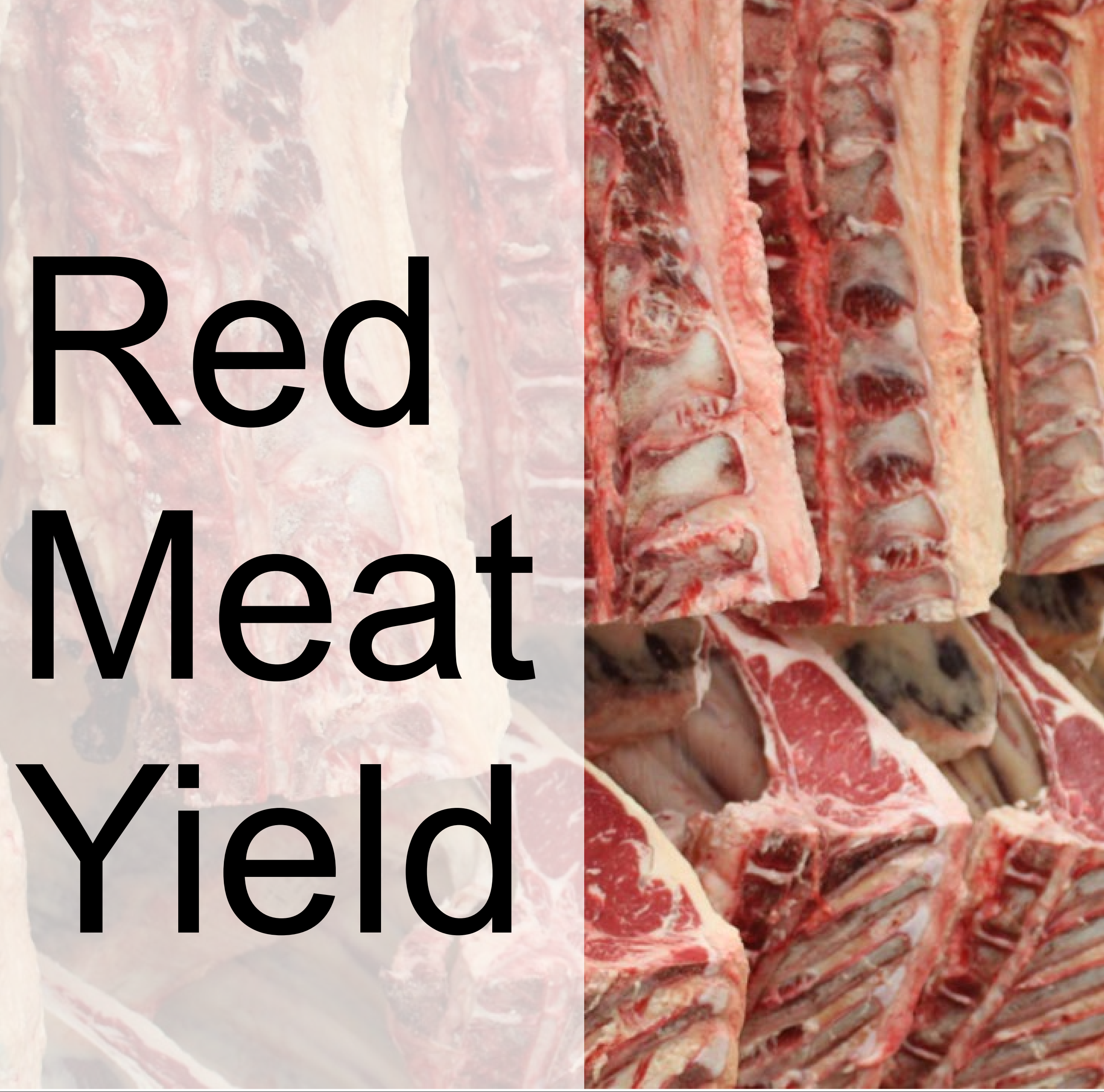
Red Meat Yield



In Today's Beef Industry

Research coordinated by the National Cattlemen's Beef Association, a contractor to the Beef Checkoff.

