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# Consumer thresholds for establishing the value of beef tenderness

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**ABSTRACT:** In the present study, a national consumer evaluation was conducted for beef tenderness on USDA Select strip loin steaks of known Warner-Bratzler shear (WBS) force values, ranging from tough (>5.7 kg) to tender (<3.0 kg), and to assess the monetary value that consumers place on tenderness by determining the average price a consumer would pay for a steak in three tenderness categories. Three supermarkets in each of five metropolitan areas (Baltimore, MD/Washington D.C.; Chicago, IL; Dallas/Fort Worth, TX; Los Angeles, CA; and Lubbock, TX) were selected to represent a wide range of income, education, and ethnicity at each city. Five trained research teams traveled to the cities to collect data during the same 10-d period. Consumers (n = 734; minimum of 15 consumers/panel, three panels/store, three stores/city, five cities) were asked to evaluate samples from each tenderness classification (tender, intermediate, or tough) for overall and tenderness acceptability, overall quality, beef flavor, juiciness, tenderness, how much they would pay for the steak (\$17.14, 14.28, or 10.98/kg), if they would pay more than current market price if guaranteed tender, and to estimate the number of meals in a 2-wk period that included beef. The consumers were 52% light beef users, consuming 0 to 8 meals containing beef in 2 wk, 41% heavy beef users (greater than 12 meals/2 wk), and

6% moderate beef users (9 to 12 meals/2 wk). Consumer tenderness acceptability increased as WBS values decreased ( $P < 0.05$ ). The transition in consumer perception from tender to tough beef occurred between 4.3 and 4.9 kg of WBS based on  $\geq 86\%$  consumer acceptability. Consumer acceptability for tenderness decreased from 86% at 4.3 kg for a "slightly tender" rating to 59% at 4.9 kg for a "slightly tough" rating. Data from the present study suggested that consumer WBS tenderness values of < 3.0, 3.4, 4.0, 4.3, and > 4.9 kg would result in 100, 99, 94, 86, and 25% customer satisfaction for beef tenderness, respectively. Seventy-eight percent of the consumers would purchase steaks if the retailer guaranteed them to be tender. The retail steak value differences found in this study would result in the opportunity for a premium to be paid for a guaranteed tender (< 3.0 kg WBS value) carcass of \$76.26 vs the toughest (> 5.7 kg) classification. A premium of \$66.96 could be paid to the tender classification carcasses vs the tough (> 4.9 kg) classification carcasses, and a premium of \$36.58 could be paid for the tender classification carcasses vs the intermediate (> 3.0 to < 4.6 kg) classification carcasses. Results from the present study show that consumers can segregate differences in beef tenderness and that consumers are willing to pay more for more-tender beef.

Key Words: Beef, Consumers, Tenderness, Valuation

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## Introduction

Tenderness is the most important factor influencing consumer satisfaction for beef palatability (Savell et al., 1987, 1989; Smith et al., 1987). The ability of con-

sumers to discern varying tenderness levels is essential for establishing the value of beef tenderness. If consumers do not have the ability to select among differences in tenderness, then all efforts to improve the tenderness of beef are of little value. Assuming that consumers can detect variation in beef tenderness, then the need exists to measure and establish the value of tenderness to the marketplace (Boleman et al., 1997). Establishing values associated with varying degrees of beef tenderness will provide the economic incentive for the beef industry to search for, manage, and market tenderness to consumers.

Shackelford et al. (1991) published the first threshold relating Warner-Bratzler shear force values to consumer data. Both Miller et al. (1995) and Huffman

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(1996) found that consumers in home or restaurant settings could differentiate among steaks varying in Warner-Bratzler shear (WBS) force values. Although the studies by Miller et al. (1995) and Huffman (1996) attempted to classify beef into tenderness threshold classes by relating consumer acceptability data to WBS force, these studies were limited in their application to all consumers because they tested a small sample of consumers who resided in one city. The objectives of this study were to conduct a national consumer evaluation of beef tenderness utilizing USDA Select strip loin steaks of known WBS values, ranging from (> 5.7 kg) tough to tender (< 3.0 kg), and to assess the monetary value consumers place on tenderness by determining the average price a consumer would pay for a steak in three tenderness categories.

