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# National Beef Tenderness Survey–2022: Consumer Sensory Panel Evaluations and Warner-Bratzler Shear Force of Beef Steaks From Retail and Foodservice

Ayleen A. Gonzalez[1], E. Paige Williams[1], Trent E. Schwartz[1], Ashley N. Arnold[2], Davey B. Griffin[1], Rhonda K. Miller[1], Kerri B. Gehring[1], J. Chance Brooks[3], Jerrad F. Legako[3], C. Chad Carr[4], Gretchen G. Mafi[5], Carol L. Lorenzen[6], Robert J. Maddock[7], and Jeffrey W. Savell[1]*

[1]Department of Animal Science, Texas A&M AgriLife Research, Texas A&M University, College Station, TX 77843, USA
[2]Texas A&M Veterinary Medical Diagnostic Laboratory
[3]Department of Animal and Food Sciences, Texas Tech University, Lubbock, TX 79409, USA
[4]Department of Animal Sciences, University of Florida, Gainesville, FL 32611, USA
[5]Division of Animal Science, Oklahoma State University, Stillwater, OK 74078, USA
[6]Division of Animal and Rangeland Sciences, Oregon State University, Corvallis, OR 97331, USA
[7]American Meat Sciences Association
*Corresponding author. Email: j-savell@tamu.edu (Jeffrey W. Savell)

**Abstract:** Beef retail steaks from establishments across 11 US cities and beef foodservice steaks from establishments in 6 US cities were evaluated by consumer sensory evaluations and Warner-Bratzler shear (WBS) force analyses. The retail tenderloin had the lowest ($P < 0.05$) WBS force value compared to other retail cuts. The retail steak with the greatest ($P < 0.05$) WBS force value was the top sirloin. Foodservice ribeye and top loin steaks had greater ($P < 0.05$) WBS force values compared to the tenderloin. All retail top blade, bone-in ribeye, Porterhouse, and tenderloin steaks were categorized as "very tender" (<31.4 N). There were no ($P > 0.05$) differences in WBS force values among USDA quality grade groups for foodservice steaks. Retail tenderloin steaks received the highest ($P < 0.05$) consumer rating for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike compared to all other retail cuts. There were no ($P > 0.05$) differences among the 4 foodservice cuts for consumer sensory ratings of overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. There were no ($P > 0.05$) USDA quality grade differences for ribeye, top loin, top sirloin, and tenderloin foodservice steaks for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. Regardless of source (foodservice or retail), USDA grade group, or beef cut, measures of tenderness in this survey reveal ratings and values that should meet most consumer expectations in the marketplace.

**Key words:** beef, consumer panels, market survey, tenderness, Warner-Bratzler shear force
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## Introduction

The National Beef Tenderness Survey (NBTS)–2022 is the sixth such study conducted over the past 3 decades to evaluate beef palatability in the United States (Morgan et al., 1991; Brooks et al., 2000; Voges et al., 2007; Guelker et al., 2013; Martinez et al., 2017). These surveys have been a valuable resource for the beef industry by documenting retail and foodservice palatability data on an ongoing basis.

Tenderness is one of the leading factors influencing consumer satisfaction, as reported in the Beef Customer Satisfaction studies (Neely et al., 1998; Lorenzen et al., 1999; Neely et al., 1999; Savell et al., 1999). Tenderness is often credited as the most important factor affecting the overall steak acceptability (Dikeman, 1987). The NBTS is a recurring study that benchmarks the

tenderness of U.S. retail and foodservice beef steaks approximately every 5 y. On behalf of the National Cattlemen's Beef Association, Texas A&M University led a collaborative effort with Oklahoma State University, University of Florida, University of Missouri, Oregon State University, Texas Tech University, and North Dakota State University to conduct the 2022 survey.

There were 3 principal changes in how this survey was conducted. In our previous work (Morgan et al., 1991; Brooks et al., 2000; Voges et al., 2007; Guelker et al., 2013; Martinez et al., 2017), steaks from the round primal were included. It was concluded that round steaks needed additional assistance in reducing Warner-Bratzler shear (WBS) force values and increasing consumer acceptance (Morgan et al., 1991; Brooks et al., 2000; Voges et al., 2007; Guelker et al., 2013; Martinez et al., 2017). Even with utilizing different cooking methods (e.g., moist heat) to aid in reducing WBS force values, steaks from the round primal continuously possessed lower consumer acceptance, and in consultation with the funding agency, we decided to omit round steaks for the 2022 survey. Our thought was that research should be focused on improving the tenderness of retail cuts from the round rather than collecting more information about the differences in tenderness compared to the rib and loin retail cuts. After the second NBTS, tenderloin steaks were removed from the selection list, but tenderloins were reintroduced for both retail and foodservice collections in 2022 to gauge their relative tenderness to other cuts and to see whether, in fact, they may be considered as "too tender" by consumers. In past surveys, data on postmortem aging were collected from retail stores' backroom refrigerated storage (Morgan et al., 1991; Brooks et al., 2000; Voges et al., 2007; Guelker et al., 2013; Martinez et al., 2017); however, postmortem aging information was not obtained for the 2022 survey because of the increasing difficulty to obtain such information.

