BEEF YIELD GRADING: ***History, Issues, and Opportunities***

Ty E. Lawrence, Ph.D., Professor of Animal Science, West Texas A&M University, Canyon

Beef grades have been in use in the United States for almost 100 years. They were developed to assist in uniform marketing of dressed beef across the country. Grades were initially based solely upon quality, but were amended 50 years ago to assess carcass lean meat yield as well.

Beef yield grading history

The United States beef yield grade arose from industry interest in lean meat yield measurement beginning in the 1950s. Landmark data from which the yield grade is derived was presented at the American Society of Animal Production meetings in Chicago in 1960 and consisted of 162 beef carcasses representative of the period (Murphey et al., 1960). Those data evaluated 17 independent variables of fat content, weight, muscle content, maturity, or carcass dimensions to develop 23 multiple-linear prediction equations for predicting bone-in or boneless retail yield. An equation to estimate percentage boneless closely trimmed round-loin-rib-chuck (BCTRLRC) was derived using 12th rib fat depth, percentage kidney-pelvic-heart fat, hot carcass weight and ribeye area; this equation accounted for 91% of the variation in boneless retail yield. A second equation, the calculated yield grade, was developed as a 1-through-5 index using the same four carcass variables to estimate ranges of BCTRLRC. Yield grading began as a one-year trial in July 1962 and was put into effect on June 1, 1965.

Since the industry began using the yield grade equation, much research (Abraham et al., 1968; Abraham et al., 1980; Reiling et al., 1992; Farrow et al., 2009) has evaluated the relationships of the four chosen variables to percentage boneless lean yield. Subcutaneous fat depth measured at the 12th rib is most closely related ($r = -0.53$ to -0.66) to boneless lean yield, followed by percentage kidney-pelvic-heart fat ($r = -0.18$ to -0.58), ribeye area ($r = -0.18$ to 0.51), and hot carcass weight ($r = -0.03$ to -0.53). These linear correlation coefficients are highly variable and indicate weak ($r < 0.30$) to moderate ($r > 0.50$) relationships to boneless lean yield. In comparison, the original data from which the yield grade equation was created was more strongly correlated to boneless retail yield; -0.79 for 12th rib subcutaneous fat depth and -0.63 for percentage kidney-pelvic-heart fat.

At inception, the yield grade was determined from a single measure of 12th rib fat depth at a point three-quarters of the medial-lateral distance of the ribeye from the split chine bone (using a fat ruler or subjective assessment), ribeye cross-section area between the 12th and 13th ribs (using a dot grid or subjective assessment), a visual estimate of the percentage of the hot carcass weight represented by kidney-pelvic-heart fat and the kidney itself, and the hot carcass weight. By 1978, the Government Accountability Office reported to the U.S. Congress that yield grade needed to be assessed more accurately (Woerner & Belk, 2008). Development of an electrical instrument grading system began in 1980 and through several iterations of improvement and validation, instrument grading became a reality in September 2009. The two instruments approved for use today can assess marbling score, subcutaneous fat depth, ribeye area, ribeye width, ribeye depth, and lean color. Camera derived yield grade is calculated from the hot carcass weight, subcutaneous fat depth, ribeye area, and an algorithm predicted or assumed constant percentage of kidney-pelvic-heart fat. Research illustrating the agreement between USDA human grading and instrument camera grading (McEvers et al., 2012) suggests poor and variable agreement between human and camera grading yield grading outcomes. No industry standard exists concerning use of subjective human versus objective instrument grading. Instrument grading use ranges from no use at processors that have not purchased the technology to its utilization as the sole determinant of yield and quality grade; approximately 72% of fed cattle are graded for both quality and yield or for yield only using camera technology.

Economics of yield grading

Value-based sales in which yield grade premiums and discounts may alter the final carcass value are an ever-increasing proportion of beef cattle/carcass marketings (Figure 1). The maximum premium offered for a yield grade 1 equals $8/cwt. whereas a yield grade 5 carcass carries up to a $20/cwt. discount (USDA, 2016a). When the maximum reported yield grade premium or discount is applied to a 900-pound carcass, carcass value is altered by +$72, +$45, -$135, and -$180 for yield grades 1, 2, 4, and 5, respectively. Application of the previous values to the annual fed beef population indicates the potential industry value for yield grade valuation is +$108 million, +$326 million, -$309 million, and -$61 million for yield grades 1, 2, 4, and 5, respectively (USDA, 2016a; USDA, 2016b). Producers may sell cattle on formula based marketing systems whereby each animal is eligible for premiums and discounts, however threshold grids are more popular. A threshold grid compares each pen or lot of cattle to a rolling plant average for the respective sex classification or in many cases breed type (i.e. dairy influenced vs native) or origin (i.e. U.S. vs Mexican vs Canadian). In this manner, discounts or premiums are not tallied until the percentage of hot carcass weight in the specific lot exceeds the plant average for each quality and yield component. Furthermore, this method of carcass valuation allows a discount to become a premium when the cattle are better than the plant average and a premium to become a discount when the cattle are worse than the plant average. Value-based grid marketing is now the industry standard – as such, a robust and reliable yield grade estimation system is paramount to ascertain true carcass value and report back to producers a better estimation of saleable yield supplied to the beef complex.