## Materials and Methods

### *Tenderness Classification*

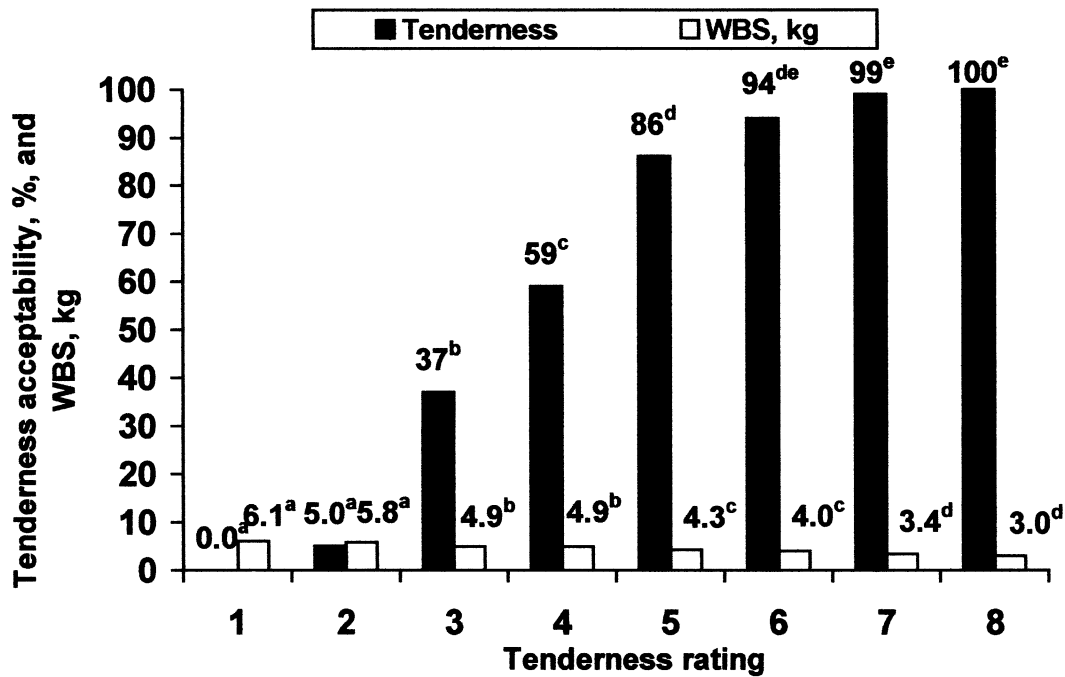
Simbrah steers and heifers of known sire and dam (n = 1,036) were placed in a commercial feedlot, where similar implant and feeding strategies were applied to all cattle. All animals were fed 180 to 210 d before slaughter at a commercial processing facility. Carcasses from the USDA Select quality grade were then selected for use in the study. Strip loins (IMPS #180) were obtained from the carcasses after chilling at 2°C for 48 h and fabricated into 2.5-cm-thick steaks 3 d postmortem. The first four steaks were randomly assigned to 3-, 7-, 14-, and 21-d aging treatments for trained sensory analysis. The next four steaks were randomly assigned to the same aging treatments for WBS force, followed by a 7- and 21-d aged steak for consumer evaluation. Steaks were identified by animal number, aging treatment, and evaluation treatment (sensory, WBS force, or consumer evaluation), vacuum packaged, and cooler aged at 3°C for the appropriate time and then frozen at -20°C. The steaks for WBS force evaluations were broiled on Farberware Open Hearth electric broilers (Bronx, NY) to an internal temperature of 41°C and then turned and cooked to an end point of 71°C internally. The steaks were chilled and wrapped with polyvinyl chloride film for 24 h at 3°C. Six 1.3-cm-diameter cores from each steak were removed parallel to the muscle fiber orientation and sheared once with a WBS instrument (Manhattan, KS) to establish the tenderness of each steak. The average WBS force results for 7- or 21-d aged steaks were used to classify the remaining steaks into tender (WBS ranging from 1.62 to 2.29 kg), intermediate tenderness (3.92 to 4.50 kg), and tough (5.42 to 7.42 kg) categories. The steaks were identified according to their tenderness classification. Steaks within each tenderness classification were removed from frozen storage and randomly assigned to each city and store. Steaks, while still frozen, were vacuum packaged before shipment to each of the five cities for consumer evaluations.