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The USDA Yield Grade system was introduced 1965 based on external fat thickness, surface area of the ribeye, hot carcass weight, and percentage of kidney, pelvic, and heart (KPH) fat.

60 years later, advancements in genetics and production management have resulted in substantially larger, faster growing cattle, but the Yield Grade system remains unchanged.

Market signals, in the form of premiums and discounts as determined by the outdated Yield Grade system, no longer provide accurate feedback to producers.

Modern technologies and data analysis capabilities provide an opportunity to capture absolute measurements of carcass composition and modernize the Yield Grade system.

This content is adapted from a three-piece article series which further identifies the inaccuracies of the current yield grading system and explores how the evolution of cattle type and management provides an opportunity to update the current tool to more precisely characterize today's cattle. This article series, on behalf of the Red Meat Yield Round Table, aims to raise awareness of current carcass yield assessments and make advancements more accessible to producers who select higher-value cattle and receive accurate recognition for true carcass yield.

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Introduction to Grading

The U.S. beef industry has benefited from a voluntary beef grading service since May 1927[1]. Grading of beef enables differentiation of carcass quality and yield in the value transaction between producers and processors. Grading also ensures uniform marketing and promotes market differentiation of subprimal and retail cuts.

Initially, beef carcass grading was based solely upon quality – originally estimated from outward carcass finish (and later via marbling) and maturity to estimate “how good” a carcass was. In 1960, a group of scientists at Texas A&M University fabricated 162 beef carcasses to predict the percentage of closely trimmed retail cuts on a bone-in and boneless basis from the round, loin, rib, and chuck primals. They evaluated a variety of factors to develop such a prediction, including body length, round plumpness index, round circumference, and ratio of major to minor retail cuts[2]. Ultimately, the most predictive model included four factors: a single measurement of external fat thickness, surface area of the ribeye, hot carcass weight, and percentage of kidney, pelvic, and heart (KPH) fat[2]. This research served as the basis for the USDA Yield Grading system introduced on June 1, 1965.

Source: beefresearch.org

Fig.1: The four components used in the linear yield grade equation. A single measure of fat thickness (evaluated at the 12th rib), surface area of the ribeye, hot carcass weight, and percentage of kidney, pelvic and heart fat.

Beef quality grades are well understood across industry segments; likewise, customers both domestic and international seek specific quality grades to meet their palatability expectations. In contrast, now, nearly 60 years after their inception, yield grades are poorly understood by industry participants, and consumers have no knowledge of their existence.

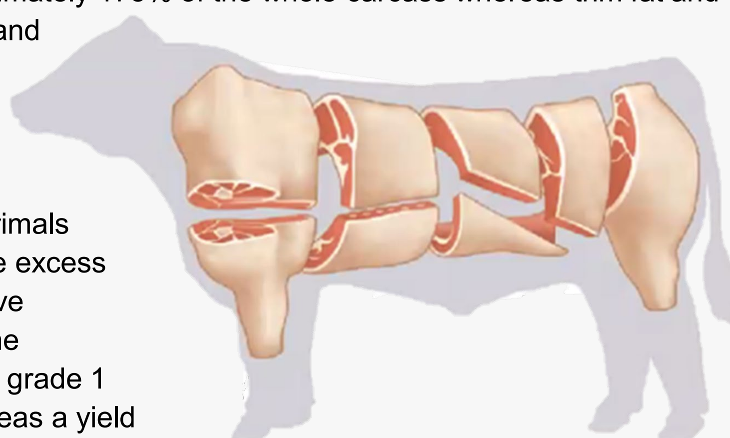
Evolution of Grading Standards

At its introduction, beef quality grades were established to be discerned and subjectively applied by experienced, knowledgeable beef experts. Since then, quality grading has continually evolved and has been amended/updated 15 times to reflect the latest science and to improve beef marketability [1]. Updates to quality grading standards have included modernization of terms, methodology changes, and modification of standards. Industry frustration with inconsistent application of both quality and yield grades led to the development of an electrical instrument grading system that became a reality in September 2009[1]. Camera-grading instruments are currently approved to assess marbling score, subcutaneous fat depth, ribeye area, and lean color. Camera-derived yield grade is calculated from the hot carcass weight, subcutaneous fat depth, ribeye area, and either actual algorithm-predicted or assumed constant percentage of KPH fat. Approximately 78% of fed cattle are graded today using camera technology.

