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# Valuing Fed Cattle Using Objective Tenderness Measures

**John Michael Riley, Ted C. Schroeder, Tommy L. Wheeler, Stephen D. Shackelford, and Mohammad Koohmaraie**

Beef tenderness is critical in consumer satisfaction with beef steak products. Current fed cattle valuation systems do not differentiate carcasses based upon tenderness variation. However, considerable research indicates consumers are willing to pay more for tender relative to tough beef steak. This article develops a tenderness-augmentation to current fed cattle grid pricing systems. Using a large set of actual carcasses, we determine that a tenderness-augmented price grid would reorder fed cattle value by on average nearly $5.00/cwt dressed relative to current valuation methods. Substantial opportunity is present to improve beef tenderness through new price signals to producers.

*Key Words:* beef quality, meat tenderness, cattle value, cattle price

**JEL Classifications:** Q11, Q13, M31

Tenderness is one of the most important attributes affecting consumer eating experience for beef products. Lusk et al. found that when consumers were provided information regarding beef steak tenderness together with completing a taste test, 90% of them preferred a tender relative to a tough steak. Furthermore, 51% were willing to pay an average premium of $1.84/lb for a tender relative to a tough steak. Many studies have found similar results (e.g., Boleman et al.; Lusk and Schroeder; Miller et al.; Platter et al.; Shackelford et al. 2001). Though tenderness of beef is affected by a number of factors including processing, aging, and food preparation, cattle producers have important influence on beef tenderness through genetics and animal feeding protocols (Tatum). Despite the importance of beef tenderness to consumers, and the ability of producers to influence beef tenderness, fed cattle valuation systems that pay price differentials for cattle with varied beef tenderness levels have not been developed.

The purpose of this study is to develop a tenderness-based fed cattle valuation system that could be used to augment current grid pricing systems. The tenderness-augmented grid is used to assess how fed cattle valuation would change if it were adopted. Using a large random sample of cattle carcasses we estimate the amount of price adjustment fed cattle would typically realize if a tenderness price adjustment were added to current cattle pricing systems.

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Fed cattle are valued using predominantly one of two methods, (1) a live (or dressed) price, or (2) a grid pricing system. In live or dressed pricing, all animals in a pen receive the same average price. Under grid pricing, cattle are valued based upon individual carcass quality and yield grade attributes. Yield grade is used to predict red meat yield of the carcass and quality grade is intended to reflect differences in eating quality of beef products obtained from a carcass. However, beef tenderness is not strongly related to quality grade. That is, many Choice grade carcasses produce tough steaks and many Select grade carcasses produce tender steaks. Wheeler, Cundiff, and Koch found that shear force (a mechanical measure of tenderness) as well as sensory panel tenderness and juiciness ratings improved only slightly as marbling increased. Marbling is the dominant determinant of beef quality grade. Furthermore, marbling explained only 5% of the variation in product palatability across carcasses. Wulf et al. found a correlation of only −0.12 between marbling and shear force value and the correlation between marbling and consumer panel tenderness ratings of beef products was only 0.11 whereas they found a correlation between shear force and consumer rated tenderness of −0.76).[1]

In addition to tenderness, other product quality attributes including flavor and juiciness are also important beef product quality and eating experience attributes (Killinger et al.). Beef flavor is strongly associated with marbling and beef quality grade (Tatum).[2]

As such, we propose a carcass valuation method that augments, instead of replaces, current grid pricing systems to maintain a premium or discount for flavor associated with quality grades.

Developing a tenderness-based enhancement to fed cattle grid pricing requires first determining appropriate carcass premiums for beef tenderness and discounts for beef toughness. We rely on past literature on consumer willingness to pay for tender relative to tough steaks to propose a tenderness premium and discount schedule. A common method used to assess beef tenderness is the Warner-Bratzler shear force (WBSF). Figure 1 illustrates WBSF values for longissimus muscles by carcass quality grade for a sample of beef carcasses described later. Considerable variability in beef tenderness is present within each carcass quality grade. For example, numerous Select grade carcasses are more tender than Choice (the higher of the two quality grades). Similarly, many Choice grade carcasses produce beef steaks that are tougher than many Select grade carcasses. Thus, USDA quality grades do a poor job of valuing each carcass based on tenderness. We determine economic value differences when a carcass is priced using a traditional grid based upon USDA quality grades instead of one that incorporates a direct measure of beef tenderness. This is essential in development of a new fed cattle valuation method that builds on the current grid structure with emphasis on valuing carcasses based upon tenderness.

## Tenderness Valuation

The most common objective instrumental methods used to assess beef tenderness are Warner-Bratzler shear force and slice shear force (SSF) tests (see Huffman et al.; Boleman et al.; Shackelford et al. 1999; Wheeler, Shackelford, et al. 1997). Shear force technology involves removing a sample from a cooked steak and measuring the amount of force required to shear through the sample. For WBSF, six 1.27 cm diameter round cores are removed parallel to the muscle fibers and sheared with a V-shaped blade. For SSF, one slice that is 1 cm thick and 5 cm long is removed parallel to the muscle fibers and sheared with a flat edge blade. The amount of force required to shear the sample determines its tenderness level. A lower value indicates less force required to

[1] Negative correlation is because smaller shear force value is more tender.