### *Consumer Selection and Tenderness Evaluation*

Five diverse metropolitan areas (Baltimore, MD/Washington D.C.; Chicago, IL; Dallas/Fort Worth, TX; Los Angeles, CA; and Lubbock, TX) were selected to represent a wide range of consumer income, education, and ethnicity for each location. The major supermarket chains in each city were consulted, and the chain with the most diversity of consumers was selected. Corporate supermarket management evaluated the consumer statistics for each store in each metropolitan area in the chain and selected one high-, average-, and low-income store, which met the requirements for diverse education, ethnicity, and income level. Five trained research teams consisting of six persons traveled to the respective metropolitan areas to collect data during the same 10-d period. The teams cooked steaks (as described previously for WBS) at stores of similar income level in each city to the same degree of doneness at the same time on the same day to reduce the variation that could occur among locations. Three panels were served at each store, each panel containing one steak from each tenderness category with the same WBS force ( $\pm 0.5$  kg) between each replication. A total of 734 consumers (minimum of 15 consumers/panel, three panels/store, three stores/city, five cities) sampled two 1-cm cubes (six total cubes for each consumer) from each of three steaks representing tender, intermediate, and tough classifications. Consumers were asked to evaluate samples from each tenderness class (tender, intermediate, and tough). Each consumer evaluated the two cubes from each steak for overall and tenderness acceptability (acceptable or not acceptable), overall quality, beef flavor, juiciness, and tenderness (8 = like extremely, like extremely, extremely juicy, extremely tender; 1 = dislike extremely, dislike extremely, extremely dry, extremely tough). Consumers also were asked how much they would pay for the steak (\$10.98, 14.28, or 17.14/kg) based on the average prices from all stores in all cities for select, choice, and top choice program prices during the time of the study. Each consumer was asked whether they would pay more than the current market price for a steak that was guaranteed tender. Consumers also were asked to estimate the number of meals in a 2-wk period that included beef, whether eaten at home or away from home, to determine whether they were light, moderate, or heavy beef users, to ensure that the consumers in the study were beef eaters.

### *Statistical Analysis*

The data were analyzed as a RBD with city as the block. When no differences were found for stores, stores within cities, or cities, the variation was accounted for in the error term and the data were pooled. Mean WBS values and consumer sensory results for each steak were determined using the PROC GLM and LSM means options of SAS (SAS Inst. Inc., Cary, NC). Means were separated with the PDIF option at a significance level



<sup>a,b,c,d,e</sup> Means with different superscripts differ ( $P < 0.05$ ).

**Figure 1.** Percentage of steaks at each tenderness rating acceptable in tenderness by consumers with corresponding Warner-Bratzler shear (WBS) force values ( $n = 734$ ).

of  $P < 0.05$ . Consumer estimates of the number of meals in a 2-wk period including beef, consumer tenderness, overall acceptability for each steak, and whether they would be willing to pay more for a steak of the same quality grade if guaranteed tender, were analyzed using the chi-square option in SAS (SAS Inst. Inc., Cary, NC) to compare percentages of each response.

## Results and Discussion

The consumers in this study were 52% light beef users, consuming 0 to 8 meals in 2 wk containing beef; 6% moderate beef users (9 to 12 meals); and 41% heavy beef users (greater than 12 meals). Consumers were able to differentiate among New York strip steaks from different WBS categories and could detect differences in tenderness similar to those found by the WBS instrument. Tenderness acceptability by consumers increased as tenderness ratings increased (Figure 1). A high degree of consumer acceptability and higher tenderness ratings were achieved in New York strip steaks with lower WBS values (Figure 1;  $P < 0.05$ ). The transition from tender to tough beef occurred between 4.3 to 4.9 kg of WBS based on percentage of consumer acceptability of  $\geq 86\%$  (Figure 1). The average transition between tough and tender occurred at 4.6 kg of WBS. The percentage of consumer acceptability for tenderness decreased from 86% at 4.3 kg for a “slightly tender” rating to 59% at 4.9 kg for a “slightly tough” rating (Figure 1;  $P < 0.05$ ). Although tenderness acceptability decreased ( $P < 0.05$ ) to 37% for moderately tough, mean WBS did