Aside from utilizing camera grading technology to determine individual parameters and calculate the yield grade, no meaningful change has occurred in yield grade assessments since origination six decades ago. Unlike quality grade standards, yield grading is stagnant.

Concept of Red Meat Yield

Lean meat yield evaluation allows processors to estimate and thus value carcasses based on component values of muscle subprimals, trim fat, and bone. In the current market, boneless subprimals are valued ($/cwt) approximately 175% of the whole carcass whereas trim fat and bone are valued approximately 19% and 2% of the whole carcass value, respectively. In this manner, value-based carcass transactions result in premiums for carcasses that are a greater proportion of lean subprimals and discounts for carcasses that have excess backfat or are lightly muscled and have disproportionate amounts of bone. The maximum premium offered for a yield grade 1 carcass currently equals $8/cwt whereas a yield grade 5 carcass may be penalized up to $25/cwt [3]. Producers may sell cattle on value-based marketing systems whereby each animal is eligible for premiums and/or discounts. Alternatively, they may market cattle against a threshold, which compares each lot of cattle to a rolling plant average per cattle type. The threshold method of carcass valuation allows a discount to become a premium when cattle grade better than the plant average and a premium to become a discount when cattle grade worse than the plant average.



The current industry standard is value-based grid marketing where each individual animal is valued and eligible for premiums and/or discounts. A robust and reliable yield grade estimation system is paramount to ascertain true carcass value. Scientific investigations comparing yield grades to actual red meat yield are often disappointing and demonstrate that 0 to 50% of the variation in red meat yield can be accounted for. In other words, 100 to 50%

of the variation in red meat yield is accounted for by factors not used in the yield grade equation. When yield grade was developed, the industry was dominated by two breeds that had been selected for small-framed early-maturing traits that are not representative of the genetic diversity raised and fed today. Furthermore, contemporary cattle are fed longer and to ever increasing weights using the latest in growth enhancement technology to maximize growth and favorably alter the composition of gain. The population of cattle from which the yield grade equation was derived had an average hot carcass weight of approximately 600 pounds [2]. Vast improvements in genetic selection and growth technologies have led to hot carcass weight gains exceeding five pounds annually. Soon, hot carcasses will average 1,000 pounds – the approximate live weight of the animals originally used to develop the yield grade equation. The relationship between hot carcass weight and ribeye area is assumed to be linear. However, multiple scientists have demonstrated the relationship is actually curvilinear. As carcass weights continue to increase, the distribution of yield grades will shift to an ever-increasing percentage of "fatter" carcasses because they are unable to maintain the expected ribeye area size.