[2] Tatum summarized research demonstrating beef flavor, especially for products derived from the rib and loin, is strongly related to beef marbling. Beef flavor improves linearly as marbling increases (Smith et al. 1980). Marbling degree is the major determinant of beef quality grade for fed steers and heifers. Thus, beef quality grade is a proxy for beef product flavor.

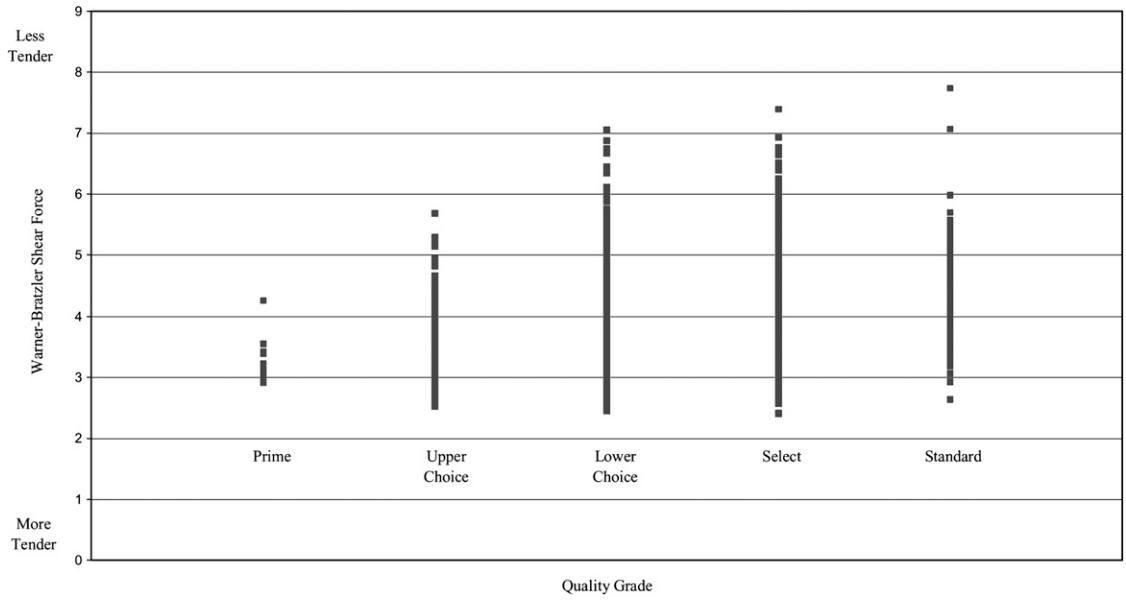


**Figure 1.** Warner-Bratzler Shear Force Values by Quality Grade of MARC Carcass Data

shear the meat and thus a more tender meat product.

WBSF and SSF measures more accurately predict consumer evaluation of meat product tenderness than USDA quality grades. Wulf et al. reported a correlation between shear force and consumer sensory panel rated meat product tenderness of −0.76 (lower shear force had greater sensory panel tenderness ratings). Shackelford et al. (1999) found a correlation of −0.77 between WBSF and of −0.82 between SSF and consumer sensory evaluation of tenderness. Wheeler, Shackelford, and Koohmaraie found an $R^2$ between SSF and consumer tenderness evaluation of 0.85. Given the high degree of correlation between shear force and consumer rating of beef tenderness, this technology provides a way to rank beef carcasses according to steak tenderness levels.

A majority of consumers consider tenderness the most important beef palatability factor (Savell et al.; Smith et al. 1987, 1995) and consumers are willing to pay more for tender beef. Feldkamp et al. conducted a nonhypothetical consumer evaluation study where participants were given a generic 12 oz ribeye steak and asked to place binding bids to exchange the generic cut for a "guaranteed tender" steak. Consumers exhibited a willingness to pay (WTP) of $0.95 per 12 oz. steak ($1.27/lb) more for the guaranteed tender product. In another nonhypothetical consumer evaluation study, Platter et al. concluded as WBSF decreased by 1 lb (1 lb of force required to slice the steak) the average mean bid price for strip loin steak increased $0.46/lb. Lusk et al. found that consumers were willing to pay $1.84/lb more for tender steaks via a similar binding consumer evaluation study when participants were informed that the steak was "guaranteed tender" and $1.23/lb when participants based their WTP on taste alone.

Miller et al. through a nationwide[3] in-store consumer evaluation survey determined that 78% of participants were willing to pay more for steaks that were guaranteed tender by the retailer. Shackelford et al. (2001) found that 50% of consumers would "definitely pay" or "probably pay" $0.50/lb more for a steak with a low shear force value (i.e., was tender).[4] Lusk and Fox concluded from survey results examining consumer WTP for

[3] Surveys were conducted in Baltimore, MD/Washington, D.C.; Chicago, IL; Dallas/Ft. Worth, TX; Los Angeles, CA; and Lubbock, TX.