not change (Figure 1). This decrease in acceptability could be explained by the influence of flavor and juiciness on consumer tenderness ratings, which did differ between slightly and moderately tough (Figure 2;  $P < 0.05$ ). The ability of these consumers to differentiate the degree of tenderness in this fashion is important for the beef industry and its attempt to implement a tenderness threshold classification system that would pay premiums for the more tender carcasses. Data presented in Figure 1 show that a WBS threshold of  $< 3.0$  kg would result in 100% consumer acceptability for beef steak tenderness and that a WBS value of 3.4, 4.0, and 4.3 kg would result in 99, 94, and 86% customer satisfaction for tenderness, respectively ( $P < 0.05$ ). The data collected from the 734 consumers in the present research study show that the beef industry could apply the recommendation of Wheeler et al. (1997) in setting different tenderness threshold categories to meet different consumer tenderness expectations. Steaks having WBS values of 4.0 kg or less were all the same ( $P > 0.05$ ) for consumer tenderness acceptability ratings 6, 7, and 8, having 94, 99, and 100% tenderness acceptability. Data from this study suggest tenderness threshold classes of  $< 3.0$ , 3.0 to 4.3, and  $> 4.9$  kg WBS would result in 100, 93, and 25% customer satisfaction for beef New York strip steak tenderness, respectively ( $P < 0.05$ ). An interesting finding in this study was that a high number of consumers rated “slightly” (59%) and “moderately tough” (37%) beef acceptable for tenderness (Figure 1). The overall acceptability ratings shown in Figure 3 indicated a 70% consumer acceptance rate

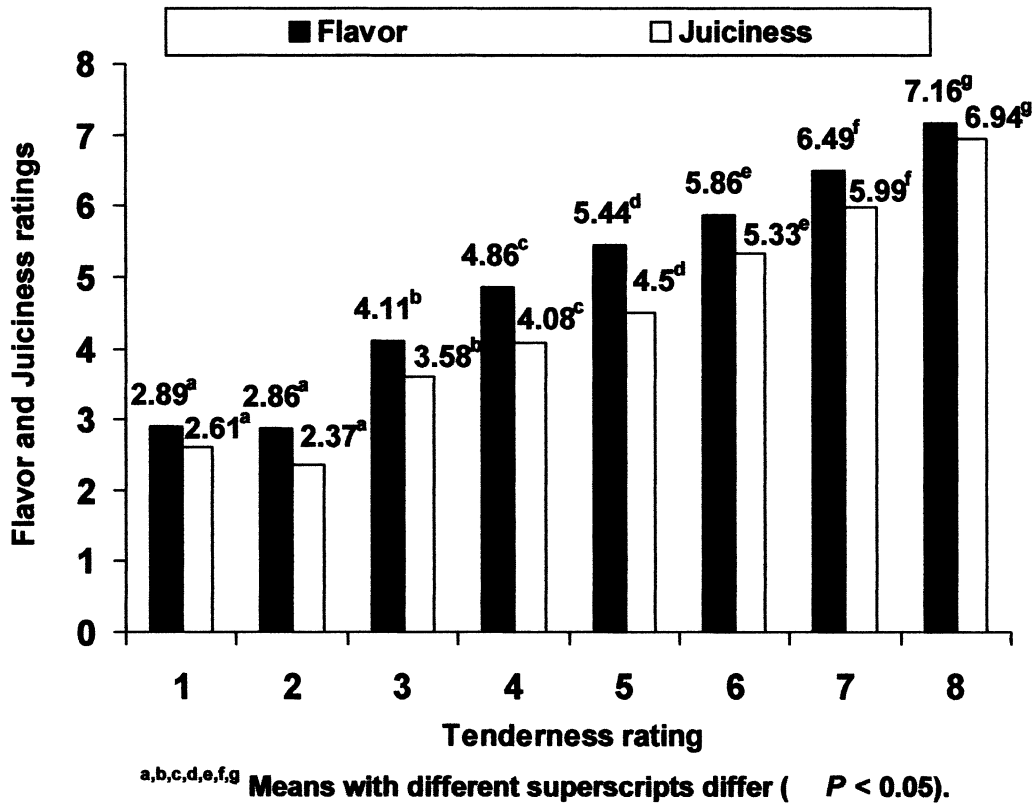


Figure 2. Relationship of flavor and juiciness ratings to corresponding tenderness ratings by consumers (n = 734).