Inconsistencies and challenges

The era in which the yield grade was developed was dominated by small-framed early maturing cattle which were primarily purebred Herefords. In contrast, the current fed beef population is a kaleidoscope of genetic diversity that is medium and large in frame; the greatest population of purebred animals is now represented by the Holstein breed. Moreover, cattle feeding technology including growth promoting implants, beta-adrenergic agonists, and genomic testing offer cattle feeders the opportunity to maximize growth and manipulate composition of gain. When growth promoting implants are managed to target a compositional endpoint, they are unlikely to alter the ultimate yield grade of a carcass. In contrast, if implanted cattle are managed to a lighter weight or shorter days on feed endpoint, they are often marketed “greener” and have a resulting yield grade that is lower and leaner. Zilpaterol hydrochloride, a beta adrenergic agonist, causes a noticeable improvement in red meat yield – not all of which can be accounted for via the yield grade (Lawrence et al., 2010). Similarly, ractopamine hydrochloride supplementation appears to improve yield grade and red meat yield, yet in a more subtle manner (Arp et al., 2014).

Improvements in genetic selection and growth technology have resulted in annual hot carcass weight gains of 5 pounds for steers and 6 pounds for heifers (Figure 2). Continuation of the current trend suggests that mean hot carcass weights will reach 1000 pounds in the years 2040 and 2046 for fed steers and heifers, respectively. In contrast, the population of cattle from which the yield grade equation was derived ranged from 350-900 pounds with a mean hot carcass weight of approximately 600 pounds. Discount rates for YG 4 or 5 carcasses have changed little since mandatory price reporting began, however because carcass weights have steadily increased the resulting penalty is ever increasing on a per animal basis. For instance, as we began the 21st century, steers average approximately 800 pounds – a \$120 discount at \$15/cwt – that has increased to \$135 for today’s 900-pound carcass.

The relationship between hot carcass weight and ribeye area has been assumed to be linear as denoted in the yield grade equation (USDA, 1997) and displayed on a ribeye measurement dot grid. In contrast, we have demonstrated (Figure 3) the true relationship is quadratic in total, with a linear portion that is represented by a lesser rate of longissimus muscle growth than assumed (Lawrence et al., 2008). Extrapolation of data reported in the 2011 National Beef Quality Audit (Moore et al., 2012) are a further support of this concept; as carcass weight increased from 550-650-750-850-950 pounds, square inches of ribeye area per hundred pounds of carcass decreased from 2.10-1.92-1.76-1.64-1.54. As carcass weights continue to increase past 825 pounds, an ever-increasing percentage of carcasses will be stamped a YG4 or greater because they are unable to maintain a linear ribeye growth rate.

When yield grades derived from the multiple-linear equation are compared to red meat yield, 40% of the variation in red meat yield can be accounted for in beef-type carcasses (Figure 4; Lawrence et al., 2010). However, 0% of the variation in red meat yield can be accounted for when the yield grade equation is applied to Holstein steers (Figure 5; Lawrence et al., 2010); dairy-type cattle represent approximately 9.9% of the fed-beef population (Moore et al., 2012). The lack of relation in Holstein steers is most likely due to limited or disproportional subcutaneous fat deposition as compared to other lipid depots combined with a lesser muscle to bone ratio. The Canadian Beef Grading Agency is considering adoption of the U.S. yield grading system to further harmonize North American grading. There, government and academic researchers have tested the U.S. yield grade equation and concluded that it accounts for 38% of the variation in boneless, closely trimmed, round-loin-rib-chuck retail cuts (Lopez-Campos et al., 2015); they concluded the current yield equations require updating.

The last 50 years have also seen substantial changes in beef marketing and trim standards. At implementation of the yield grade in 1965, the industry standard for beef processing was fundamentally an abattoir that sold carcasses downstream to boning establishments or direct to retailers whom employed in-house butchers. The skilled butcher primarily fabricated the carcass using a bandsaw, and the final trim of retail cuts was often 0.5”. With development of the boxed beef industry and more recently case-ready cuts, retail and foodservice establishments reduced or eliminated their employment of skilled butchers and demanded cuts trimmed to leaner specifications. Furthermore, U.S. consumers have continued to demand ever leaner cuts, so that the current standard is a retail cut with no trimmable waste fat. This change in market signal is another indication of the paramount need to accurately estimate carcass lean yield.

When yield grading began in 1965, the whole number (i.e. 1, 2, 3, 4, 5) was applied to the carcass. With the advent of camera grading technology, the multiple linear regression equation can be calculated to multiple decimals at the speed of commerce. The industry now has the opportunity to value fractions of a yield grade rather than a whole number. For instance, a 900-pound carcass with a calculated yield grade of 3.99 has an estimated red meat yield of 67.48% whereas the same weight carcass with a calculated yield grade of 4.00 has an estimated red meat yield of 67.46% (Lawrence et al., 2010). Very little change in yield (0.02 percentage points) occurred, particularly with respect to the application of a $135 discount.