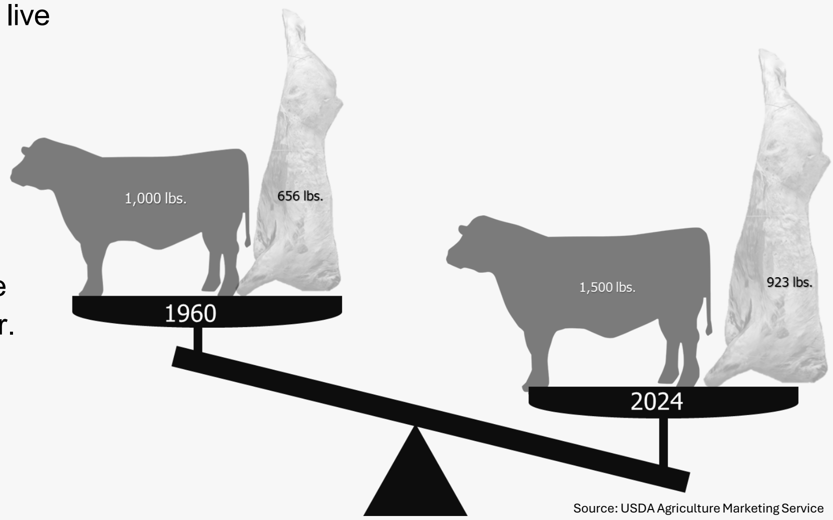


Fig 2: Carcass weights now rival the live weights of past generations – a stark reminder of how drastically animal size has increased.

Our beef carcass yield estimation system was developed from a small population of cattle of a biological type that no longer exists and is now used to predict the lean meat yield of carcasses increasingly more variable in genetic type and becoming larger with each passing year. Beef industry leadership has concluded that the status quo is no longer acceptable, and yield grade standards are long overdue an improvement.

Challenges to Understanding Product Yield

External fat is the predominant fat depot in carcasses from fed beef cattle and is highly related to the percentage of retail cuts. In beef carcasses, fat thickness measurement is obtained between the 12th and 13th ribs at a distance from the vertebral column that is three-quarters the length of the ribeye. Not all external fat negatively influences retail cut yield, as some external fat is left on many products through the supply chain (e.g., New York strip steak). Today's beef industry produces subprimals and retail cuts to a much more closely trimmed, specified external fat thickness (e.g., 1/8 inch) than it did 50+ years ago (e.g., 1/4 to 1/2 inch). Hence, the current yield grade formulation may not accurately account for the considerable amount of external fat being removed in the present-day industry. Ribeye area was included in the yield grade equation because, in tandem with hot carcass weight, it accounts for the proportion of muscle and bone in a carcass. The original yield grading system was based on the linear relationship between the four predicting factors and the percentage of retail cuts. As carcass weight increases, yield grade does not change if the ribeye area also increases at a directly proportional and linear rate. However, research of historical averages of the ribeye area and hot carcass weight has very clearly demonstrated that the biological relationship between these two factors is, in fact, very non-linear. Hot carcass weight has increased by a nearly constant five pounds every year for each of the past 50+ years [4]. Thus, the heavy carcass weights of modern-day cattle far exceed the proficiency of the equation to accurately model the biological relationship between ribeye area and hot carcass weight.

The original yield research speculated that KPH fat may be related to non-external fat depots, predominantly in the form of seam fat, or fat between muscles. At the time, KPH fat was expressed as a percentage of the carcass weight from an estimated visual appraisal, not an actual weight, which likely introduced error into the prediction. In today's fed cattle population, the average percentage of actual (not estimated) KPH fat is 3.0 to 3.5% but can commonly exceed 6% in certain cattle types [5]. Some commercial processors remove KPH fat at the time of harvest (after obtaining hot carcass weight) and before grading to facilitate chilling and fabrication. Moreover, today's fabrication styles include the separation of a greater number of whole muscle cuts, and less corresponding seam fat, than when yield grade was developed. Thus, the importance of seam fat to carcass yield must not be overlooked in modern cattle. The development and implementation of camera grading systems in the U.S. have immensely improved the ability to obtain accurate measurements of fat thickness and ribeye area at the 12th rib. Measurement of KPH fat is much less standardized and more difficult given current industry practices. Many processors calculate and pay for cattle based on company yield grades determined by either a standardized or camera-predicted KPH fat percentage that is often much less than the industry average. Nevertheless, it is not the measurement of

> **"... inaccuracy exists because the relationship between the [measurement] factors is no longer predictive of the actual carcass yield in modern cattle."**

individual factors that contribute to the inaccuracy of yield grades; the inaccuracy exists because the relationship between the factors is no longer predictive of the actual carcass yield in modern cattle.