The primary objectives of the NBTS-2022 were (1) to establish a new benchmark of tenderness and other sensory attributes of retail and foodservice steaks using WBS force and consumer sensory panel and (2) to collect supplementary information from packaging about branding, claims, quality grade, and other marketing strategies of steaks sold in the U.S.

## Materials and Methods

### *Retail product selection*

Eleven cities—Atlanta, GA; Chicago, IL; Denver, CO; Houston, TX; Kansas City, MO; Las Vegas, NV; Los Angeles, CA; New York, NY; Philadelphia, PA; Seattle, WA; and Tampa, FL—were sampled by Texas A&M University, Oklahoma State University, University of Florida, Oregon State University, Texas Tech University, and North Dakota State University from October 2021 through February 2022. Cities were chosen to represent a broad geographical range while also upholding historical association with cities that have been used in former NBTS. Representatives from the retail marketing team from the National Cattlemen's Beef Association assisted in compiling the retail chains and wholesale clubs that were surveyed. The selected retail chains within each city were chosen to represent at least one-third the total area market share for each city. Two or three retail chains were selected, with four stores per chain being sampled, resulting in 8 to 12 supermarket stores per metropolitan area. To represent the consumer demographics within a given region, retail stores represented high, medium, and low economic markets. Retail membership club chains were sampled in each city, even if not included in the top one-third of the total area market share.

The following cuts were sampled from the retail case. Corresponding Universal Product Codes (UPC) (Industry-Wide Cooperative Meat Identification Standards Committee, n.d.) are shown parenthetically: Top blade steak (UPC 1144); Ribeye steak, lip on, boneless (UPC 1203); Ribeye steak, lip on, bone-in (UPC 1197); Top loin steak, boneless (UPC 1404); Top loin steak, bone-in (UPC 1398); T-bone steak (UPC 1369); Porterhouse steak (UPC 1330); Top sirloin steak, boneless, cap off (UPC 1426); and Tenderloin steak, side muscle off, defatted (UPC 1190).

Following collection, steaks were shipped to the Rosenthal Meat Science and Technology Center at Texas A&M University, College Station, Texas in insulated containers using a standardized shipping protocol (Gonzalez, 2022). Upon arrival, steaks were stored (2 to 4°C), and within 2 d of arrival, all packaging information, including branding, quality grade, tenderization, enhancement, and other marketing claims, was recorded. Then, steaks were removed from store packaging, and if steaks were greater than or equal to 5 cm in thickness, they were portioned into 2 equally thick pieces. If steaks were greater than approximately 20 cm in width, they were portioned into separate steaks. External fat and steak thicknesses were measured by calculating the average of 3 different locations to represent the entire steak. All steaks were individually identified, vacuum packaged, and stored in a −40°C freezer.

Retail cuts were grouped by steak type and randomly assigned to consumer sensory panel (approximately 60%) or WBS force evaluation (approximately 40%). Each retail consumer panel steak was assigned a random, non-repeating, three-digit code using Microsoft Excel with a number generator formula. Consumer panel steaks were divided among Texas A&M University, Oklahoma State University, Texas Tech University, University of Florida, and North Dakota State University. Retail consumer panel steaks were shipped to each designated university in insulated containers with refrigerant material.

### Foodservice product selection

For foodservice, U.S. Department of Agriculture (2020) Institutional Meat Purchase Specifications (IMPS) descriptions were used to procure the following: Ribeye steak, lip-on, boneless (IMPS 1112A); Strip loin steak, boneless (IMPS 1180); Top sirloin butt steaks, boneless (IMPS 1184); and Tenderloin steak, side muscle off, defatted (IMPS 1190). When available, 8 steaks within each 4 USDA quality grade/brand category (Prime, Top Choice, Choice, and Select) were purchased from foodservice purveyors in 6 cities: Atlanta, GA; Auburndale, FL; Denver, CO; Edison, NJ; Houston, TX; and Las Vegas, NV. Steaks were shipped directly to Texas A&M University, College Station, Texas.

Steaks were measured, assigned to subsequent WBS force or consumer sensory evaluations, vacuum packaged, frozen (−40°C), and stored. All foodservice steaks were shipped in insulated containers with refrigerant material to the University of Missouri, Columbia, Missouri, for consumer sensory and WBS force evaluations.