Potential modifications and other systems

In August 2014, USDA sought input to revise the beef grading standards, specifically requesting comments for beef yield grading. Twenty-one comments were received; of those 12 recommended or supported improving beef carcass yield estimation, two did not support change, and seven did not express an opinion. Notably, three of the four largest U.S. beef processors provided an opinion; all three support improving the yield estimate.

Camera grading technology has the ability to redefine appropriate linear measures to predict red meat yield of beef carcasses. However, today camera systems continue to use the equation generated from 162 carcasses harvested in the 1950s. Farrow et al. (2009) demonstrated that other variables (ribeye width, subcutaneous fat area) could be generated to improve predictability of red meat yield; both variables could be captured with camera technology. Although no official changes are slated to be made to alter the yield grade equation, this author suspects that individual beef processors have gathered and are using such information in-house.

In considering how to improve upon the USDA system, it is imperative that we reflect on what other nations are doing. Canada developed its current beef yield system in 1992; that system uses metrics of muscle width (dorsal-ventral distance), muscle length (medial-lateral distance), and subcutaneous fat depth to predict percentage carcass lean (Figure 6). Notably, the Canadian system does not include hot carcass weight or percentage kidney-pelvic-heart fat. Similarly, a system developed to predict yield of Japanese beef carcasses measures subcutaneous fat depth, rib thickness, and ribeye area – albeit at the 6th rib location as well as a cold carcass weight specific to the left carcass side. Recent work from our team (Schmitz, 2015) indicates the Canadian and Japanese systems accounted for 37% and 13% of the variation in red meat yield, respectively; in comparison the U.S. yield grade was able to account for 50% of the variation in red meat yield. Beef producers in Europe have still another method of lean prediction, a subjective evaluation of carcass muscle conformation combined with a subjective evaluation of fat deposition.

Beef quality grading standards, originally promulgated in June 1926, were amended in July 1939, November 1941, October 1949, December 1950, June 1956, June 1965, July 1973, April 1975, October 1980, November 1987, April 1989, and finally in January 1997. These amendments collectively represent the will of the industry to improve the grading standards and comprise updates to beef carcass terms (i.e. Medium to Commercial; Good to Select), elimination of fat color evaluation, lowering minimum quality to achieve Prime and Choice, lessening emphasis on physiological maturity changes, separating quality designation of young bulls, and altering marbling/maturity requirement for specific grades. In contrast, the yield grade has remained static since inception in June 1965.

If the industry were to re-parameterize the yield grade equation, the sample population would need to be representative of the current mixture of fed cattle available for harvest. The genetic diversity of today is inclusive of purebred cattle of British, European, and Indian origin, their infinitum of crosses, as well as two popular dairy breeds, their crosses, and multiple crosses to beef-type breeds of British and European origin. Moreover, the finishing diet is inclusive of a myriad cereal-grain x grain-processing opportunities x co-product inclusion outcomes. Furthermore, our industry comprises additional complexity represented by growth technologies: non-hormone treated cattle, use of estrogen, use of trenbolone acetate, use of beta adrenergic agonists. Given sample size parameters (effect size = 0.02; α = 0.05; β = 0.80; 4 factors), a representative population of approximately 600 cattle would be required to update the equation to current cattle industry outcomes.

In summary, we continue to use a beef carcass yield estimation system developed from a small population of cattle of a biological type that no longer exists to predict red meat yield of cuts from carcasses that are increasingly more variable in genetic type and management. We apply that estimate to carcasses that weigh beyond the inference of which it was designed and we have ignored the opportunity to develop new yield estimates afforded by camera grading. Leadership within the beef community must decide if the status quo is acceptable, or if improvement is warranted.

Literature Cited

Abraham, H.C., Z.L. Carpenter, G.T. King, and O.D. Butler. 1968. Relationships of carcass weight, conformation and carcass measurements and their use in predicting beef carcass cutability. J. Anim. Sci. 27:604-610.

Abraham, H.C. C.E. Murphey, H.R. Cross, G.C. Smith, and W.J. Franks. 1980. Factors affecting beef carcass cutability: an evaluation of the USDA yield grades for beef. J. Anim. Sci. 50:841-851.

Arp, T.S., S.T. Howard, D.R. Woerner, J.A. Scanga, D.R. McKenna, W.H. Kolath, P.L. Chapman, J.D. Tatum, and K.E. Belk. 2014. Effects of dietary ractopamine hydrochloride and zilpaterol hydrochloride supplementation on performance, carcass traits, and carcass cutability in beef steers. J. Anim. Sci. 92:836-843.

Lawrence, T.E., R.L. Farrow, B.L. Zollinger, and K.S. Spivey. 2008. Technical note: The United States Department of Agriculture beef yield grade equation requires modification to reflect the current longissimus muscle area to hot carcass weight relationship. J. Anim. Sci. 86:1434-1438.