Research efforts to better assess carcass yield are ongoing. One of the research challenges lies in defining the outcome – carcass yield. Packers generally define yield as the weight of finished subprimals (i.e., boxed beef) and trimmings. Contrarily, retailers define yield as the weight of product packaged for retail display after sectioning subprimals, removing portions of fat and/or bone, and accounting for purge lost during transport, aging, and cutting.

Some research has defined carcass yield as the composition of muscle, fat, and bone in their pure form, which is generally very precise but not entirely reflective of how beef is merchandised in the supply chain. The way cuts are produced, or the cutout style, also influences the definition of yield, and the yields associated with differing fabrication schemes are highly company-specific and proprietary. Consumer demand greatly influences fat thickness specifications, bone-in versus boneless cutout style, and the popularity of lesser known but innovative cuts. The collection of yield data is also exorbitantly laborious and, consequently, expensive because the weight of every cut must be captured. It is also critical that error from imprecise knife work be avoided, as it is difficult to accurately predict inconsistent outcomes. Even so, yield data is most industry-relevant when it is collected at the rapid line-speed of commercial production.

Fig 3: Cattle have changed drastically since the yield grade equation was developed – the original sample population was significantly more moderately framed and quicker maturing, vastly different from today's cattle. The challenge remains: using the same system to accurately predict yield across vastly different types shaped by decades of progress.

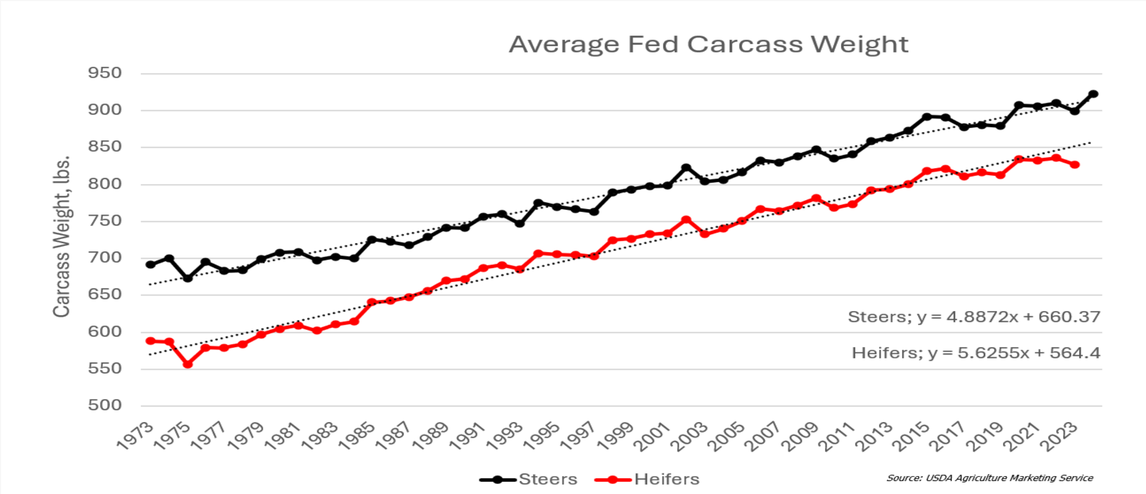


Figure 4: Average carcass weight in the U.S. has increased five or more pounds yearly for 60 years.

Challenges in Yield Measurement

Evolution of Cattle

Since the creation and adoption of the USDA Yield Grading system in the early 1960s, the capacity to assess differences in composition among animals has been influenced by the ever-changing beef animal. Changes in predominant breeds, cattle size and type, and cattle management, including growth modifiers and changes in days on feed, have all caused a decline in the ability of USDA Yield Grade to accurately depict differences in red meat yield (RMY). The intention of yield grade is to accurately represent the percentage of carcass weight comprised of boneless, closely-trimmed retail cuts (%BCTRC) from the major primals. However, continual changes in the size, conformation, and composition of cattle and their carcasses has reduced the accuracy of yield grade to an all-time low. Very recent studies have demonstrated that the current yield grade equation explains less than 35% of the variation in true red meat yield in modern cattle[6].