### Cookery method

All collaborating universities followed the same cooking protocol. All frozen steaks were thawed at 4°C for 48 h before cooking. Grated, non-stick electric grills were used to cook all retail steaks. Grills were pre-heated for 15 min to reach an approximate surface temperature of 177°C. Garland™ gas grills (Garland Commercial Ranges Ltd, Mississauga, Ontario, Canada) were used to cook all the foodservice steaks, and grills were pre-heated until the surface temperature reached approximately 232°C. To monitor the internal temperature of steaks, a thermocouple reader (Omega™ HH506A, Stamford, CT) with a 0.02-cm diameter copper-constantan Type-T thermocouple wire was inserted into the geographic center of the steak. All steaks were flipped at 35°C internal temperature and removed from the grill once the internal temperature reached 70°C. Before and after cooking, all steaks were weighed to record raw and cooked weights to calculate cook yields. In addition, cook times were determined by recording the time each steak was placed on and removed from the cooking surface. Cook times and cook yields are reported in Gonzalez (2022). Cooked sensory panel steaks were placed, when necessary, in an Alto-Shaam warmer set at 60°C for no longer than 20 min before serving to panelists. Steaks for WBS force evaluation were placed on trays to avoid overlapping, covered with clear plastic wrap, and stored at 2 to 4°C for 12 to 18 h.

### Warner-Bratzler shear force

Steaks were removed from the cooler (2 to 4°C), allowed to equilibrate to room temperature, and trimmed of visible connective tissue to expose the muscle fibers' orientation. At least six 1.3-cm cores were removed parallel to the muscle fibers using a handheld coring device. Cores were removed from the *M. longissmus thoracis* from the ribeye steaks and from the *M. gluteus medius* from the top sirloin steaks. For T-bone and Porterhouse steaks, 6 cores were removed from the *M. longissimus lumborum* and 4 cores from the *M. psoas major*. Cores were sheared once, perpendicular to the muscle fibers, using the TMS-Pro Food Texture Analyzer (Food Technology Corporation, Sterling, Virginia) at a crosshead speed of 200 mm/min using a 250 N load cell and a 1.02-cm-thick V-shaped blade with a 60° angle and a half-round peak.

### Consumer panels

The 6 collaborating universities recruited panelists from their surrounding communities. All panelists signed a consent form and completed a demographic questionnaire (Table 1) and consumption pattern survey (Table 2). Cooked steaks were portioned (1.27 cm × 1.27 cm × steak thickness), and each panelist received 2 pieces of each steak. Nabisco Unsalted Tops Premium Saltine Crackers (Kraft Foods Global, Inc., East Hanover, NJ) and double-distilled deionized water were used as palate cleansers between samples. Panelists were served up to 8 random steak samples. Steaks were characterized for overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely;

**Table 1.** Demographic attributes of retail panelists ($n = 541$, combined universities[1]) and foodservice[2] panelists ($n = 104$)

| Item | Retail panel frequency (%) | Foodservice panel frequency (%) |
|---|---|---|
| **Gender** | | |
| Male | 46.6 | 61.6 |
| Female | 53.0 | 38.5 |
| **Age, y** | | |
| <20 | 8.7 | 21.2 |
| 21 to 25 | 20.6 | 25.0 |
| 26 to 35 | 24.7 | 20.2 |
| 36 to 45 | 16.8 | 13.5 |
| 46 to 55 | 13.3 | 11.5 |
| 56 to 65 | 12.9 | 2.9 |
| ≥66 | 2.8 | 5.8 |
| **Current working status** | | |
| Not employed | 3.8 | 8.7 |
| Full-time | 53.3 | 39.4 |
| Part-time | 9.8 | 13.5 |
| Student | 33.1 | 38.5 |
| **Income, US$** | | |
| <25,000 | 23.0 | 26.0 |
| 25,000 to 49,999 | 19.9 | 24.0 |
| 50,000 to 74,999 | 18.2 | 10.6 |
| 75,000 to 99,000 | 12.7 | 17.3 |
| ≥100,000 | 25.1 | 21.2 |
| **Food allergy or dietary restrictions?** | | |
| No | 93.6 | 95.2 |
| Yes | 6.3 | 3.9 |
| **Do you or any of your immediate family work for a market research firm, advertising firm, or food manufacturing company?** | | |
| No | 95.6 | 95.2 |
| Yes | 3.7 | 4.8 |
| **Ethnic background** | | |
| Caucasian | 64.3 | 82.7 |
| Hispanic | 20.1 | 5.8 |
| Asian or Pacific | 8.9 | 5.8 |
| Black | 3.6 | 2.9 |
| American Indian | 1.8 | – |
| Other | 1.3 | – |
| **Do you eat meat?** | | |
| No | 0.2 | – |
| Yes | 99.3 | 100 |

[1]Retail panels were conducted at Texas A&M University, Oklahoma State University, Texas Tech University, University of Florida, and North Dakota State University.

[2]Foodservice panels were conducted at the University of Missouri.

