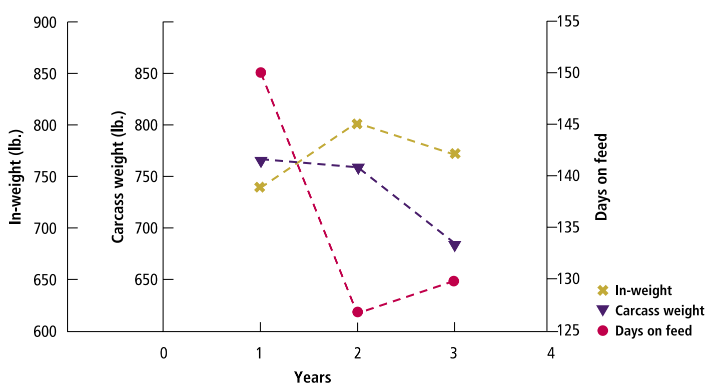
There is a large number of other factors (listed earlier) that may influence carcass characteristics. Again, no valid objective method exists for adjusting for these factors under commercial conditions. All the same, they should be recognized as factors with the potential to change carcass traits.

Common carcass problems

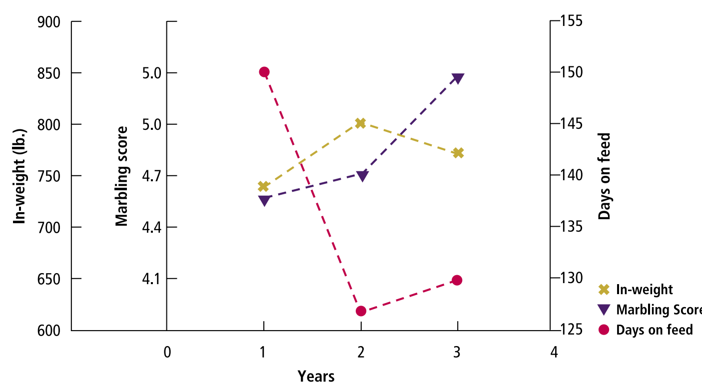
The whole point of obtaining carcass data is to allow producers to learn about the quality of their final product. As more producers have obtained carcass data, a few common problems have become evident (Smith et al. 2000):

- excessive size or weight (high carcass weights)
- excessive external fat (large fat thickness)
- inadequate marbling (low quality grades)
- lack of uniformity

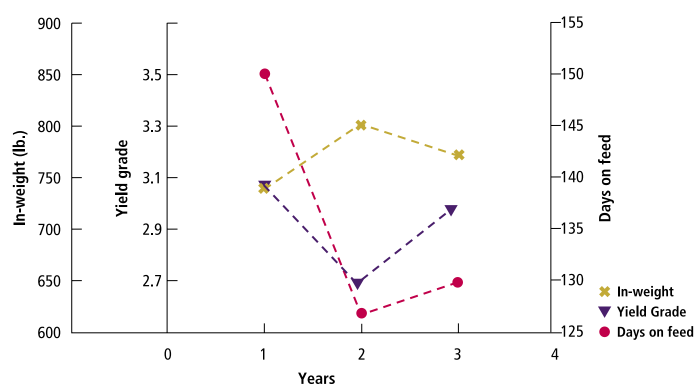
Producers should use actual carcass data from their own cattle to assess their carcass quality. If those data are not available, producers should assume that the four



a. Carcass weight dropped over a 3-year period. Days on feed declined, but in-weight also changed.



b. Marbling score increased over a 3-year period. Days on feed declined, but in-weight also changed.



c. Yield grade improved from year 1 to 2 and then declined in year 3 to about the same level as in year 1. Days on feed declined, but in-weight also changed.

Figure 8 a, b, and c. Panels a, b, and c show carcass weight, marbling score, and yield grade for steers over 3 years at the same feedlot with variable days on feed and in-weights. The plots allow you to simultaneously consider different in-weights and days on feed in relation to three carcass traits (unpublished data).

problems listed above are present in their cattle. Efforts to improve carcass quality should be focused on these areas unless actual carcass data prove otherwise.

Part II: Improving Beef Quality

METHODS FOR IMPROVING CARCASS QUALITY

Efforts to improve carcass quality should be part of a total herd improvement program that also focuses on growth and reproductive traits. In some marketing situations, improved carcass quality may mean higher selling prices and thus increased income. Improved carcass quality can also enhance consumer acceptance of beef by increasing consumer satisfaction. Over the long term this may strengthen consumer demand and prices, which may filter down to higher prices for the producer. Since genetic and management changes that improve carcass quality may also affect growth and reproduction, management decisions must take into account the total effects on growth, reproduction, and carcass.