Lawrence, T.E., N.A. Elam, M.F. Miller, J.C. Brooks, G.G. Hilton, D.L. VanOverbeke, F.K.McKeith, J. Killefer, T.H. Montgomery, D.M. Allen, D.B. Griffin, R.J. Delmore, W.T. Nichols, M.N. Streeter, D.A. Yates, and J.P. Hutcheson. 2010. Predicting red meat yields in carcasses from beef type and calf-fed Holstein steers using the United States Department of Agriculture calculated yield grade. J. Anim. Sci. 88:2139-2143.

Lopez-Campos, O., I. Larsen, N. Prieto, M. Juarez, M.E.R. Dugan, and J.L. Aalhus. 2015. Evaluation of the Canadian and United States beef yield prediction equations and dual energy x-ray absorptiometry for a rapid, non-invasive yield prediction in beef. 61st Int. Cong. Meat Sci. Tech.

McEvers, T. J., J.P. Hutcheson, G.G. Hilton, D.L. VanOverbeke, and T.E. Lawrence. 2012. Technical note: Comparison of USDA yield grading characteristics of steer and heifer carcasses evaluated by subjective and objective methods. Prof. Anim. Sci. 28:477-481.

Moore, M. C., Gray, G. D., Hale, D. S., Kerth, C. R., Griffin, D. B., J.W. Savell, C.R. Raines, K.E. Belk, D.R. Woerner, J.D. Tatum, J.L. Igo, D.L. VanOverbeke, G.G. Mafi, T.E. Lawrence, R.J. Delmore Jr., L.M. Christensen, S.D. Shackelford, D.A. King, T.L. Wheeler, L.R. Meadows, and M.E. O'Connor. (2012). National Beef Quality Audit-2011: In-plant survey of targeted carcass characteristics related to quality, quantity, value, and marketing of fed steers and heifers. J. Anim. Sci. 90:5143-5151.

Murphey, C.E., D.K. Hallett, W.E. Tyler, and J.C. Pierce. 1960. Estimating yields of retail cuts from beef carcasses. 62nd American Society of Animal Production, Chicago, IL.

Reiling, B.A., G.H. Rouse, and D.A. Duello. 1992. Predicting percentage of retail yield from carcass measurements, the yield grading equation, and closely trimmed, boxed beef weights. J. Anim. Sci. 70:2151-2158.

Schmitz, A. N. 2015. An evaluation of grading parameters and fabrication yields of beef carcasses. M.S. Thesis. West Texas A&M University, Canyon.

USDA. 1997. Official US Standards for Grades of Carcass Beef. Agricultural Marketing Service, USDA, Washington, DC.

USDA. 2016a. National weekly direct slaughter cattle – premiums and discounts. Available at: http://www.ams.usda.gov/mnreports/lm_ct155.txt. Accessed: 22Jan2016.

USDA. 2016b. National summary of meats graded. Available at: http://www.ams.usda.gov/sites/default/files/media/FY%202015%20Grade%20Volume%20Report.pdf. Accessed: 22Jan2016.

Woerner, D.R. and K.E. Belk. 2008. The history of instrument assessment of beef. National Cattlemen's Beef Association, Centennial, CO.