**Table 2.** Consumer panelists' consumption patterns for the retail (combined universities[1], $n = 541$) and foodservice[2] ($n = 104$) panels

| Item | Retail panel frequency (%) | Foodservice panel frequency (%) |
|---|---|---|
| **Meat types consumed** | | |
| Chicken | 97.0 | 99.0 |
| Pork | 91.9 | 99.0 |
| Beef | 99.1 | 99.0 |
| Fish | 88.5 | 93.3 |
| **Overall beef consumption** | | |
| Daily | 8.6 | 6.7 |
| 5 or more times per wk | 14.7 | 11.5 |
| 3 or more times per wk | 42.7 | 53.9 |
| 1 time per wk | 25.9 | 20.2 |
| 1 time every 2 wk | 5.3 | 4.8 |
| Less than once every 2 wk | 2.8 | 1.9 |
| **At home beef consumption** | | |
| 0 times per wk | 4.5 | 1.9 |
| 1 time per wk | 25.9 | 15.4 |
| 2 times per wk | 25.7 | 31.7 |
| 3 times per wk | 24.6 | 35.6 |
| 4 times per wk | 9.7 | 8.7 |
| 5 or more times per wk | 9.7 | 6.7 |
| **In restaurant beef consumption** | | |
| 0 times per wk | 9.0 | 9.6 |
| 1 time per wk | 40.9 | 45.2 |
| 2 times per wk | 26.3 | 21.6 |
| 3 times per wk | 15.0 | 11.5 |
| 4 times per wk | 4.7 | 4.8 |
| 5 or more times per wk | 4.1 | 5.8 |
| **Degree of doneness** | | |
| Rare | 6.8 | 2.9 |
| Medium rare | 29.7 | 21.2 |
| Medium | 7.7 | 1.9 |
| Medium well | 38.1 | 58.7 |
| Well done | 17.6 | 14.4 |
| **Purchase tendencies for beef** | | |
| Grass-fed | 17.7 | 9.6 |
| Traditional | 70.4 | 75.0 |
| Aged | 5.6 | 2.9 |
| Organic | 6.4 | – |

[1]Retail panels were conducted at Texas A&M University, Oklahoma State University, Texas Tech University, University of Florida, and North Dakota State University.

[2]Foodservice panels were conducted at the University of Missour

1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1 = dislike extremely).

## *Statistical analysis*

Sensory panel and WBS force data for foodservice steaks and sensory panel data for retail steaks were submitted by collaborating universities to Texas A&M

University for data entry and analysis. Retail and foodservice data were analyzed and reported separately.

Data were analyzed utilizing JMP Pro (v. 15.2.1; SAS Institute, Cary, NC). The Fit *Y* by *X* function was used for one-way analysis of variance, and mean comparisons were conducted using Student's *t* test and an alpha of <0.05. Data were generated and reported by steak for retail and steak or USDA quality grade for foodservice. For Fit *Y* by *X*, the "*Y*, response" variable was the effect being analyzed, and "*X*, factor" was the steak or USDA Quality Grade. Frequency distribution was used to analyze percentages of steaks stratified into previously defined tenderness classes (Shackelford et al., 1991; Belew et al., 2003).

# Results and Discussion

## Product branding

Thirty different retail/wholesale chains were sampled. Approximately 66.4% of retail packages contained a form of branding, and 55.9% possessed a marketing claim. This is a numerical increase from the survey by Martinez et al. (2017), where only 34.5% of retail packages included any form of branding or marketing claim. This survey also reported the greatest amount of retail packages with store branding depicted compared to past NBTS, with the previous highest amount reported by Guelker et al. (2013) of 64%. Additionally, 40.7% of foodservice steak packaging included a brand logo, of which 77.1% was Certified Angus Beef. Approximately 27.9% of foodservice steaks were mechanically tenderized, which is a common form of tenderization in this channel.

## Product characteristics

Steak thickness, external fat thickness, and steak weights for retail and foodservice steaks are reported in Table 3. Historically, the thickest retail steak cuts came from the rib or loin primal. This remains true for this current survey, as the thickest retail cut was the tenderloin from the loin primal at 3.31 cm, whereas the thinnest cut ($P < 0.05$) was from the chuck primal (top blade, 1.85 cm). Retail bone-in top loin steaks had more ($P < 0.05$) external fat (0.47 cm) compared to the tenderloin steaks (0.12 cm). In addition, the Porterhouse steaks were heaviest ($P < 0.05$) with a mean weight of 0.59 kg, whereas the lightest ($P < 0.05$) retail steak was the top blade with a mean weight of 0.14 kg.