Quality grade, yield grade, and carcass weight are the main carcass traits of economic interest; of these, quality grade and carcass weight are the most easily addressed carcass issues. Yield grade and reduced fat thickness are also of economic consequence, but are problematic because they have the potential to impact female reproduction when replacement heifers are kept from raised females. The following sections discuss how genetics and management (environment) can be used to improve carcass characteristics.

Improvement through genetics

The greatest and most practical opportunities to improve carcass traits are through genetics, but simply switching to an Angus bull will not guarantee satisfactory carcass quality among the resulting calves (Drake and Forero 2001). There is a wide range in carcass genetics in all breeds, so efforts to improve the genetics associated with carcass quality must be based on individual animals' performance, not the reputation of a breed or general trends for a breed. Producers using traditional rotational cross-breeding or pure breeds should consider both the selection of individuals with superior carcass traits within their current breeding program and the use of terminal sires. Terminal sires can be used on a portion of the herd, with their calves going entirely for slaughter. This offers huge advantages in genetics by using sire breeds and individual bulls that are superior in carcass traits. Since females from these matings will not be entering the cow herd, large genetic advances directed solely at carcass traits are the focus instead of the more balanced, multi-trait selection practiced when replacement cows are to be kept. The best method for evaluating the genetics of individuals for selection is through expected progeny differences (EPDs), determined either by carcass evaluation or ultrasound, or through specific gene testing.

Quality grade. Quality grade is determined on the basis of the amount of marbling or intramuscular fat. Intramuscular fat is only a small portion of the total fat in a beef carcass (R. D. Sainz, personal communication). Intramuscular fat is found in fat cells (adipocytes), and the marbling score is more closely related to the number of fat cells per gram of tissue than to the size of those fat cells (Cianzio et al. 1985). Grain-fed cattle have been found to have more intramuscular fat cells than other cattle, but those fat cells are smaller than in other cattle (Prior 1983). There are also genetic differences between breeds in the number of fat cells and thus the potential for marbling. In one study, the rate of fat cell development was twice as high in Wagyu cattle as Angus (May et al. 1994). Efforts to increase the number of fat cells in muscle tissue should lead to increases in marbling, the marbling score, and consumer acceptance. Both genetic and management methods may be effective in increasing the number of intramuscular fat cells.

Approaches to improving the cattle's genetic disposition for marbling may include traditional EPDs and newer specific genetic tests. Carcass EPDs are used in the same way as other EPDs to estimate the differences in progeny between compared individuals (usually sires). Because carcass traits are moderately heritable, management decisions based on EPDs are effective in effecting changes. One trial (Vieselmeyer et al. 1996) comparing high-marbling EPD Angus sires to low-marbling Angus sires showed an increase in the number of Choice-graded carcasses among animals sired by high-marbling EPD Angus bulls. The high-marbling EPD sires had 77 and 72 percent Choice steers and heifers, respectively, compared to 47 percent for steers and heifers from low-marbling EPD sires (Table 6).

Carcass EPDs are developed and provided by breed associations whose methodologies and terminology vary. Most carcass EPDs are calculated from carcass data, but ultrasound carcass measurements are being used increasingly to estimate carcass EPDs. EPDs for marbling are reported as carcass (marbling) or ultrasound measurements (intramuscular fat [%IMF]). When possible use carcass marbling EPDs, which will also incorporate ultrasound measurements.

Using high- and low-marbling EPD sires, Vieselmeyer showed that marbling could be increased without increasing the yield grade (Table 6). Sires selected on the basis of ultrasound intramuscular fat (%IMF) and %IMF EPDs have also shown improvements in marbling and quality grades among their calves (Sapp et al. 2002). In both cases, quality grades were improved with more intramuscular fat deposition but without any increase in external fat thickness and yield grade. This demonstrates that marbling fat can be increased without increasing fat cover. The opportunity to select for marbling without impacting fat thickness is also supported by data from the American Angus Association that show a low genetic correlation between marbling and fat thickness.

Table 6. Steer and heifer calves from high-marbling EPD sires had higher quality grades than similarly treated calves from low-marbling EPD sires (Vieselmeyer et al. 1996).