[4] Consumers in this study were asked how willing they would be to pay $0.50 per pound more to purchase the tender steak.

beef steak attributes that as tenderness increased one unit (on a scale of 1–10), average consumer WTP increased $1.13/lb.

There is a considerable and consistent body of research demonstrating consumer willingness to pay premiums for tender relative to tough beef cuts. Current fed cattle pricing systems, which rely largely on USDA quality grades for assessing meat quality, are not accurate predictors of meat tenderness level. This research is the first to develop and compare a tenderness-based fed cattle valuation system to more traditional grid pricing systems to determine how cattle valuation would change when accounting for estimated beef tenderness differences across carcasses.

## Methods

To determine whether fed cattle are overvalued or undervalued using traditional pricing methods relative to tenderness-based valuation, we calculate values for selling cattle using traditional dressed and grid pricing mechanisms and compare these to a hypothetical tenderness-based valuation scheme. The dressed value for each carcass is calculated as:

$$(1) \qquad DressVal_{n,t}(\$/\text{cwt}) = DressP_t$$

where *DressVal* is the total dressed value of carcass $n$ at time period $t$ and *DressP* is the dressed price ($/dressed cwt).

Grid values were formulated for each carcass using:

$$(2) \qquad GridVal_{n,t}(\$/\text{cwt}) = Base_t + QGPRem_{n,t} + YGPRem_{n,t}$$

where *GridVal* is the total grid value of carcass $n$ at time period $t$. *Base* is the base price of the grid ($/cwt), *QGPrem* is the quality grade premium/discount ($/cwt), and *YGPrem* is the yield grade premium/discount ($/cwt) associated with each carcass. The base price for grids is the dressed price, *DressP*.

To incorporate carcass tenderness, the current grid pricing format is augmented by using WBSF tenderness measures to determine a tenderness premium/discount schedule. Platter et al. (2005) estimated an equation for consumer WTP for tender beef strip loin steaks based on experimental data as:

$$(3) \qquad \text{WTP}(\$/\text{lb}) = 4.672001 - 0.461077 \times \text{WBSF}$$

This gives the value ($/lb retail weight) that consumers are willing to pay for tenderness of beef as measured by WBSF. Only part of the bovine carcass will be valued based upon tenderness because some of the carcass is ground and processed or prepared in ways where tenderness is not as important. Therefore we distribute the WTP amount over the percentage of the carcass for which tenderness most directly matters, steak products. Foutz et al. reported that about 17% of hot carcass weight (HCW) is composed of ribeye, top sirloin, bottom sirloin, strip loin, tenderloin, and top round and Wheeler, Cundiff, et al. (1997) estimated these cuts to be approximately 22% of HCW. Thus, we assume that 20% of the typical carcass weight would have a tenderness premium or discount driven by equation (3) and the remaining 80% of carcass value would be invariant to WBSF measures. Tenderness of some beef cuts other than steaks (e.g., roasts) may also matter to consumers. However, little research has documented this or estimated consumer willingness to pay for tenderness in beef products other than steaks. As such, we do not differentiate carcass values based on tenderness levels of muscles other than those used to produce steaks.

Conducting a shear force on a beef carcass involves taking a steak from the loin, cooking it, and conducting a shear force measure on that product. As such, a shear force test is somewhat invasive and expensive in commercial slaughter plant operations. The estimated premium we use for beef tenderness allows for this cost as the premium for a tender relative to a tough carcass implied by the equation we use to assign tenderness is $0.92/lb (e.g., WBSF going from 3.4 kg to 5.4 kg) and binding consumer WTP studies indicate a retail premium of $1.84/lb is attainable (Lusk et al.).

Beef flavor is strongly associated with beef marbling which is the main driver of quality grades (Smith et al. 1980; Tatum). Flavor is an

important product attribute affecting consumer eating experience (Killinger et al.). Traditional grids with premiums and discounts for marbling levels (quality grade) reflect flavor valuation difference. Thus, we augment, rather than replace, current grid systems with Platter et al.'s estimated tenderness value equation by adding a tenderness premium to tender carcasses and discounting tough carcasses in addition to traditional quality and yield grade grid premiums and discounts. Quality grades are related to juiciness, flavor, and tenderness of beef cuts. As such, some portion of quality grade premiums for Prime carcasses and discounts for Select and Standard carcasses relative to Choice reflect expected differences in beef tenderness. Ideally, we would like to isolate and remove the portion of the quality grade premium or discount associated with just expected tenderness prior to augmenting the grid with tenderness premiums or discounts. However, we could not devise a method to partition the quality grade premium or discount into that attributable to tenderness from that associated with juiciness and flavor. By leaving the quality grade premiums and discounts in place, our method likely results in overvaluing tender Prime and undervaluing tender Select and Standard grade carcasses. However, given that past research demonstrates quality grade is a poor predictor of beef tenderness (e.g., Wheeler et al. 1994; Wulf et al.), we expect any overvaluations or undervaluations associated with our method to be economically small.