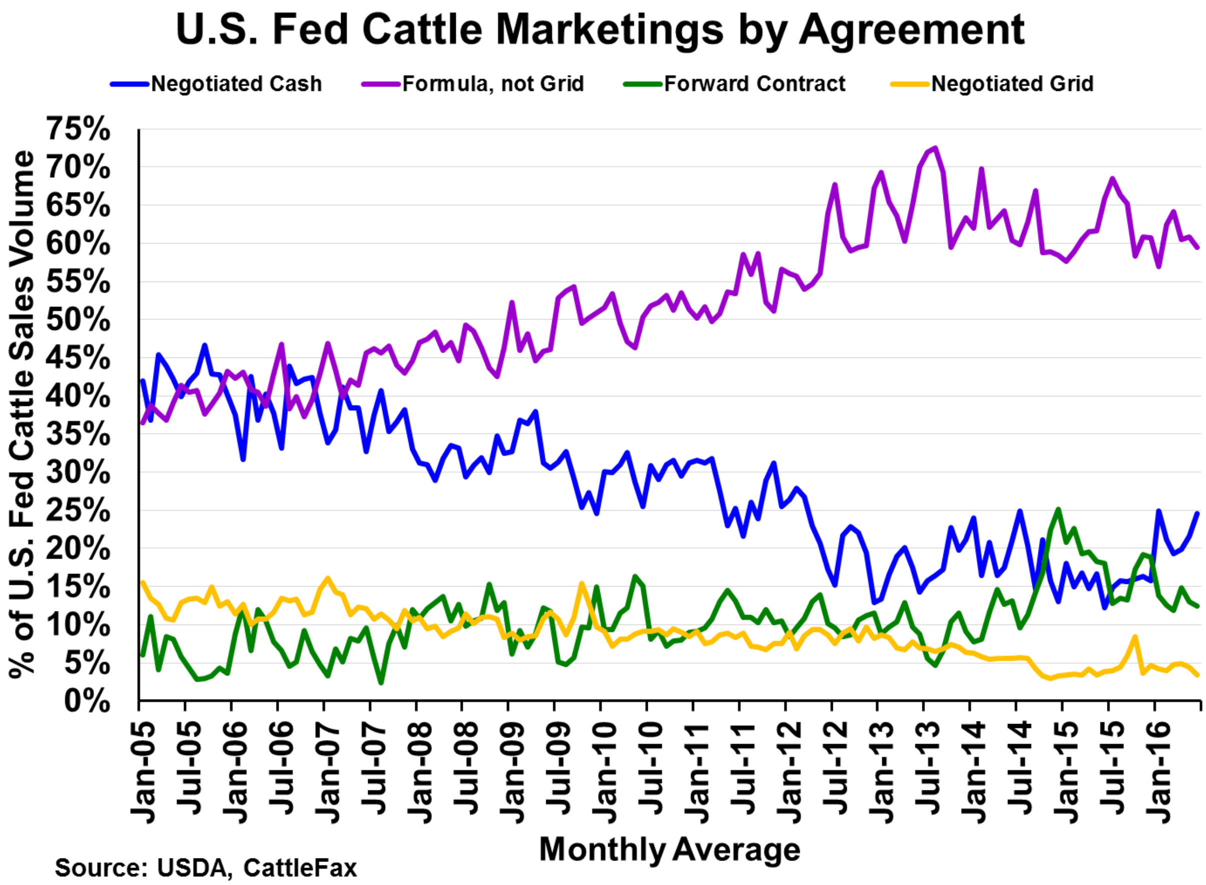


Figure 1. Historic U.S. fed cattle marketings by agreement type for the period from January 2005 through July 2016.

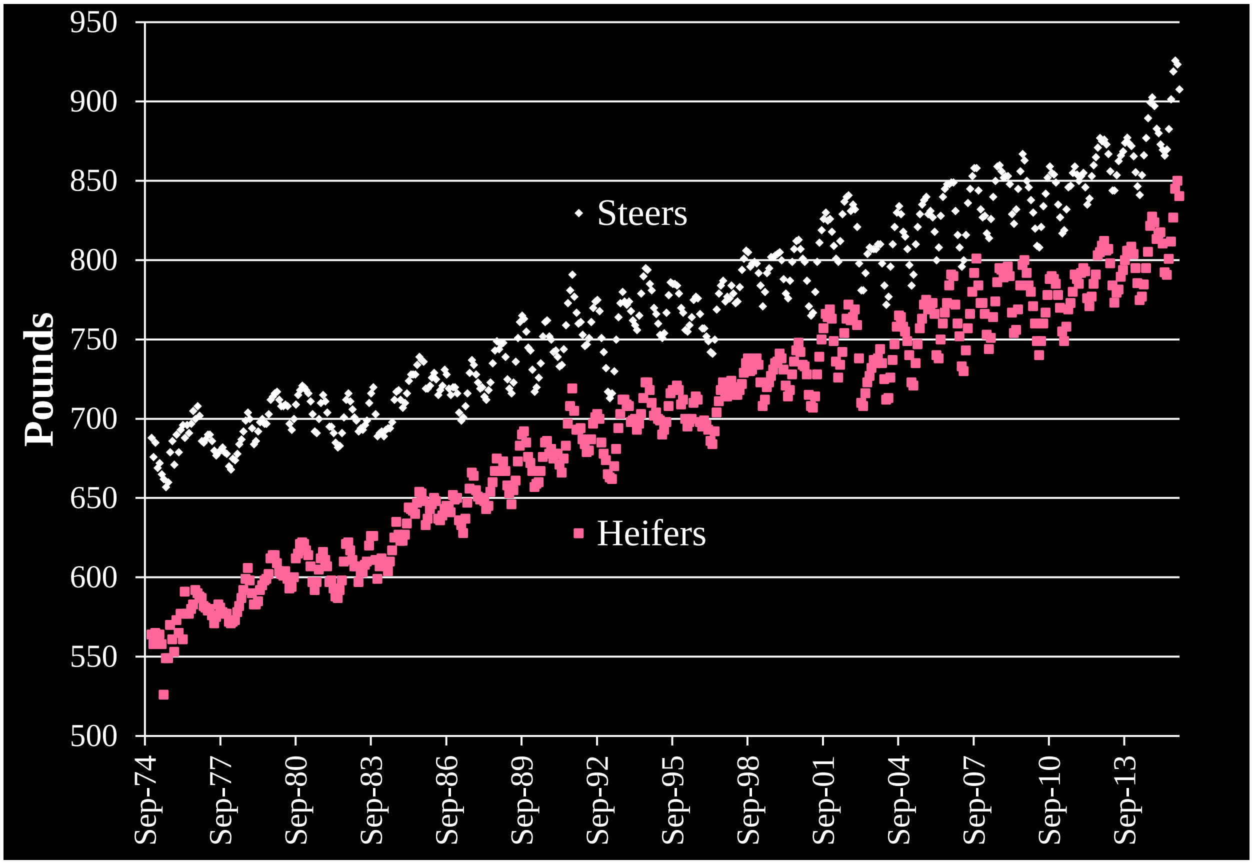


Figure 2. Historic U.S. beef steer and heifer hot carcass weights at federally inspected slaughter establishments for the period from January 1975 through December 2015 (Source: Don Close).