For foodservice steaks, the tenderloin was the thickest ($P < 0.05$) steak, at 4.85 cm. In the most recent survey, Martinez et al. (2017), the thickest ($P < 0.05$) foodservice steak was the ribeye at 2.91 cm; however, in this survey, the ribeye steak was the thinnest ($P < 0.05$) at 2.55 cm. This differs from Guelker et al. (2013) where there were no ($P > 0.05$) differences in steak thickness for ribeye, top loin, and top sirloin cuts. Foodservice tenderloin and top sirloin steaks had the

**Table 3.** Least-squares means ± SE from retail and foodservice establishments for steak thickness, external fat thickness, and steak weights stratified by steak within source

| Source/steak | *n* | Steak thickness, cm | | External fat thickness, cm | | Steak weight, kg | |
|---|---|---|---|---|---|---|---|
| **Retail** | | | | | | | |
| Top blade | 74 | 1.85$^{g}$ | (± 0.11) | 0.14$^{d}$ | (± 0.04) | 0.14$^{g}$ | (± 0.02) |
| Ribeye, lip on, boneless | 278 | 2.85$^{c}$ | (± 0.04) | 0.36$^{b}$ | (± 0.01) | 0.41$^{c}$ | (± 0.01) |
| Ribeye, lip on, bone-in | 98 | 2.63$^{d}$ | (± 0.06) | 0.37$^{b}$ | (± 0.02) | 0.50$^{b}$ | (± 0.01) |
| Top loin, boneless | 338 | 2.96$^{b}$ | (± 0.03) | 0.44$^{a}$ | (± 0.01) | 0.36$^{d}$ | (± 0.01) |
| Top loin, bone-in | 54 | 2.40$^{ef}$ | (± 0.08) | 0.47$^{a}$ | (± 0.03) | 0.37$^{d}$ | (± 0.01) |
| T-bone | 35 | 2.52$^{de}$ | (± 0.10) | 0.41$^{ab}$ | (± 0.03) | 0.49$^{b}$ | (± 0.02) |
| Porterhouse | 82 | 2.58$^{de}$ | (± 0.07) | 0.46$^{a}$ | (± 0.02) | 0.59$^{a}$ | (± 0.01) |
| Top sirloin, boneless, cap off | 471 | 2.27$^{f}$ | (± 0.05) | 0.27$^{c}$ | (± 0.02) | 0.28$^{e}$ | (± 0.01) |
| Tenderloin | 232 | 3.31$^{a}$ | (± 0.08) | 0.12$^{d}$ | (± 0.03) | 0.23$^{f}$ | (± 0.01) |
| *P* value | | <0.0001 | | <0.0001 | | <0.0001 | |
| **Foodservice** | | | | | | | |
| Ribeye | 174 | 2.55$^{c}$ | (± 0.04) | 0.34$^{b}$ | (± 0.01) | 0.35$^{a}$ | (± 0.00) |
| Top loin | 156 | 2.98$^{b}$ | (± 0.04) | 0.44$^{a}$ | (± 0.01) | 0.34$^{b}$ | (± 0.00) |
| Top sirloin | 82 | 2.66$^{c}$ | (± 0.06) | 0.02$^{c}$ | (± 0.02) | 0.23$^{c}$ | (± 0.00) |
| Tenderloin | 188 | 4.85$^{a}$ | (± 0.04) | 0.00$^{c}$ | (± 0.01) | 0.23$^{c}$ | (± 0.00) |
| *P* value | | <0.0001 | | <0.0001 | | <0.0001 | |

$^{a–g}$Within a column, within a source, least-squares means with different superscript letters differ ($P < 0.05$).

least ($P < 0.05$) amount of external fat at 0.00 cm and 0.02 cm on average, respectively. The top loin steak had the most ($P < 0.05$) external fat (0.44 cm). Ribeye steaks were the heaviest ($P < 0.05$) average weight at 0.35 kg, which is similar to the findings of Martinez et al. (2017), whereas the lightest ($P < 0.05$) foodservice steaks were the top sirloin and tenderloin, both at 0.23 kg.

### *Warner-Bratzler shear force*

Least-squares means for WBS force values of retail steaks are reported in Table 4. Tenderloin steaks had the lowest ($P < 0.05$) WBS value at 13.3 N. Morgan et al. (1991) reported similar findings of the tenderloin having the lowest ($P < 0.05$) shear force compared to other retail rib and loin cuts, at 2.61 kg (25.60 N). The top blade steak also had lower WBS force values ($P < 0.05$) compared to the other retail rib and loin steaks. The top blade steak did not ($P > 0.05$) differ from the retail rib and loin steaks in Guelker et al. (2013) or Martinez et al. (2017).

Foodservice steak WBS force values are reported in Table 5. The tenderloin and top sirloin steaks had the lowest WBS force values, and the ribeye steak had the highest. WBS force values of ribeye (36.7 N) and top loin (30.3 N) cuts were numerically higher than the findings of Martinez et al. (2017) of 29.6 N and 24.6 N, respectively.

Tenderness categories developed by Shackelford et al. (1991) and Belew et al. (2003) were used to display threshold differences between retail and foodservice steaks (Table 6). All of the top blade, bone-in ribeye, Porterhouse, and tenderloin retail cuts had shear force values in the very tender (<31.4 N) category.