To develop a tenderness premium schedule we modify equation (3) by adjusting the constant term so that we can establish a baseline for tenderness that provides a premium for carcasses that are more tender than a base WBSF and those that are more tough to be discounted. To determine the appropriate modification to equation (3), we relied on past literature that has estimated WBSF thresholds associated with tenderness classifications. Brooks et al. report least squares means of Choice WBSF values for ribeye, top loin, T-bone, and top sirloin ranging between 2.8 kg and 3.0 kg (2.8–3.1 for Select) in the 1998 National Beef Tenderness Survey. George et al. report WBSF values of 3.4 kg for Choice (3.5 for Select) top sirloin and 2.9 kg for Choice (3.2 for Select) strip loin. Voges et al. used a cutoff point between tender and intermediate of about 3.9 kg and they reported mean WBSF values for upper Choice grade top sirloin of 2.8 kg and ribeye of 3.0 kg for foodservice steaks from the 2006 National Beef Tenderness Survey. For carcass data used to exemplify impacts of a tenderness premium in this study (discussed below), the median WBSF value was 3.8 kg. Based on these studies, if we wanted to set a base for tenderness that would leave the average price for fed cattle approximately unchanged relative to current pricing mechanisms by augmenting the current grids with a tenderness premium, a base of 3.8 kg for WBSF is most reasonable. Rescaling the constant term of equation (3) to reflect the 3.8 kg WBSF base, converting to \$/cwt, gives (recall this applies to only 20% of the carcass weight):

$$\text{Tenderness Premium (\$/cwt)} = 175.21 - 46.1077 \times \text{WBSF} \tag{4}$$

In equation (4) a WBSF value of 3.8 kg would have a tenderness premium of \$0/cwt. Each 1 kg difference in WBSF relative to 3.8 kg would be associated with a \$46.11/cwt premium or discount for 20% of the carcass, or a \$9.22/cwt price change for the entire carcass.

The tenderness-augmented grid schedule developed here is likely a low conservative estimate as premiums at retail could be larger than those used in our tenderness-augmented grid. For example, Lusk et al. estimated a premium of \$1.84/lb when the consumer is told that a steak is assured tender relative to a tough steak. The grid developed here would imply a \$1.16/lb premium in going from a tough to a tender steak (Platter et al.).

Platter et al. report four thresholds of tenderness: "Very Tender," "Slightly Tender," "Slightly Tough," and "Very Tough." The transition from slightly tender to slightly tough is at a WBSF value of 4.4 kg. Boleman et al. give three levels of tenderness: "Tender," "Intermediate," and "Tough" with WBSF ranges for these being 2.27−3.58 kg, 4.08−5.4 kg, and 5.9−7.21 kg, respectively. The median of the intermediate group is 4.74 kg. Wheeler,

Shackelford and Koohmaraie (1997) found that at a WBSF level of 3.0 kg or less, 100% of steaks are accepted as tender and for WBSF of 5.7 kg and higher, 100% of steaks were considered tough. Therefore, they set levels for three thresholds giving a median value (of the intermediate threshold) of 4.35 kg. Shackelford et al. (1991) concluded a WBSF of 4.6 kg was the threshold for moving from tender to tough steaks. Therefore, based on this body of literature, an alternative base of 4.6 kg WBSF is also feasible and is analyzed in this article along with the 3.8 kg base. Under this format any carcass with a 4.6 kg WBSF or higher would receive a discount and any carcass with a WBSF less than 4.6 kg would receive a premium in accordance with the following modification to equation (3), after adjusting the constant term, the 4.6 kg WBSF base would be (applied to 20% of carcass weight):

$$\text{Tenderness Premium (\$/cwt)} = 212.095 - 46.1077 \times \text{WBSF} \quad (5)$$

For some carcasses, the calculated price they would receive under the tenderness grid equation is low because the carcass has a high WBSF value. A lower-bound threshold for a tough fed cattle carcass is a cull-cow price which represents a carcass that is likely to be ground or highly processed. Thus, we use the cull-cow price as the lower bound for tough carcass values.

## Data

Carcass data from the U.S. Meat Animal Research Center (USMARC) were used in this study. USMARC collected traditional fed cattle valuation measures (e.g., carcass weight and USDA quality and yield grades) and WBSF values for 3,563 beef cattle carcasses. In addition, trained sensory panel ratings were collected for tenderness, juiciness, and flavor on a ribeye steak from each of the carcasses.[5] Carcasses that weighed more or less than acceptable ranges as defined by typical grids (i.e., carcasses weighing less than 600 lb or more than 900 lb) were deleted, reducing the number of carcasses used in the analysis to 3,154. The data were used to assess how cattle would have been valued under traditional dressed and grid pricing systems compared with prices augmented with meat tenderness value as assessed by the WBSF instrument. Table 1 presents summary statistics of the carcass data obtained from USMARC.