	Steers		Heifers	
	Low-marbling EPD sires	High-marbling EPD sires	Low-marbling EPD sires	High-marbling EPD sires
Percentage Choice grade	47	77	47	72
Yield grade	2.82	2.90	2.52	2.47

Table 7a. Marbling score and quality grades from cattle of various GeneSTAR conditions (thyroglobulin gene). 1-star condition was intermediate to 0- or 2-star condition. Effects were more apparent for yearling fed cattle where the upper Choice grade cattle were particularly impacted, with twice as many upper Choice grades (Anon. 2002).

	GeneSTAR condition		
	0 star	**1 star**	**2 star**
Yearling – fed			
n = 475			
Marbling score	425	447	468
% Choice	58	62	74
% Select	42	38	26
% Upper Choice	10	16	21
Calf – fed			
n = 591			
Marbling score	358	369	370
% Choice	34	41	53
% Select	66	59	47

Selection for specific genes that affect marbling is possible. For instance, a specific gene (thryroglobulin, or GeneSTAR marbling gene) has been identified with increased marbling and Choice grade. The gene controls thyroglobulin, a precursor molecule to thyroid hormone. A private company, Genetic Solutions, has identified three forms of the gene or genotypes that they call 2 star, 1 star, or no star. Tissue (hair) samples are used to determine the form of the gene. Trials have shown that cattle with 2 stars, when maintained under the same conditions as cattle with fewer stars, will have more marbling and higher quality grades (Anon. 2002) (Table 7a). The 1 star genotype has shown variable responses, in some cases intermediate in marbling and in others more similar to those of the no star genotype. Knowing the genetic content, herd managers can breed

Table 7b. Expected thryroglobulin gene condition in progeny from various matings.

Condition of sire	Condition of dam	Expected condition of progeny (%)		
		0 star	1 star	2 star
0	0	100		
0	1	50	50	
0	2		100	
1	0	50	50	
1	1	25	50	25
1	2		50	50
2	0		100	
2	1		50	50
2	2			100

their cattle to achieve the desired genotype.

GeneSTAR has proposed breeding outcomes (Table 7b) for various crosses of 2 star, 1 star, and no star cattle. The potential for rapid genetic change is great, according to specific gene tests. To help illustrate, we can compare this marbling gene test to the practice of breeding to remove horns. By observation of horned and polled cattle, we know the genotype of the individual and can make our breeding plans based on the genotype. With the marbling gene, we know the genotype not by looking at a physical trait but by checking the laboratory result. As with the selection process for horned and polled cattle, if we test sires, for example, and use only sires with the 2 star genotype, the first generation of offspring will be entirely 1 star or 2 star for marbling, with no 0 star calves. If we continue to use only 2 star sires, the population will be about 90 percent 2 star after 4 generations.

Most researchers recognize that this is only one of several genes that affect marbling. It does appear, however, that a breeding program that focuses on enhancing this gene can have sufficient impact to improve marbling and quality grades. Additional work will likely identify additional genes that affect marbling.

Carcass weight. Excessive carcass weight is a common carcass problem that a breeder can reduce based on carcass weight EPDs. Carcass weights that are too heavy will receive increasing discounts in carcass value: the exact meaning of “too heavy” varies, but it starts at about 800 pounds depending on the market and demand. A steer with a carcass weight of 800 pounds will have a live finished weight of about 1300 pounds. Generally, cattle with carcass weights of less than 800 pounds will have ribeyes of about the desired size. Producers can use breeding decisions based on carcass weight EPDs as an initial step in obtaining carcasses of the desired size. To help maintain or fine-tune the size of the ribeye, they can then turn their attention to ribeye area EPDs. By using EPDs to breed for carcass weights of about 750 pounds in steers and ribeye areas of 13 to 14 square inches, producers will also improve their yield grades.

The use of bulls with lower carcass weight EPDs to reduce their calves’ eventual carcass weights will also tend to decrease the calves weaning weights as the two factors are positively correlated. In general, carcass size has a positive correlation to weaning weight, yearling weight, mature size, and frame score. As carcass size is decreased, then, weaning weight, yearling weight, mature weight, and frame score will generally decline. To keep this from happening, producers can track both carcass weight EPDs and weaning weight EPDs to ensure that they are achieving the desired genetic changes. This is *multi-trait* rather than *single-trait* selection. Selection solely on the basis of carcass weight could have serious detrimental effects on weaning weight and thus on calf sale income. Calf income might be depressed so far that carcass premiums would not be able to compensate for the reduction. To decrease carcass size and increase weaning weights, producers should look for lighter carcass weight EPDs and heavier weaning weight EPDs.