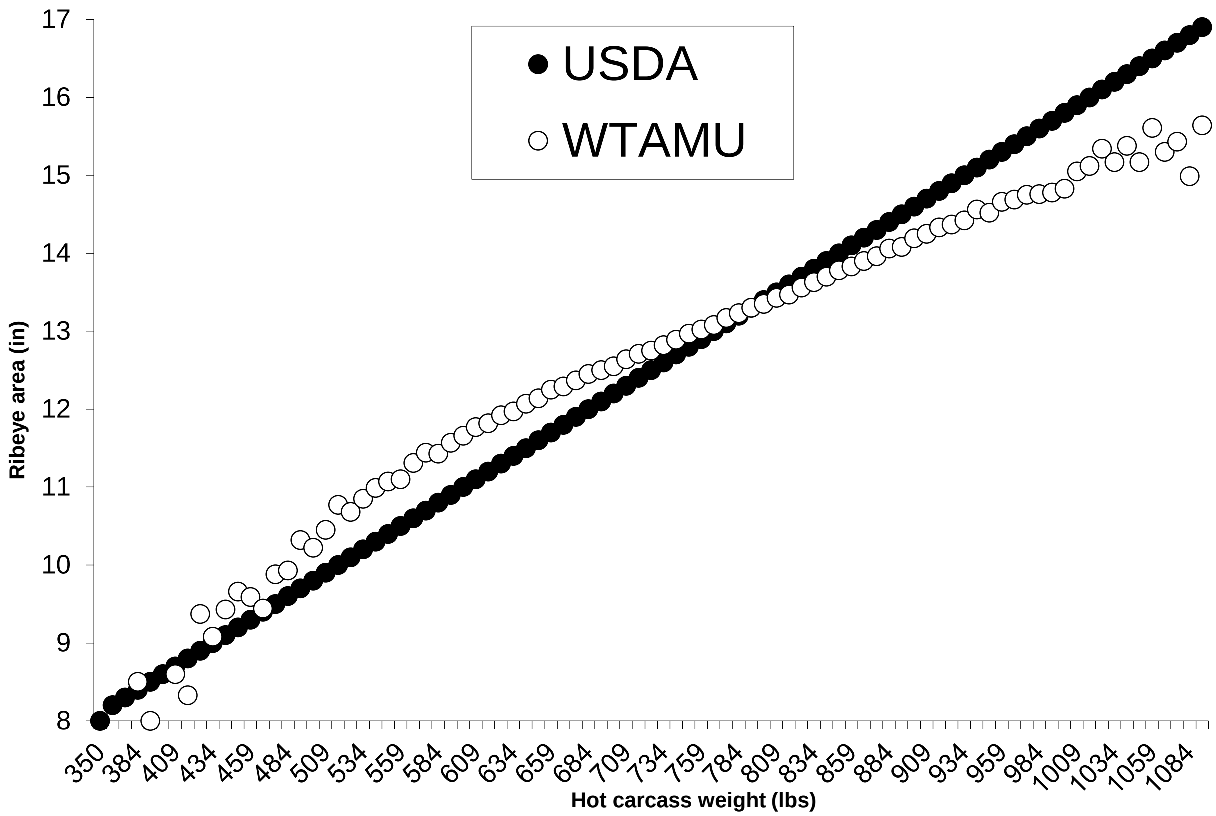


Figure 3. The assumed linear relationship between ribeye area and hot carcass weight (open circles denote the assumed relationship) and the actual quadratic relationship between ribeye area and hot carcass weight measurements from 434,381 beef carcasses evaluated by WTAMU (adapted from Lawrence et al. 2008).