Figure 2 illustrates the distribution of WBSF measures for the 3,154 carcasses used in this study. The majority of carcasses fall between a shear force of 3 kg and 5 kg. Generally, meat with shear force of 3.5 kg or less (about 30% of carcasses) would be considered assured tender, muscle cuts with a 3.5–5 kg shear force (about 60% of carcasses) would be intermediate tender levels, and cuts with greater than 5 kg shear force (10% of carcasses) would be tough.

To assign grid values to these carcasses, we start with a base dressed fed steer price obtained from the *USDA-AMS 5 Area Weekly Weighted Average Direct Slaughter Cattle* report for the week of September 30, 2007. The same dressed steer price was used as the base price for the traditional grid and the tenderness-augmented grid. This price is based on a 50% Choice and 50% Select grade pen of cattle. The base price was \$149.40/cwt carcass weight.

*USDA-AMS National Weekly Direct Slaughter Cattle—Premiums and Discounts* reported prices were used for grid premiums and discounts for the same week. Because we use a 50% Choice, 50% Select carcass as the base carcass price, grid premiums and discounts added to the base are adjusted accordingly since grid premiums and discounts reported by USDA are based on a pen of 100% low choice cattle (i.e., the low Choice premium published by USDA is \$0/cwt). To make this adjustment, low Choice carcasses were assigned a premium of one-half the Select discount and Select carcasses a discount of one-half the Select discount and all other grid quality grade premiums and discounts were adjusted relative to these. For example, the premium for Prime relative to Choice was \$10.77/cwt and becomes \$15.02/cwt after a \$4.25/cwt low Choice adjustment relative to a 50% Choice

[5] Ratings were based on a scale of 1–8 with 1 being the worst and 8 the best.

**Table 1.** Summary Statistics of Carcass Data

| | Count (%) | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|---|
| Live weight (lb) | | 1,199.5 | 114.5 | 892.0 | 1,544.0 |
| Hot carcass weight (lb) | | 736.4 | 73.3 | 600.0 | 900.0 |
| Dressing percentage (%) | | 61.4 | 2.1 | 50.3 | 72.4 |
| Marbling score[a] | | 504.2 | 67.6 | 280.0 | 890.0 |
| Quality grade[b] | | 1.6 | 0.7 | 0.0 | 4.0 |
| No. of Prime | 11 (0.3%) | | | | |
| No. of upper 2/3 Choice | 182 (5.8%) | | | | |
| No. of lower 1/3 Choice | 1,460 (46.3%) | | | | |
| No. of Select | 1,397 (44.3%) | | | | |
| No. of Standard | 104 (3.3%) | | | | |
| Yield Grade | | 2.9 | 0.8 | 0.4 | 6.9 |
| No. of yield Grade 1 | 415 (13.2%) | | | | |
| No. of yield Grade 2 | 1,299 (41.2%) | | | | |
| No. of yield Grade 3 | 1,097 (34.8%) | | | | |
| No. of yield Grade 4 | 302 (9.6%) | | | | |
| No. of yield Grade 5 | 41 (1.3%) | | | | |
| Warner-Bratzler Shear Force (kg) | | 3.9 | 0.7 | 2.4 | 7.7 |
| Tenderness sensory score[c] | | 4.9 | 0.8 | 1.5 | 8.0 |
| Juiciness sensory score[c] | | 5.1 | 0.5 | 3.5 | 7.1 |
| Flavor sensory score[c] | | 4.9 | 0.4 | 2.9 | 6.4 |
| Number of observations | 3,154 | | | | |

[a] 200 = Practically devoid, 300 = traces, 400 = slight, 500 = small, 600 = modest, 700 = moderate, 800 = slightly abundant, 900 = moderately abundant.

[b] 4 = Prime, 3 = upper Choice, 2 = lower Choice, 1 = Select, 0 = Standard.

[c] Sensory panel rating assigned ranging from 1 = least desirable to 8 = most desirable.

50% Select price. The Choice-to-Select price spread during the week of September 30, 2007 was $8.50/cwt.

For any carcass whose calculated value based on the applied tenderness discount was lower than a cull-cow price of $121.47/cwt (dressed carcass weight), this price was assigned as a lower bound of what a very tough carcass would be worth.

## Results

Table 2 reports summary statistics of valuing the 3,154 MARC carcasses using three different grids (1) a traditional grid, (2) a 3.8 kg WBSF base tenderness-augmented grid, and (3) a 4.6 kg WBSF base tenderness-augmented grid. The traditional grid serves as a benchmark from which to compare the tenderness-augmented grids. The 3.8 kg tenderness base grid has a net price that, by design, is very similar in magnitude on average to the traditional grid cattle with the traditional grid price being $0.65/cwt higher across all carcasses than the 3.8 kg base grid price. The 4.6 kg tenderness base grid has a net price for all cattle that is just under $7/cwt higher than the traditional grid. Because a 4.6 kg base grid implies much higher prices for fed cattle under a tenderness augmented grid than what current market conditions would likely support, it would likely not be adopted as a viable base by industry. We will focus our discussion on the 3.8 kg base as it is more feasible for adoption given its similar overall average price to traditional grid carcass values.