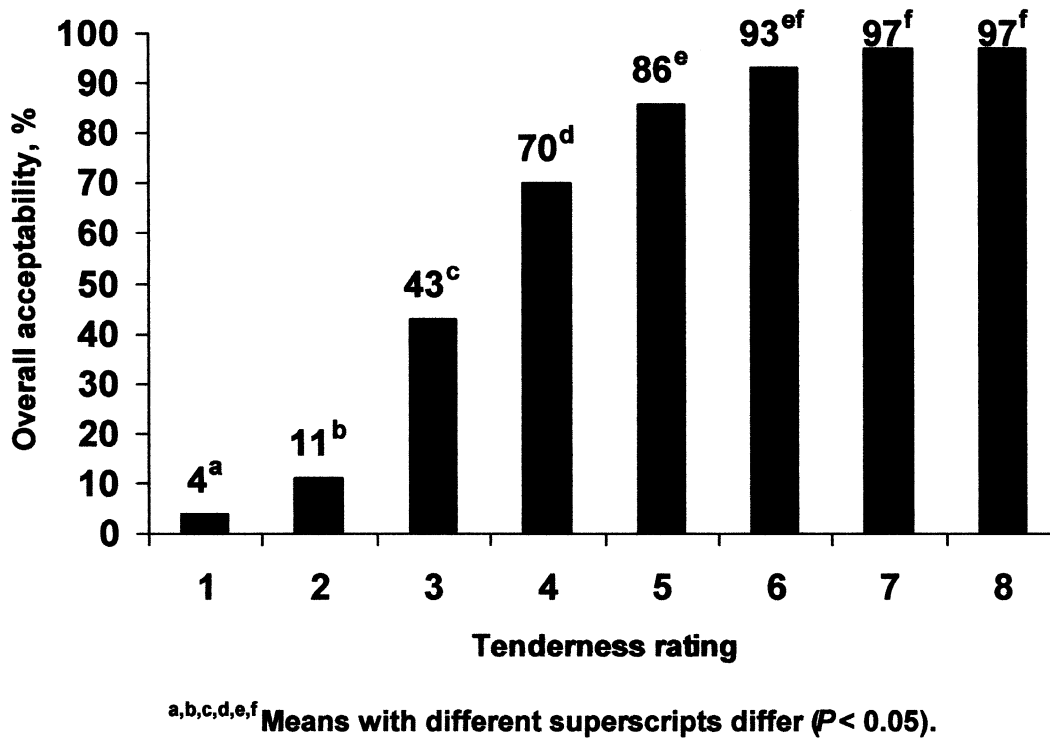
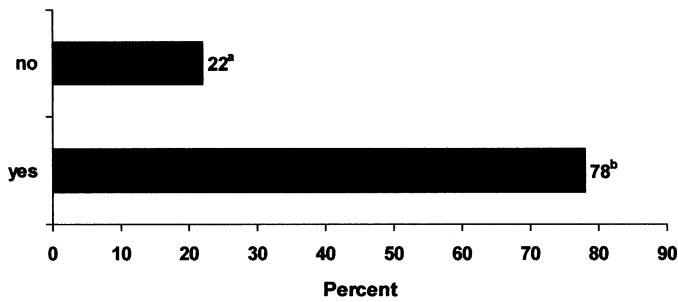


Figure 3. Percentage of steaks rated acceptable in overall palatability by consumers (n = 734).