**Table 4.** Least-squares means and SE for Warner-Bratzler shear force values (N) of retail steaks

| Steak | *n* | Shear force mean, N[1] | SE |
|---|---|---|---|
| Top blade | 30 | 16.7[d] | 0.99 |
| Ribeye, lip on, boneless | 108 | 19.7[c] | 0.52 |
| Ribeye, lip on, bone-in | 36 | 19.9[bc] | 0.90 |
| Top loin, boneless | 132 | 18.6[cd] | 0.47 |
| Top loin, bone-in | 21 | 20.6[abc] | 1.18 |
| T-bone | 15 | 23.1[ab] | 1.40 |
| Porterhouse | 29 | 20.6[abc] | 1.00 |
| Top sirloin, boneless, cap off | 179 | 22.0[ab] | 0.41 |
| Tenderloin | 86 | 13.3[e] | 0.58 |
| *P* value | | <0.0001 | |

[1]Warner-Bratzler shear force was determined using 1.27 cm diameter cores.

[a–e]Least-squares means with different superscript letters differ ($P < 0.05$).

**Table 5.** Least-squares means and SE for Warner-Bratzler shear force values (N) of foodservice steaks

| Steak | *n* | Shear force mean, N[1] | SE |
|---|---|---|---|
| Ribeye | 84 | 36.7[a] | 0.64 |
| Top loin | 76 | 30.3[b] | 0.67 |
| Top sirloin | 40 | 26.7[c] | 0.93 |
| Tenderloin | 92 | 25.4[c] | 0.61 |
| *P* value | | 0.0001 | |

[1]Warner-Bratzler shear force was determined using 1.27 cm diameter cores.

[a,b]Least-squares means with different superscript letters differ ($P < 0.05$).

Voges et al. (2007) had similar findings for the retail bone-in ribeye steaks. When comparing the 2022 data to the information reported in Voges et al. (2007), Guelker et al. (2013), and Martinez et al. (2017), the present work had the highest percentage of each individual cut being in the "very tender" category. The retail top sirloin steak was the only cut that fell into the "tough" (>45.1 N) category and had the highest percentage in the "intermediate" (38.3 N < WBS < 45.1 N) grouping.

**Table 6.** Percentage distribution of retail and foodservice steaks stratified into tenderness categories based on Shackelford et al. (1991) and Belew et al. (2003)

| Source/steak | Very Tender, WBS force[1] < 31.4 N | Tender, 31.4 N < WBS force < 38.3 N | Intermediate, 38.3 N < WBS force < 45.1 N | Tough, WBS force > 45.1 N |
|---|---|---|---|---|
| Retail | | | | |
| Top blade | 100.0 | | | |
| Ribeye, lip on, boneless | 95.4 | 4.6 | | |
| Ribeye, lip on, bone-in | 100.0 | | | |
| Top loin | 98.5 | 0.8 | 0.8 | |
| Top loin, bone-in | 95.2 | 4.8 | | |
| T-bone | 93.3 | 6.7 | | |
| Porterhouse | 100.0 | | | |
| Top sirloin, boneless, cap off | 93.9 | 3.9 | 1.1 | 1.1 |
| Tenderloin | 100.0 | | | |
| Foodservice | | | | |
| Ribeye | 13.1 | 51.2 | 27.4 | 8.3 |
| Top loin | 60.5 | 31.6 | 6.6 | 1.3 |
| Top sirloin | 80.0 | 20.0 | | |
| Tenderloin | 87.0 | 9.8 | 3.3 | |

[1]WBS force = Warner-Bratzler shear force values.

For foodservice cuts (Table 6), the tenderloin steak had the highest percentage in the "very tender" (< 31.4 N) category, but also had a higher percentage in the "intermediate" category compared to the top sirloin steak. A decrease in the percentage of foodservice ribeye steaks in the "very tender" (<31.4 N) category was observed compared to those reported by Voges et al. (2007) at 81.4%, Guelker et al. (2013) at 81.1%, and Martinez et al. (2017) at 68.8%. However, there was a notable decrease to 13.10% of ribeye with a shear value under 31.4 N. This might be attributed to thinner foodservice ribeye steaks, resulting in faster cook times, which may have impacted WBS values. Miller et al. (2019) found that steak thickness along with cook surface temperature and quality grade impacted palatability ratings of top loin steaks. Foodservice ribeye steaks had a 12.4% (0.36 cm) steak thickness decrease and a 37.8% faster cook time (data not reported in tabular form), compared to those from Martinez et al. (2017). For foodservice ribeye steaks to meet weight requirements with ribeyes getting larger and heavier (Steele et al., 2020), foodservice establishments are forced to cut steaks thinner. Foodservice ribeye steaks had the highest numerical prevalence in "tender" (51.2%), "intermediate" (27.4%), and "tough" (8.3%) tenderness categories. There were more steaks in the "tough" (>45.1 N) category (8.3%), compared to the previous NBTS results (0.9%, 0.0%, and 3.8%) reported in Voges et al. (2007), Guelker et al. (2013), and Martinez et al. (2017), respectively.