The tenderness-augmented grid results in considerably greater variation (a standard deviation about twice as large) in carcass value than traditional grids across all carcasses. Referring back to Figure 1, this is not particularly surprising because several upper Choice and many lower Choice grade carcasses have WBSF values of 5 kg or greater, implying a tenderness

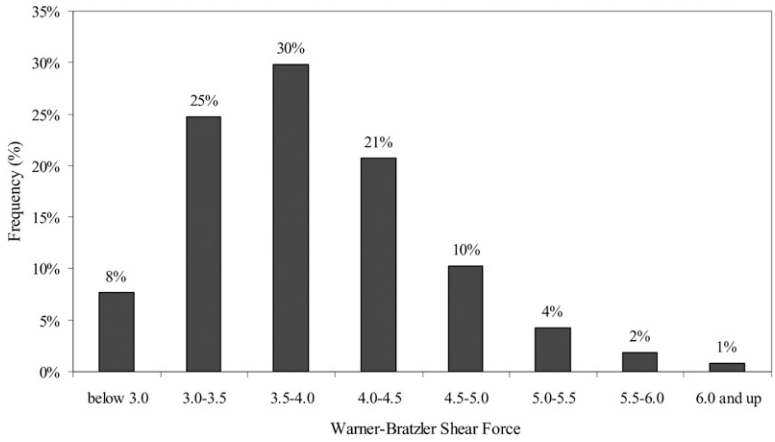


**Figure 2.** Distribution of Warner-Bratzler Shear Force Beef Tenderness Measures for Sample of 3,154 Carcasses

discount on these carcasses of at least $11/cwt with the 3.8 kg tenderness base price.

The tenderness-augmented grid results in premiums on average for higher quality grade carcasses than traditional grid valuation. For example, Prime carcasses on average would receive a $4.42/cwt and upper Choice a $1.18/cwt higher price with the tenderness grid than under the traditional grid. This reflects the fact that many carcasses with higher quality grades

**Table 2.** Summary Statistics of Carcass Valuation for Traditional Grid[a] and Tenderness-Augmented Grid with 3.8[b] kg and 4.6[c] kg Bases

| Quality Grade | Valuation Method | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| | | | ($/cwt carcass weight) | | |
| | Traditional grid | $148.76 | $5.88 | $125.82 | $167.34 |
| All carcasses | 3.8 kg Tender base | $148.09 | $9.28 | $121.47 | $171.44 |
| | 4.6 kg Tender base | $155.43 | $9.40 | $121.47 | $178.82 |
| | Traditional grid | $154.06 | $7.46 | $145.09 | $167.34 |
| Prime | 3.8 kg Tender base | $158.48 | $6.31 | $152.81 | $171.44 |
| | 4.6 kg Tender base | $165.85 | $6.31 | $160.18 | $178.82 |
| | Traditional Grid | $152.27 | $6.88 | $136.90 | $159.15 |
| Upper Choice | 3.8 kg Tender base | $154.09 | $8.62 | $128.52 | $168.16 |
| | 4.6 kg Tender base | $161.46 | $8.62 | $135.90 | $175.54 |
| | Traditional grid | $151.85 | $5.58 | $134.32 | $156.57 |
| Lower Choice | 3.8 kg Tender base | $152.12 | $8.40 | $121.47 | $168.97 |
| | 4.6 kg Tender base | $159.49 | $8.42 | $121.47 | $176.35 |
| | Traditional grid | $145.76 | $3.25 | $125.82 | $148.07 |
| Select | 3.8 kg Tender base | $144.03 | $7.40 | $121.47 | $159.39 |
| | 4.6 kg Tender base | $151.34 | $7.63 | $121.47 | $166.77 |
| | Traditional grid | $138.73 | $0.95 | $136.57 | $139.57 |
| Standard | 3.8 kg Tender base | $134.52 | $6.81 | $121.47 | $148.77 |
| | 4.6 kg Tender base | $141.73 | $7.22 | $121.47 | $156.15 |

[a] Traditional grid refers to carcasses valued based on traditional quality and yield grade grid.

[b] 3.8 kg Tender base refers to carcasses valued using a tenderness-augmented grid with 3.8 kg WBSF as tender base.

[c] 4.6 kg Tender base refers to carcasses valued using a tenderness-augmented grid with 4.6 kg WBSF as tender base.