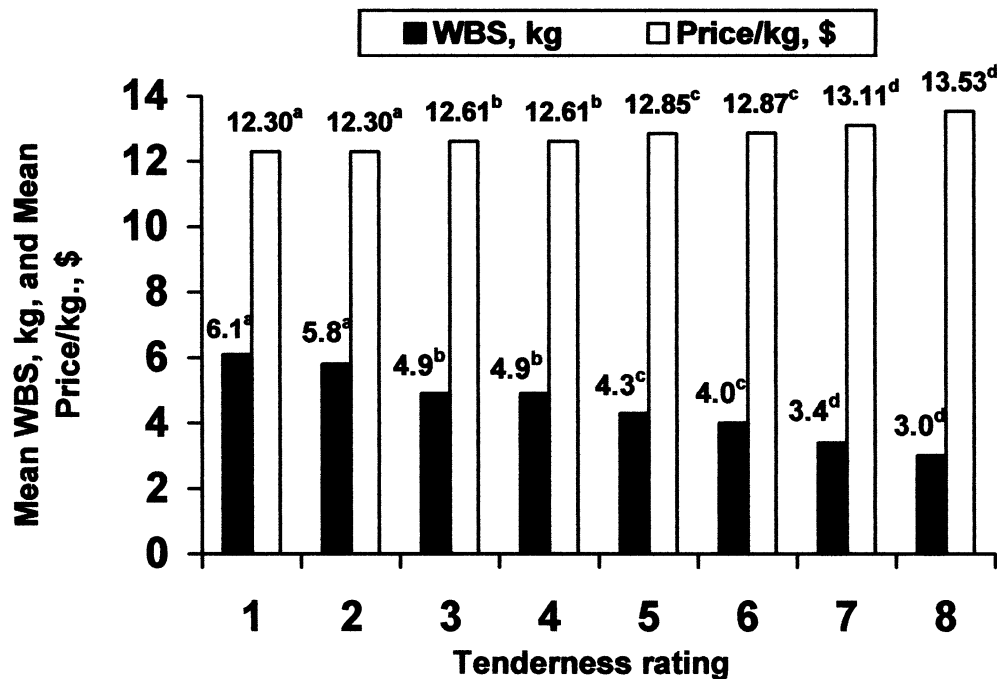
<sup>a,b</sup>Means with different superscripts differ ( $P < 0.05$ ).

**Figure 4.** Percentage of consumers willing to pay more per pound for a guaranteed tender steak at retail ( $n = 734$ ).

for “slightly tough” beef (4 on the tenderness scale) and show that other factors (juiciness and flavor) may contribute to the consumer acceptability of beef, or that not all consumers can detect differences in tenderness. Miller et al. (1995) and Neely et al. (1998) reported that all consumers may not require the same tenderness in beef to be satisfied and that either beef flavor or juiciness may influence their perception of tenderness and their overall acceptability ratings. Results from the present study show the tenderness acceptability (Figure 1) was significantly affected by juiciness and flavor (Figure 2) when WBS remained the same. The impact of juiciness and flavor became increasingly important to beef consumer satisfaction when tenderness was not

acceptable. Therefore, the suggested WBS tenderness threshold classes from the present study are  $< 3.0$  kg for 100% consumer tenderness acceptability, 3.0 to 4.6 kg (the average transition in kilograms between slightly tender and slightly tough) for 93% consumer tenderness acceptability and  $> 4.6$  kg. The final tenderness classification (tough) would require some additional tenderization treatment (blade tenderization or  $\text{CaCl}_2$  enhancement) before retailing the meat to consumers.

The data from this nationwide study clearly established that consumers could differentiate among tenderness levels. The ability of the beef industry to use different tenderness thresholds and to assign different values that consumers are willing to pay for steaks of varying tenderness is very important. Seventy-eight percent of the consumers said they would purchase steaks if the retailer guaranteed them to be tender (Figure 4). These findings support and agree with the findings of Boleman et al. (1997). To determine the value consumers associated with tender vs tough beef, consumers were asked to choose a price they would be willing to pay for each steak they sampled (\$17.14, 14.28, or 10.98/kg). All steaks were of the USDA Select quality grade. The average price for each steak was calculated and a value determined for each WBS force tenderness threshold category (Figure 5). Steaks in the tender classification (100% tenderness acceptability rating, Figure 1) having WBS values  $< 3.0$  kg had a value of \$13.53/kg assigned by consumers at retail (Fig-



<sup>a,b,c,d</sup>Means with different superscripts differ ( $P < 0.05$ ).