From the 1950s to the present, U.S. cattle breeds have evolved in response to market demands. Initially, British-origin breeds like Angus, Hereford, and Shorthorn dominated due to their moderate size, early maturity patterns, fertility, fleshing ability, and what was thought to be high feed conversions. However, this shifted drastically in the late 1970s through the 1990s as Continental European breeds became popular for their larger size, delayed maturity patterns, leaner carcasses, and accelerated growth, driven by consumer demand for leaner beef. The last 25 years has seen a return to more moderate, earlier maturing cattle with greater genetic potential for marbling. The movement since the 1990s has been largely in response to grid-based marketing of cattle via their carcasses, which has historically placed great emphasis on maximizing USDA Quality Grade, qualifying for branded beef programs, and optimizing with heavier carcass weights (vs. live weights). On average, today's cattle are producing greater amounts of marbling and are heavier than ever before, as carcass weight has steadily increased five or more pounds year over year for 60 years.

The evolution of cattle breeds and cattle types has been further influenced by the overwhelming advancements and improvements in growth-promoting technologies and genetic tools. Advancements of growth-promoting technologies, including hormonal implants and beta-adrenergic agonists (beta-agonists), in the past 25 years have profoundly impacted animal performance and carcass composition. These growth-promoting technologies universally add carcass weight, and, in most cases, promote increased muscle mass and contribute to greater red meat yield. Additionally, the availability and affordability of genomic selection for desirable carcass traits, namely ribeye area and marbling score, have largely influenced today's cattle population, and genomic tools may have the greatest influence on carcass composition in the future.

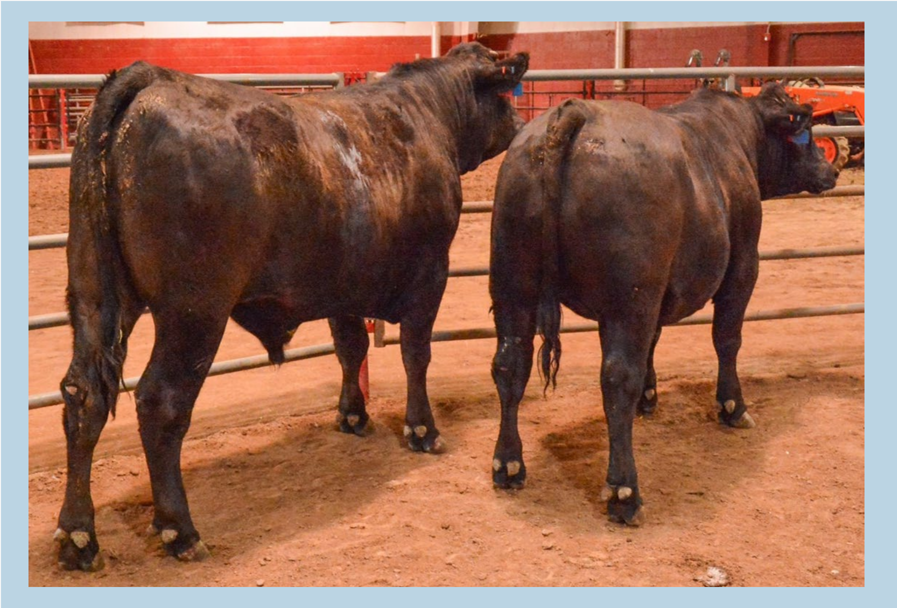


Fig 5: Visually, these two steers appear to have drastically different yields, yet their calculated yield grade is the same – highlighting the need for a system that better recognizes carcass merit.