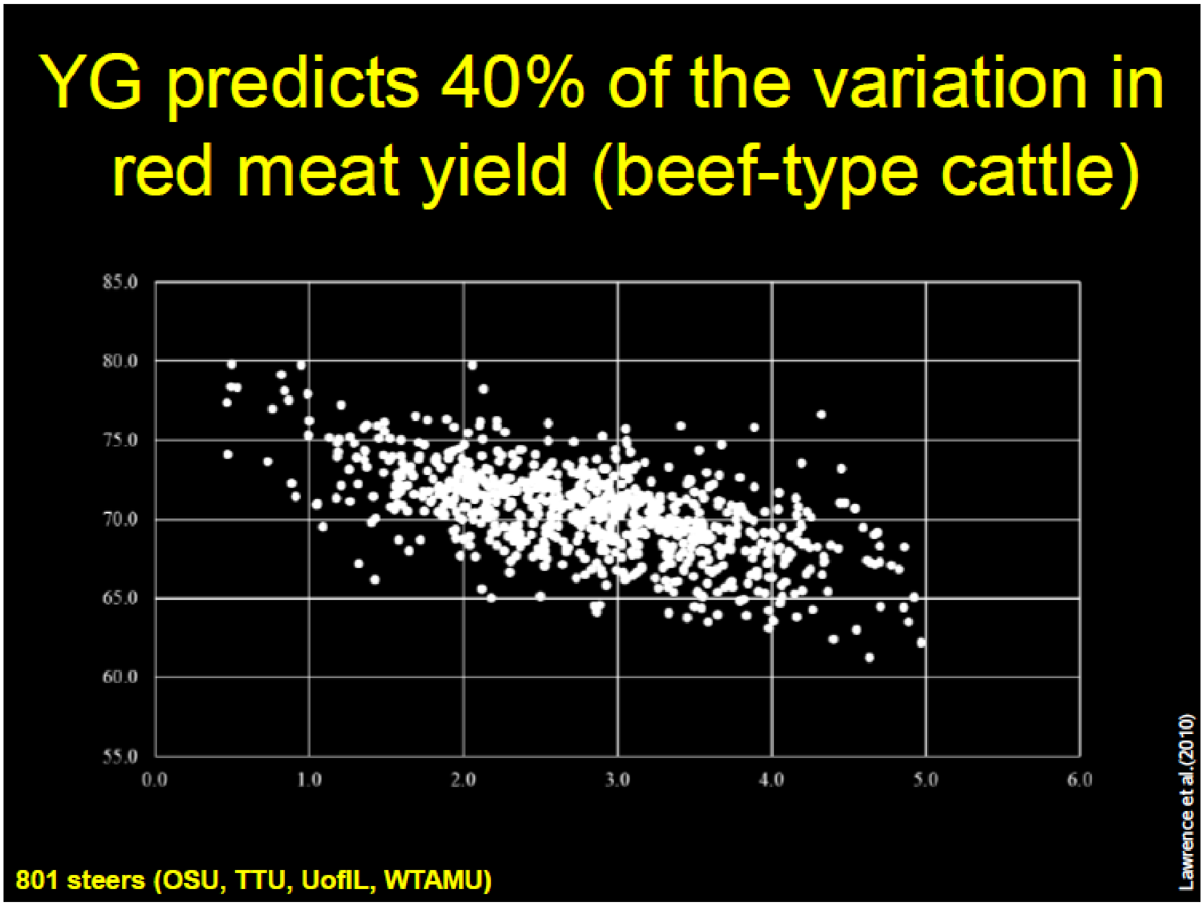


Figure 4. The relationship between calculated yield grade and the actual red meat yield from 801 beef carcasses (adapted from Lawrence et al. 2010).