**Figure 5.** Relationship of Warner-Bratzler shear (WBS) force values and price relationships of steaks to tenderness ratings by consumers ( $n = 734$ ).

$$\begin{aligned}
 &341 \text{ kg carcass weight} \times 26\% \text{ rib and loin yield} = 88 \text{ kg rib and loin} \\
 &88 \text{ kg} \times 70\% \text{ yield of steaks from rib and loin} = 62 \text{ kg saleable steaks} \\
 &\$13.53 - \$12.30 = \$1.23 \text{ difference in price between steaks with } >5.8 \text{ kg WBS value (toughest) and tender steaks} \\
 &\quad (<3.0 \text{ kg WBS value}) \\
 &\$13.53 - \$12.45 = \$1.08 \text{ difference in price between steaks with } >4.9 \text{ kg WBS value (tough) and tender steaks} \\
 &\quad (<3.0 \text{ kg WBS value}) \\
 &\$13.53 - \$12.94 = \$0.59 \text{ difference in price between steaks from } >3.4 \text{ to } \geq 4.6 \text{ kg WBS value (intermediate) and} \\
 &\quad \text{tender steaks } (<3.0 \text{ kg WBS value}) \\
 &62 \text{ kg saleable retail steaks} \times \$1.23 = \$76.26 \text{ margin/carcass for tender vs toughest steaks} \\
 &62 \text{ kg} \times \$1.08 = \$66.96 \text{ margin/carcass for tender vs tough steaks} \\
 &62 \text{ kg} \times \$0.59 = \$36.58 \text{ margin/carcass for tender vs intermediate steaks}
 \end{aligned}$$

**Figure 6.** Calculations used to determine the value differences among tenderness thresholds for the assignment of value premiums to more-tender beef carcasses. WBS = Warner-Bratzler shear force.

ure 5). The intermediate classification (86% tenderness acceptability rating, Figure 1) had a WBS value ranging from  $> 3.0$  to  $< 4.6$  kg and had a value of \$12.94/kg assigned by consumers at retail (Figure 5). The tough classification had a WBS value  $> 4.9$  kg and had a value of \$12.45/kg. The lowest value (\$12.30/kg) given was for the steaks rated either a 1 or 2 tenderness rating (very or extremely tough, Figure 5). These two categories had only an average 2.5% tenderness acceptability rating (Figure 1). The value difference between the tender ( $< 3.0$  kg WBS) and intermediate classifications ( $> 3.0$  and  $\leq 4.6$  kg) is \$0.59/kg (Figure 5). The difference between the tender and tough classifications ( $> 4.9$  kg) is \$1.08/kg. The value difference between the tender classification ( $< 3.0$  kg) and the toughest beef classification ( $> 5.7$  kg) is \$1.23/kg (Figure 5). The consumers were able to reflect a value relationship among tenderness threshold classifications. The \$1.23/kg (toughest), \$1.08/kg (tough), and \$0.59/kg (intermediate) retail value difference between the most tender and the toughest, tough, and intermediate beef tenderness threshold classifications would allow the beef industry to segment beef into tenderness classifications. The retail steak value differences found in this study would result in the opportunity for a premium to be paid to a guaranteed-tender ( $< 3.0$  kg WBS value) carcass of \$76.26 vs the toughest ( $> 5.7$  kg) classification (Figure 6). The premiums calculated for the carcasses represent only the differences associated with the value of the rib and loin. A premium of \$66.96 could be paid to the tender classification vs the tough classification carcasses and a premium of \$36.58 could be paid for the tender classification vs the intermediate classification carcasses. These data show that consumers can determine value differences of various beef tenderness threshold classifications and that the beef industry could implement a tenderness-based sorting system that reflects the value of tenderness to the consumer

at retail by using a method of tenderness prediction at the point of carcass segregation prior to fabrication and packaging.

## Implications

The beef industry consistently produces steaks of the same quality grade that vary in tenderness. The industry currently produces about 15 to 20% tough steaks that are sold to consumers. The present study showed consumers could differentiate between steaks of different Warner-Bratzler shear force levels and were willing to pay a higher price for more tender steaks of the same USDA quality grade. Consumers were able to assign added value to more tender steaks, showing the potential for the beef industry to pay premiums to producers who select for more tender beef. Consumer perceptions of beef flavor and juiciness have a greater impact on consumer overall acceptability levels of New York strip steaks as the Warner-Bratzler shear force and toughness levels increase. As beef steaks become tougher, flavor and juiciness have a greater effect on consumer satisfaction. Finally, consumers can segregate differences in beef tenderness and are willing to pay more for more-tender beef.

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