If the cow herd’s total weaning weight is reduced due to single-trait selection for smaller carcass size, the reduction in total weight weaned could be overcome by increasing the total number of cows. Since the individual females would be smaller, the total feed requirements would remain relatively stable even with a greater total number of animals.

Another way to manipulate carcass weight to the desired level would make use of terminal sires. Producers with small cows that may be appropriate for their ranch environment might, if bred to similarly small bulls, produce calves that were too small and would have to be discounted at market. A producer who simply uses a larger bull and retains heifers will eventually end up with cows that are too large for the ranch environment. When adult cows are bred to significantly larger terminal sires, however, they usually do not have calving difficulties, but produce calves of intermediate carcass weight (and weaning weight), which could in this case be ideal. When a producer uses terminal sires, it is most important that he or she resist the temptation to retain heifers.

Yield grade. Efforts to improve yield grade may be more problematic. Yield grade is affected primarily by fat thickness. Reducing fat thickness may be counterproductive for the cow herd and for reproduction when replacement heifers are kept from females raised in the herd. Females with a reduced potential to deposit excess energy in the form of external fat during times of plentiful feed may store too little fat to support them in later periods of inadequate nutrition. They might be thought of as "hard-doers," or cows that do not easily gain body condition. The negative effects of reduced fat cover have not been studied directly, but based on their own work MacNeil et al. (1984) suggested that selection for reduced fat cover could lead to an increase in mature weight, an increase in age and weight at puberty, and a reduction in fertility.

Until we have a better understanding of the ramifications of reducing fat cover, efforts to genetically change fat thickness should be very conservative. Fortunately, fat thickness and marbling are not closely related genetically. This means that producers can still select cattle with a propensity for marbling and not affect fat thickness. Thus it may be possible to improve quality grades without impacting fat cover and its possible detrimental effects on stored energy. This, however, would do little to improve yield grade.

An alternative, once again, is to use terminal sires. A terminal slaughter group of calves would be selected from females—usually cows of four-plus years of age bred to a terminal sire. If replacement heifers were needed, they could be obtained from a second group of cows. Bulls that were used with the cows producing terminal slaughter calves could be of low fat thickness EPDs, or could even be of another breed with low fat cover. All of their offspring would go to slaughter. This option allows the use of bulls with extreme carcass traits, since no replacements would come from this breeding. The cows used in a terminal sire breeding group could be relatively small with excellent maternal traits. Their progeny would be moderate in carcass traits, and ideally would attain the desired carcass goals.

Improvement through management

Management during the pre-weaning, post-weaning, or feedlot phase impacts final carcass quality. While many management factors can affect carcass quality, three are most significant and potentially susceptible to manipulation: days on feed (in the feedlot), in-weight, and age. The single most important item impacting carcass quality is days on feed. Increasing the days on feed will increase marbling (improving quality grade), increase numerical yield grade (decreasing lean meat yield), and increase carcass weight. Genetics will shape the strength of these relationships. These relationships are illustrated for carcass weight, yield grade, marbling score, ribeye area, fat thickness, and %KPH fat in Figures 2 through 7 (data from Short et al. 1999). These figures represent cattle from high-growth-potential sires (Charolais) or moderate-growth-potential sires (Hereford) bred to moderate British-bred cows and placed into the feedlot at 6, 12, or 18 months of age and finished for various numbers of days, up to 270.

Feedlot phase. Days on feed (i.e., date of slaughter) are generally determined when there is adequate fat thickness over the ribs to achieve corresponding marbling for a low Choice grade. With increased days on feed come corresponding increases in marbling, quality grade, external fat cover, carcass weight, and yield grade. When the target quality grade is Choice, cattle are fed in a way that will provide them with sufficient fat cover for them to marble and grade as Choice. As cattle have more days on feed (eating high-grain diets), they gain weight, get fatter, and increase marbling: carcass weights, quality grade, and numerical yield grade also increase. It would be easy to attain sufficient marbling and quality grade merely by increasing the number of days on feed. But with an increase in the number of days on feed come increases in carcass size and external fat cover. In addition, the animals' feedlot performance suffers. As carcass weights approach the upper limits of desirability (which vary depending on market, but generally run about 800 pounds, with discounts for heavier weights), feedlots will process cattle even if they lack adequate fat cover and quality grade, just to keep them from attaining excessive weight. In the sample data (Figure 2), calves from moderate-growth-rate sires were placed into the feedlot at 6 months of age and required nearly 200 days on fed to attain carcass weights of 500 pounds, and almost 300 days to attain carcass weights of 600 pounds, which are at the lower limit of acceptability. In contrast, calves from high-growth-potential sires that were placed in the feedlot at 18 months of age were over 800 pounds in carcass weight after about 100 days on feed.