Challenges Faced by the Industry

Overall, as evidenced by the evolution of cattle since 1950, cattlemen have been extremely responsive to market signals for more than 70 years. Grid-based marketing and the capture and transfer of carcass data on an individual animal basis have been some of the most influential tools shaping the U.S. cattle supply. Through grid-based marketing and genetic selection for marbling, our industry has clearly improved the quality grade performance of cattle. Conversely, red meat yield has declined, as our industry produces higher percentages of yield grade 4 and yield grade 5 carcasses each year. Even though grid systems utilize yield grade as a value-determining trait, the emphasis on yield grade as an indicator of red meat yield has diminished with disproportionately small premiums for yield grade 1 and 2 carcasses coupled with larger but decreasing discounts for yield grade 4 and 5 carcasses [3]. An increased demand for marbling score drives an increase in the number of days on feed, adding fat (external and internal), carcass weight, and dressing percent to cattle. This has resulted in diminishing the disincentive to produce fatter, lower-yielding carcasses. Not to mention, the yield grade equation is not functioning to accurately differentiate red meat yield and therefore not sending the correct market signal back to cattle feeders.

Perhaps the greatest challenge facing the industry's ability to measure and appropriately incentivize red meat yield is the disparity in ribeye area and true carcass muscling and the inability of 12th rib fat thickness and estimates of internal fat (KPH%) to explain carcass fatness. Current research has demonstrated that ribeye area, as a single factor, explains less than 5% of the variation in the proportion of saleable muscle, while 12th rib fat thickness explains less than 40% of total carcass fat, and KPH% is being underestimated by 1.5 to 2% on average.

Providing ribeye area and marbling score back to producers via carcass data sharing has led to considerable improvement through genetic selection in these traits. Seemingly, however, producers have increased ribeye area in cattle without a corresponding increase in total carcass muscling, and marbling score has increased with little regard to maintaining external fat and KPH% at a reasonable level. These realizations command that the beef industry needs an improved method for measuring and incentivizing true red meat yield and/or carcass composition.

Opportunities for Accurate and Precise Measurement

For more than 50 years the beef industry has been shaped by an inaccurate measure and market signal for red meat yield, largely due to the inadequacy of modern technology to measure and compute compositional differences at commercial production speeds. The industry needs instrumental measurements that are free from subjective, human bias and are capable of complex, holistic compositional measurements.

The most recent advancements in 3-dimensional (3D) imagery using digital, radar, and x-ray technologies coupled with computer processing speeds capable of complex computations largely referred to today as artificial intelligence, have aligned to beg for the modernization of compositional measurements of carcasses and cattle. In very recent studies funded by the Beef Checkoff, 3D digital imagery, computed tomography (CT), and radar technologies have been shown to be meaningfully accurate in predicting or measuring composition[7-10]. Advanced measurements and computations based on 3D digital imagery of beef carcasses have effectively explained greater than 90% of the variation in saleable red meat yield [7,9]. Processed CT data has been utilized to measure the composition of whole carcasses with near perfect accuracy and precision, but processing speed and carcass size remain as limitations with this technology. Lastly, radar technology has been utilized to explain more than 70% of the variation in the composition of live cattle showing promise as a predictor of red meat yield prior to harvest [10].

> “ A new system **must be applicable to live cattle production** so that seedstock operators and producers can measure it as well to **make meaningful genetic and production management changes.** ”
>
> – Red Meat Round Table Representative

The realizations of the capacity of such technologies align with the industry’s need for accurate and precise measures of composition. Although not yet fully capable of measuring every carcass at current production speed, technologies such as CT demonstrate promise to provide absolute, gold-standard measurement of carcass composition and are well served for comparison, development, and validation of evolving technologies, including 3D imagery, radar technologies, and others.

The original yield was very soundly developed to reflect yield differences among cattle at the time. Even today, yield grade directionally separates high- and low-yielding groups of animals, especially because it accounts for external fat thickness. The real challenge exists when this information is utilized on an individual animal basis to make genetic progress or management decisions. In a modern-day era of precision technology and big data management, the ability to develop not only a more accurate but also a substantially more dynamic and adaptive carcass yield assessment system is more possible than it has ever been. An established gold standard provides the opportunity for development and advancement of the industry to correct market signals and provide accurate data back to beef producers. Such a system is likely to persist well into the future as cattle populations continue to adjust to suit industry needs.

Research coordinated by the National Cattlemen’s Beef Association, a contractor to the Beef Checkoff.

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