Least-squares means for WBS force values for foodservice steaks stratified by USDA quality grades are reported in Table 7. There was no ($P > 0.05$) difference between the different USDA quality grades in WBS force values. These data differ from those reported by Guelker et al. (2013) and Martinez et al. (2017), which indicated that cuts from Prime quality grades had lower or among the lowest ($P < 0.05$) WBS force values. However, Voges et al. (2007) also reported no difference ($P > 0.05$) for WBS force values across USDA quality grades.

**Table 7.** Least-squares means and SE for Warner–Bratzler shear force values (N) for foodservice steaks stratified by USDA quality grade groups

| USDA grade group | *n* | Mean, N | SE |
|---|---|---|---|
| Prime | 80 | 29.4 | 0.86 |
| Top Choice | 92 | 30.7 | 1.11 |
| Low Choice | 75 | 29.4 | 0.83 |
| Select | 45 | 30.9 | 0.78 |
| *P* value | | 0.5727 | |

## Retail consumer sensory evaluation

Least-squares means for sensory panel ratings for retail steaks are presented in Table 8. Tenderloin steaks received the highest ($P < 0.05$) sensory panel ratings for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. After the tenderloin steak and for the overall like/dislike ratings, the remaining steaks were within 0.4 units, many of which overlapped in their lack of significant differences. This should not be a surprise considering

**Table 8.** Least-squares means ± SE for sensory panel ratings[1] for retail steaks

| Steak | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Top blade | 44 | $6.8^{b}$ | (± 0.2) | $7.3^{b}$ | (± 0.2) | $7.3^{b}$ | (± 0.2) | $6.4^{bc}$ | (± 0.2) | $7.0^{b}$ | (± 0.2) |
| Ribeye, lip on, boneless | 170 | $6.8^{b}$ | (± 0.1) | $6.9^{c}$ | (± 0.1) | $6.8^{c}$ | (± 0.1) | $6.7^{b}$ | (± 0.1) | $6.4^{c}$ | (± 0.1) |
| Ribeye, lip on, bone-in | 62 | $6.4^{cd}$ | (± 0.1) | $6.4^{de}$ | (± 0.1) | $6.3^{de}$ | (± 0.1) | $6.4^{bc}$ | (± 0.1) | $6.0^{de}$ | (± 0.2) |
| Top loin, boneless | 206 | $6.7^{bc}$ | (± 0.1) | $6.7^{cd}$ | (± 0.1) | $6.6^{cd}$ | (± 0.1) | $6.6^{b}$ | (± 0.1) | $6.3^{cd}$ | (± 0.1) |
| Top loin, bone-in | 33 | $6.5^{bcd}$ | (± 0.2) | $6.6^{cde}$ | (± 0.2) | $6.4^{de}$ | (± 0.2) | $6.6^{bc}$ | (± 0.2) | $6.2^{cde}$ | (± 0.2) |
| T-bone | 20 | $6.6^{bcd}$ | (± 0.2) | $6.7^{bcde}$ | (± 0.2) | $6.7^{cde}$ | (± 0.2) | $6.5^{bc}$ | (± 0.2) | $6.5^{bcde}$ | (± 0.3) |
| Porterhouse | 53 | $6.4^{cd}$ | (± 0.1) | $6.4^{de}$ | (± 0.1) | $6.3^{e}$ | (± 0.1) | $6.5^{bc}$ | (± 0.1) | $5.9^{e}$ | (± 0.2) |
| Top sirloin, boneless | 292 | $6.4^{d}$ | (± 0.1) | $6.4^{de}$ | (± 0.1) | $6.3^{e}$ | (± 0.1) | $6.3^{c}$ | (± 0.1) | $6.0^{e}$ | (± 0.1) |
| Tenderloin | 146 | $7.8^{a}$ | (± 0.1) | $8.3^{a}$ | (± 0.1) | $8.3^{a}$ | (± 0.1) | $7.3^{a}$ | (± 0.1) | $7.4^{a}$ | (± 0.1) |
| *P* value | | <0.0001 | | <0.0001 | | <0.0001 | | <0.0001 | | <0.0001 | |

[a–e]Least-squares means within a column with different superscript letters differ ($P < 0.05$).

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

that these steaks should be more similar than different in palatability.

Our purpose for including the tenderloin steak in this survey was to see whether, in fact, that with improvements in tenderness we have observed in other rib and loin steaks over the years, it could now be "too tender." These sensory panel ratings certainly do not reflect any such problem with the tenderloin steak.

### *Foodservice consumer sensory evaluation*

Least-squares means for sensory panel ratings for foodservice steaks are displayed in Table 9. There were no ($P > 0.05$) differences between the cuts for all 5 sensory panel rating attributes. Martinez et al. (2017) found that ribeye and top loin steaks received higher ($P < 0.05$) sensory panel ratings than top sirloin steaks. Voges et al. (2007) and Guelker et al. (2013) reported that no ($P > 0.05$) differences were observed between ribeye, top loin, and top sirloin cuts for flavor like/dislike.