Age at feedlot entry is determined by age at weaning and whether the calves are placed directly into the feedlot or backgrounded. Since a producer can increase the quality grade to the desired level by increasing the number of days on feed, the primary question with backgrounding is what effect an increase in the number of days on feed will have on carcass weight. Carcass weights may be 200 to 300 pounds heavier for backgrounded cattle. Backgrounding may be better suited for medium- to smaller-frame cattle. Large-frame cattle that are subjected to backgrounding and then fed to acceptable levels of fat thickness will often end up with excessive carcass weights. Similarly, smaller-frame cattle placed directly into the feedlot after weaning may have unacceptably low carcass weights. The rate of gain during backgrounding (winter gains of 0.5 to 1.3 pounds per day or summer gains of 1.25 to 1.85 pounds per day) did not impact the carcass quality grade when the cattle were fed to the same fat thickness (Klopfenstein et al. 2000). This is also illustrated in Figures 2 and 4 for carcass weight and marbling of calves from high- or moderate-growth-rate sires placed on feed at either 6, 12, or 18 months and kept on feed for various lengths of time (data from Short et al. 1999). Older calves that were kept on feed long enough to achieve high marbling scores had increasingly heavier carcass weights.

Implants. When days on feed are the same for cattle with growth-promoting implants and those without implants, those with fewer implants, less-aggressive implants, or none at all achieved the best marbling scores (Platter et al. 2002). Implanted steers that are fed longer have heavier carcasses, larger ribeye areas, decreased kidney, pelvic, and heart fat, similar quality grades, and poorer yield grades. The animals' feedlot performance is improved: average daily gain increases by 13 to 22 percent more from weaning to harvest (Platter et al. 2002). Implanting strategies have been devised, however, that can capture much of the improved feedlot performance by implanting in a way that has only a minimal effect on carcass quality (Table 8).

The suitability of implants depends on cattle age, sex, frame size, weight, days on feed, projected rate of gain, marketing methods and conditions, implant history, processing facilities, and implanting skills (Pritchard 1993). For producers who retain ownership and are involved in vertical integration or other value-based operations, research suggests that the first implants should be of lower potency and that successive implants should be more aggressive as the cattle near their slaughter weights. Implants shift the date of maturity, which also delays fattening, so over the growth curve of

Table 8. A low-potency (Ralgro) implant followed by a high-potency (Revalor-S) implant had improved feedlot performance as compared to the use of only a high-potency implant (Synovex Plus) while maintaining quality grade similar to that of non-implanted steers when fed for 140 days.

	Implant regime			
	Day 1: none; day 56: none	Day 1: Synovex Plus; day 56: none	Day 1: Revalor-S; day 56: none	Day 1: Ralgro; day 56: Revalor-S
Final weight (lb.)	1191	1301	1298	1296
Average daily gain (lb.)	3.14	3.92	3.88	3.86
Dry matter intake (lb.)	20.5	22.1	21.8	21.9
Feed/gain ratio	6.56	5.63	5.63	5.69
% Choice grade or better	68	43	51	60

From Pritchard 1993.

the animal (i.e., when ownership is retained, etc.) the effects of implants early in life should be subtle, yielding smaller changes, and those later in life can be more dramatic in their effect. Marbling occurs throughout growth, not just at the end, so management steps such as implanting early in life can impact final carcass quality. Feeding periods may vary from as few as 60 days to more than 200 days, and such variations call for very different implant strategies. One example illustrates that a low-potency implant and a high-potency implant used on a single animal captured nearly as much improved feedlot performance as did a high-potency implant alone on another animal, and yielded nearly the same quality grade as an animal that was not implanted (Table 8). Producers need to examine all of these possible effects as they consider the potential economic impacts of implanting.