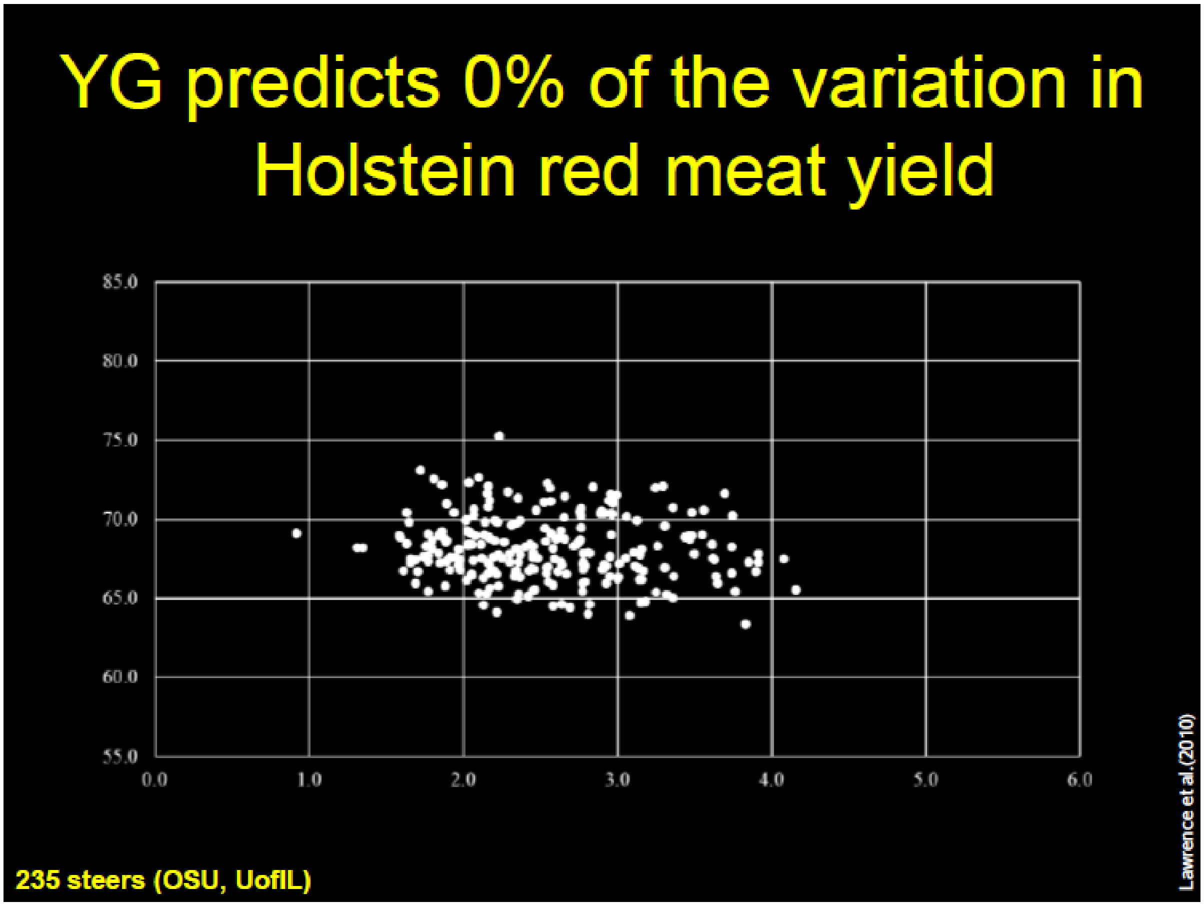
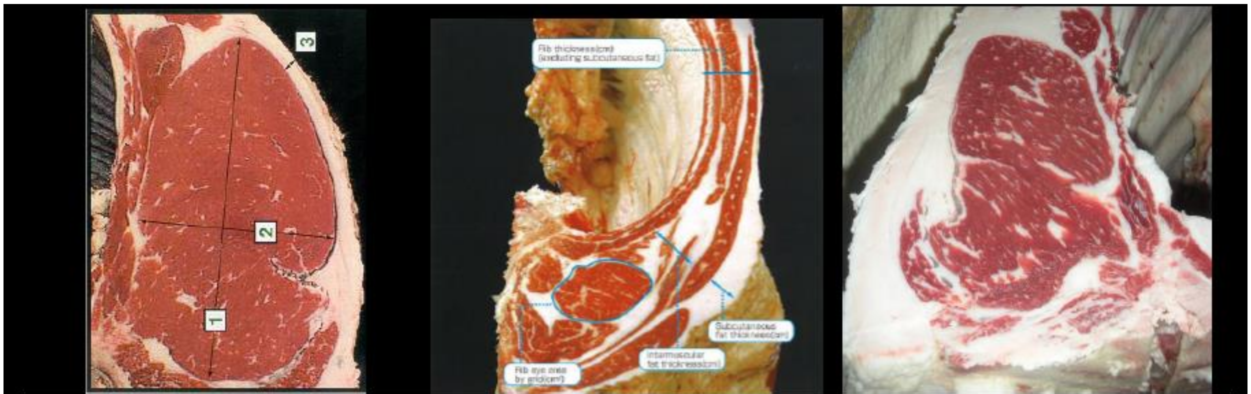


Figure 5. The relationship between calculated yield grade and the actual red meat yield from 235 dairy-type carcasses (adapted from Lawrence et al. 2010).



<table>
<tr><th colspan="2">Canadian Yield Grade (12th rib)</th><th>Japanese Yield Grade (6th rib)</th><th>U.S. Yield Grade (12th rib)</th></tr>
<tr><td>Ribeye length score (1)</td><td rowspan="2">Muscle score</td><td rowspan="2">Ribeye area, cm^2</td><td rowspan="2">Ribeye area, in^2</td></tr>
<tr><td>Ribeye width score (2)</td></tr>
<tr><td colspan="2">Grade fat (3)</td><td>Subcutaneous fat thickness, cm</td><td>Subcutaneous fat thickness, in.</td></tr>
<tr><td colspan="2">---</td><td>Cold left side carcass weight, kg</td><td>Hot carcass weight, lbs</td></tr>
<tr><td colspan="2">---</td><td>Rib thickness, cm</td><td>Kidney-pelvic-heart fat, %</td></tr>
<tr><td colspan="2">Percent lean = 63.65 + (1.05 x muscle score) – (0.76 x grade fat)</td><td>Estimated yield = 67.37 + (0.130 x ribeye area) + (0.667 x rib thickness) – (0.025 x cold left side weight) – (0.896 x subcutaneous fat thickness)</td><td>Boneless Closely Trimmed Round Loin Rib and Chuck = 51.34 - (5.78 x subcutaneous fat thickness) - (0.462 x kidney-pelvic-heart fat) - (0.0093 x hot carcass weight) + (0.74 x ribeye area)</td></tr>
<tr><td colspan="2">YG 1 ≥ 59% lean
YG 2 = 54-58% lean
YG 3 ≤ 53% lean</td><td>YG A ≥ 72% yield
YG B = 69-71% yield
YG C < 69% yield</td><td>YG 1 = >52.3 %BCTRLCR
YG 2 = 50.0 – 52.3 %BCTRLCR
YG 3 = 47.7 – 50.0 %BCTRLCR
YG 4 = 45.4 – 47.7 %BCTRLCR
YG 5 = <45.4 %BCTRLCR</td></tr>
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Figure 6. Comparison of Canadian, Japanese, and United States beef yield grading systems.