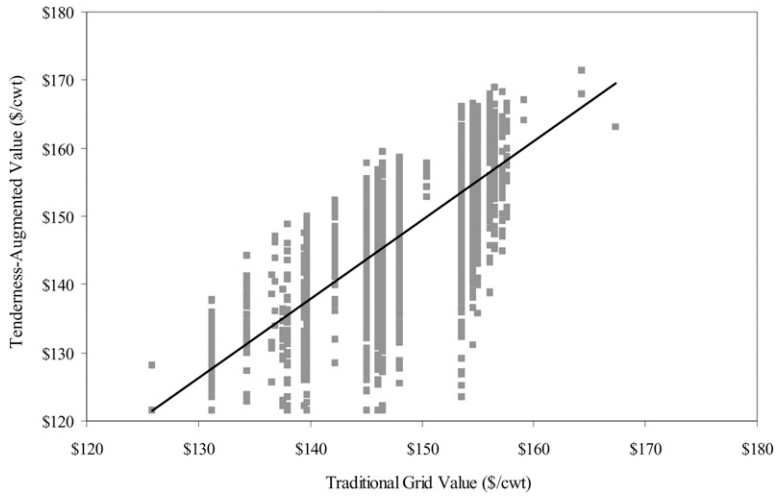


**Figure 3.** Comparison of Traditional Grid and Tenderness-Augmented Valuation at the 3.8 kg WBSF Base

have very tender meat. However, some upper Choice (36%) and lower Choice (43%) carcasses produce less tender meat than many Select grade carcasses and these carcasses would receive tenderness discounts.

A small number of carcasses in the lower Choice grade (0.07%) have such tough meat that they garner tenderness discounts in addition to possible yield grade discounts that would bring their overall carcass value below the cull-cow price of $121.47/cwt and therefore these carcasses were valued at the cull-cow price. Similarly, 1.7% of Select and 2.9% of Standard grade carcasses would garner tenderness discounts, in addition to any quality and yield grade discounts, severe enough to make the carcasses worth the lower limit of the cull-cow price.

A graphic comparison of the 3.8 kg tenderness base with the traditional grid values across all carcasses is illustrated in Figure 3. Each box in Figure 3 represents a carcass. This figure indicates the tenderness-augmented grid would substantially reorder the value of carcasses relative to the traditional grid. Figure 4 shows the distribution of the magnitude of premiums or discounts carcasses valued using the 3.8 kg base tenderness-augmented grid would receive relative to the traditional grid. About 35% of carcasses would receive a premium of more than $2.50/cwt under the tenderness-augmented grid relative to a traditional grid with 7% receiving in excess of $7.50/cwt. However, about 34% of carcasses would receive discounts of $2.50/cwt or more under the tenderness-augmented grid with approximately 14% of carcasses realizing a discount in excess of $7.50/cwt. Overall, the average of the absolute value of price differences between the tenderness-augmented grid with the 3.8 kg base and the traditional grid carcass value across all 3,154 carcasses was $4.98/cwt. This number represents the average price adjustment (up or down) carcasses would receive with a tenderness-augmentation to a traditional grid.

We further break down the premiums and discounts associated with the tenderness-augmented grid by carcass quality grade to illustrate how carcass values would be altered with the tenderness value adjustment within each quality grade. Figure 5 illustrates how carcasses in each quality grade would be revalued with the tenderness adjustment (because the data sample has only 11 Prime carcasses, we did not graph the value adjustment distribution for Prime grade carcasses).

The upper left panel of Figure 5 reveals that for the upper Choice grade, about 25% of carcasses would receive at least a $6.00/cwt higher price with tenderness premiums than under

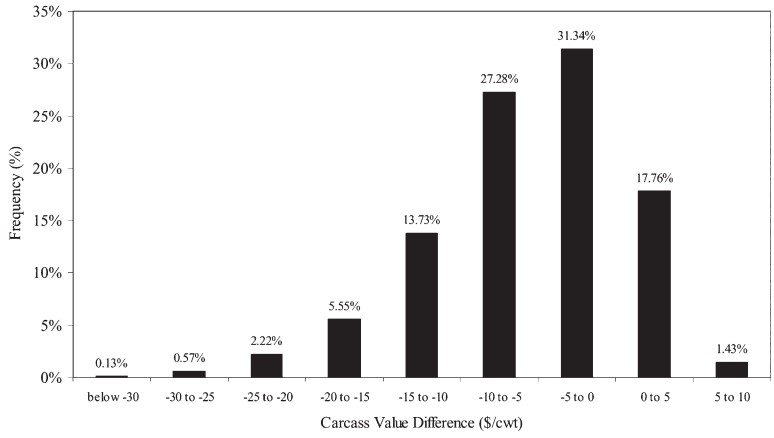


**Figure 4.** Distribution of Carcass Value for 3.8 kg WBSF Base Tenderness-Augmented Minus Traditional Grid

traditional grids. Approximately 24% of upper Choice carcasses would receive a $6.00/cwt or greater discount due to having relatively tough carcasses. Lower Choice carcasses (upper right panel of Figure 5) would also have sizeable value adjustments under a tenderness-augmented grid with about 29% earning a $4.00/cwt or more premium and 20% a $4.00/cwt or larger discount relative to traditional grid valued carcasses. Select (lower left panel of Figure 5) and Standard (lower right panel of Figure 5) carcasses show similar value realignment when