Sorting. The practice of sorting feeder cattle by in-weight, fat thickness, and marbling score based on ultrasound readings in order to increase uniformity over traditional sorting methods (such as weight sorting) has resulted in improved feedlot performance and carcass quality (Basarab et al. 1997). The degree of economic advantage has varied, but it generally runs about $25 per head. This does not account for the additional costs of ultrasound processing for the feeder cattle. Much of the economic advantage came from improved weight gains and feed efficiency, not carcass value. Sorting does not actually improve carcass characteristics. It does, however, permit increased uniformity and a greater number of cattle fed to the correct end point, and in this way improves feedlot performance and carcass quality. The extent to which ultrasound sorting will improve production depends, then, on the initial degree of variability in the cattle that are then sorted.

Creep feeding. The effects of creep feeding during the pre-weaning phase have shown mixed results on carcass characteristics, but generally they are small or insignificant. When nutrition is sufficient for cattle to attain their potential growth, creep feeds usually will not enhance their performance. When nutrition is limiting growth, however, creep feeding will be beneficial. Starch-based creep feeds fed for at least 80 days may be more effective than other types.

Trace minerals. Zinc supplements given to steers that were already receiving marginal to adequate amounts of zinc in their diets during the growing and finishing phases (NRC 1996) were shown to increase quality grade, yield grade, marbling, and backfat (Spears and Kegley 2002).

Copper supplementation during the finishing phase of cattle that were marginally copper deficient resulted in weight gain improvements but did not effect final carcass weight, ribeye area, fat thickness, or marbling (Johnson and Engle 2002). Copper-deficient cattle that received copper supplements during the growing and finishing phases had less fat thickness than cattle that did not receive the supplements (Ward and Spears 1997).

It is always best to test for adequate trace minerals before administering supplements. Unwarranted trace mineral supplementation is potentially harmful and expensive.

Health. The effects of sickness on final carcass quality depend on the severity and timing of the sickness. Heifers that were sick with bovine respiratory disease during the receiving phase but were not treated during the finishing phase have shown a carryover effect in the form of reduced quality grades (Stovall et al. 2000). Heifers that were never treated, were treated once, or were treated more than once during the receiving phase had reduced marbling scores (288, 266, and 249, respectively), lower percentages grading Choice (66.2, 59.4, and 41.1, respectively), reduced carcass values ($111.02, $110.48, and $108.71 per 100 lb. carcass, respectively), and lower net values ($782.89, $771.41, and $745.55 per head, respectively), and tended to have leaner carcasses (Table 9). Heifers treated once compared to those that received no treatment for respiratory disease during the receiving phase had similar carcass quality levels (McBeth et al. 2001).

In a ranch-to-rail program (http://animalscience.tamu.edu/ansc/publications/rrpubs/ASWeb066-2000summary.pdf), healthy cattle had faster gain, lower cost of gain and medical costs, greater financial return, and higher quality grades than cattle that were sick (Table 10). Cattle that have been healthy their entire lives will be healthier in the feedlot, and that means that feedlot health starts with the newborn calf receiving colostrum.

Illness during the feedlot phase is often reported to producers who retain ownership of their cattle. Review of those records can help a producer develop an adequate preventative health program.

Pre- and post-weaning nutrition. As discussed earlier, marbling score (a visual assessment of the amount of fat in the ribeye muscle) is more closely associated with the number of fat cells than with their size. Besides breeding cattle to increase the number of intramuscular fat cells, producers may also be able to influence intramuscular fat through nutritional regimens that are conducive to increases in intramuscular fat cells. Similarly, yield grade is most strongly influenced by external fat cover, which again involves fat cells, this time located subcutaneously.

Support data for determining the impacts of nutritional changes on tissue development in beef cattle comes from pre- and post-weaning studies done on beef heifers and on their mammary development. Heifers that are raised at higher daily gains prior to weaning have had less milk-producing mammary tissue or lower milk production compared to those raised at more moderate daily gain levels (Sejrsen et al. 1982, Buskirk et al. 1996). Generally, differences that are imposed post-weaning appear to cause no

Table 9. Carcass characteristics and values for heifers treated for bovine respiratory disease during the receiving phase (Stovall et al. 2001).