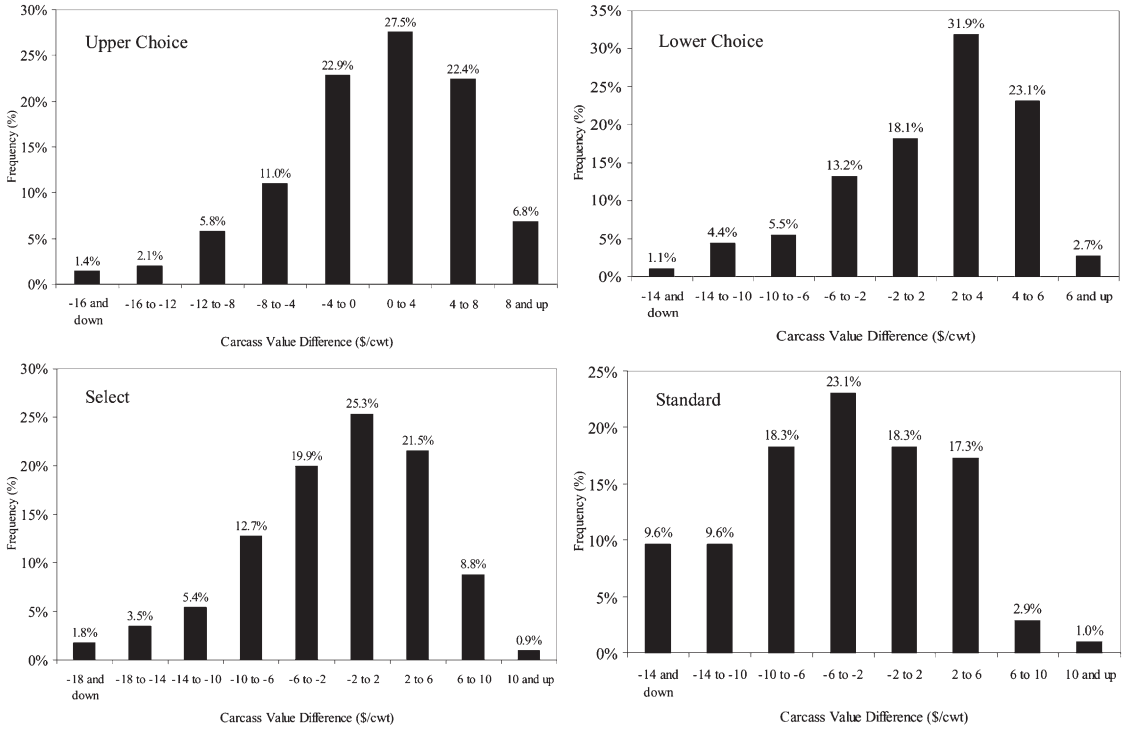


**Figure 5.** Distribution of Tenderness-Augmented Grid (with 3.8 kg base) Minus Traditional Grid for Upper Choice, Lower Choice, Select and Standard Quality Grades

priced using the tenderness grid as compared to the traditional grid.

## Implications and Conclusions

A sample of 3,154 carcasses comprising a wide range of quality grades and tenderness levels were evaluated using traditional grid pricing and a hypothetical tenderness valuation scheme. Often, tender and tough carcasses are considerably undervalued or overvalued using current grid pricing mechanisms relative to their estimated WBSF value. The average of the absolute value of the difference between a tenderness-based valuation system with a 3.8 kg WBSF base and grid pricing for all carcasses in the sample was about $5/cwt dressed weight. Changes in carcass values associated with a tenderness-augmented grid presented here are conditional on our sample of carcasses, selection of the 3.8 kg WBSF for the base price, and the tenderness premium-discount schedule used.

The precise dollar magnitude of value differences between USDA quality grade grid pricing and tenderness based carcass valuation is debatable and not our primary message. We present a tenderness valuation method that extracts tenderness premiums from reported consumer willingness to pay studies. Before any processor would adopt a tenderness grid, they would need to have a market developed for securing beef tenderness premiums downstream in order to offset the cost of testing each carcass for tenderness or have a sufficiently accurate noninvasive prediction of tenderness.

A tenderness-augmented grid would benefit producers who can cost-effectively adopt animal genetic selection strategies and animal management and feeding regiments to produce more tender beef carcasses. A host of animal feeding and management practices have been shown to influence beef tenderness. As such, producers who understand how their management decisions affect tenderness have the greatest potential to directly benefit from a tenderness-augmented grid. Producers who are unable to cost-effectively modify production techniques to target tenderness attributes would realize lower carcass values with a tenderness grid-value adjustment.

The beef industry is gradually beginning to adopt tenderness-based carcass valuation systems. Furthermore, the USDA is in the early process of designing a tenderness standard for beef. This study demonstrates why this is an important direction because USDA quality grades are poor predictors of meat tenderness, a very important trait to consumers. A beef carcass valuation system that incorporates measures of tenderness is much more closely associated with consumer sensory panel ratings of beef tenderness than prevailing USDA quality grades. Tenderness-based carcass valuation systems require objective measures of meat tenderness levels as USDA quality grades are not sufficient to provide an indication of probable meat tenderness. Furthermore, tenderness-based carcass valuation will result in considerable reordering of carcass values relative to USDA quality grades. Many Choice carcasses are overvalued and many Select carcasses are undervalued relative to the tenderness value of their meat.

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