	Number of antibiotic treatments		
	Never treated	Treated once	Treated more than once
Carcass weight (lb.)	706	705	702
Marbling score*	288a	266b	249b
% Choice grade	66.2	59.4	41.1
Yield grade	2.53	2.43	2.36
Carcass value ($/100 lb.)	$111.02a	$110.48a	$108.71b
Medical costs	$0	$7.48	$18.00
Net value ($/head)	$782.89a	$771.41b	$745.55c

** 300 = Choice*
Values within rows with different letters are significantly different (P<.05).

Table 10. Cattle treated as sick in a ranch-to-rail program had reduced performance, carcass quality, and returns compared to healthy cattle (McNeill, McCollum, and Paschal 2000).

	Sick	Healthy
Head	218	1,080
Death loss (%)	5.5	0.7
Average daily gain (lb./day)	2.65	3.08
Total cost of gain	$62.32	$49.03
Medicine cost	$26.78	$0.00
Net return	$23.31	$146.17
Quality grade (%)		
Choice	37	54
Select	53	43
Standard	10	3

differences in milk-producing tissue, but mammary fat content increases in heifers at the higher gain rates. Beef heifers that were provided with creep feed for 90 days and that weighed 37 pounds more at weaning produced 28 percent less milk (Hixon et al. 1982). This suggests that, depending on the animal's developmental age, even small changes in nutrition can influence tissue development.

The alteration of fat deposition by manipulating the cattles' nutrition requires an in-depth understanding of the end results of digestion for different feeds. Briefly, feeds digested in the rumen of cattle are converted into intermediate compounds called volatile fatty acids (VFAs). The VFAs and their usual proportions from forage based diets are 65 to 70 percent acetate, 15 to 25 percent propionate, and 5 to 0 percent butyrate. High-energy rations composed of grains produce less acetate and more propionate: 50 to 60 percent acetate, 35 to 45 percent propionate, and 5 to 10 percent butyrate. When we bring together the results from several studies and proposed mechanisms for fat deposition, it appears that forage-based diets lead to acetate production that favors external fat deposition and little intramuscular fat, while grain-rich diets increase propionate, which favors intramuscular fat deposition and not external fat covering (Smith et al. 1984, Smith and Crouse 1984, Fluharty 2003). The selective effect of diet end products appears to be consistent, irrespective of total dietary energy levels. This would mean that even very high-quality forage diets that result in rapid weight gain would not result in the degree of intramuscular fat deposition found in diets in which grains support more moderate weight gains. Diet appears to influence both the amount of weight gain (tissue gain) and the composition and site of tissue gain.

The specific application of pre- and post-weaning nutrition manipulation to enhance carcass characteristics has not been explored in detail, but potential management alternatives are apparent. Supplements that contain some grain may be beneficial for enhanced marbling if administered prior to or near weaning. These could include grains in creep feeds or supplements or forages from mature grain hays that include significant amounts of filled grain.

APPENDIX: BEEF CARCASS DATA ANALYSIS

Name:	Sample data 2001					
Cattle identifier:	Lot 770					
Harvest date:	01/25/01					
No. head:	67					
Sex:	steers					
Days on feed:	145					
In-weight:	645					
	YG1	**YG2**	**YG3**	**YG4**	**YG5**	**Totals**
Prime	**0**	**0**	**0**	**0**	**0**	**0**
Choice and Choice +	0	1	2	0	0	3
Choice –	0	4	12	1	0	17
All Choice	**0**	**5**	**14**	**1**	**0**	**20**
Select +	0	0	0	0	0	0
Select and Select –	2	13	32	0	0	47
All Select	**2**	**13**	**32**	**0**	**0**	**47**
Standard	**0**	**0**	**0**	**0**	**0**	**0**
Totals	**2**	**18**	**46**	**1**	**0**	**67**
	YG1	**YG2**	**YG3**	**YG4**	**YG5**	**Totals**
Prime	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Choice and Choice +	0.0%	1.5%	3.0%	0.0%	0.0%	4.5%
Choice –	0.0%	6.0%	17.9%	1.5%	0.0%	25.4%
All Choice	**0.0%**	**7.5%**	**20.9%**	**1.5%**	**0.0%**	**29.9%**
Select +	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Select and Select –	3.0%	19.4%	47.8%	0.0%	0.0%	70.1%
All Select	**3.0%**	**19.4%**	**47.8%**	**0.0%**	**0.0%**	**70.1%**
Standard	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Totals	**3.0%**	**26.9%**	**68.7%**	**1.5%**	**0.0%**	**100.0%***
Carcass weight	No.	%				
< 600 lb.	2	3.0%				
> 800 lb.	17	25.4%				
> 900 lb.	3	4.5%				

** Because of rounding, percentages do not always total 100.*

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