Marbling and/or USDA quality grade have been shown to be important contributors to beef palatability (Smith et al., 1985; Savell et al., 1987; Smith et al., 1987; O'Quinn et al., 2012; Emerson et al., 2013; O'Quinn et al., 2018). Emerson et al. (2013) found that as marbling score increased from Traces to Moderately Abundant, meaty/brothy and buttery/beef fat flavor increased significantly, and shear force, as measured by Warner-Bratzler and Slice, decreased significantly. With regard to grades, O'Quinn et al. (2012) found significant differences in tenderness, juiciness, flavor, and overall liking of beef strip steaks as grades increased from Standard to Prime. Table 10 provides the least-squares means for sensory panel ratings of foodservice steaks stratified by USDA quality grade. Even with so many studies that show the positive influence of marbling and/or grade on beef palatability, there were no ($P > 0.05$) differences between USDA quality grade groups for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, and juiciness like/dislike. These findings are similar to Martinez et al. (2017), who reported no ($P > 0.05$) difference for overall like/dislike, flavor like/dislike, and juiciness like/dislike between the USDA quality grades for foodservice ribeye, top loin, and top sirloin cuts.

Least-squares means for sensory panel ratings for ribeye (Table 11), top loin (Table 12), top sirloin (Table 13), and tenderloin (Table 14) foodservice steaks stratified by USDA quality grade revealed that

**Table 9.** Least-squares means ± SE for sensory panel ratings[1] for foodservice steaks stratified by steak type

| Steak type | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ribeye | 159 | 7.3 | (±0.2) | 7.5 | (± 0.2) | 7.4 | (± 0.2) | 7.2 | (± 0.2) | 6.8 | (± 0.2) |
| Top loin | 135 | 6.8 | (±0.2) | 7.1 | (± 0.2) | 6.9 | (± 0.2) | 6.8 | (± 0.2) | 6.1 | (± 0.2) |
| Top sirloin | 72 | 7.1 | (±0.2) | 7.5 | (± 0.2) | 7.3 | (± 0.2) | 7.2 | (± 0.2) | 6.4 | (± 0.3) |
| Tenderloin | 176 | 7.3 | (±0.1) | 7.3 | (± 0.2) | 7.1 | (± 0.2) | 7.2 | (± 0.1) | 6.8 | (± 0.2) |
| *P* value | | 0.0634 | | 0.3495 | | 0.1343 | | 0.2945 | | 0.0678 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

**Table 10.** Least-squares means ± SE for sensory panel ratings[1] for foodservice steaks stratified by USDA quality grade group

| USDA quality grade group | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prime | 144 | 7.3 | (± 0.2) | 7.4 | (± 0.2) | 7.3 | (± 0.2) | 7.2 | (± 0.2) | 6.5 | (± 0.2) |
| Top Choice | 174 | 7.1 | (± 0.1) | 7.2 | (± 0.2) | 7.0 | (± 0.2) | 7.1 | (± 0.1) | 6.6 | (± 0.2) |
| Low Choice | 138 | 7.0 | (± 0.2) | 7.3 | (± 0.2) | 7.3 | (± 0.2) | 6.8 | (± 0.2) | 6.3 | (± 0.2) |
| Select | 86 | 7.3 | (± 0.2) | 7.4 | (± 0.2) | 7.1 | (± 0.2) | 7.4 | (± 0.2) | 6.9 | (± 0.3) |
| *P* value | | 0.5636 | | 0.7947 | | 0.4198 | | 0.1498 | | 0.3948 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

**Table 11.** Least-squares means ± SE for sensory panel ratings[1] for ribeye foodservice steaks stratified by USDA quality grade group

| USDA quality grade group | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prime | 37 | 7.1 | (±0.3) | 7.1 | (±0.4) | 7.3 | (±0.4) | 7.0 | (±0.3) | 6.4 | (±0.4) |
| Top Choice | 46 | 7.4 | (±0.3) | 7.5 | (±0.3) | 7.2 | (±0.3) | 7.4 | (±0.3) | 7.0 | (±0.3) |
| Low Choice | 47 | 7.2 | (±0.3) | 7.3 | (±0.3) | 7.5 | (±0.3) | 6.9 | (±0.3) | 6.7 | (±0.3) |
| Select | 29 | 7.9 | (±0.4) | 8.0 | (±0.4) | 7.8 | (±0.4) | 7.6 | (±0.4) | 7.1 | (±0.4) |
| *P* value | | 0.3326 | | 0.3132 | | 0.7277 | | 0.3876 | | 0.4799 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

**Table 12.** Least-squares means ± SE for sensory panel ratings[1] for top loin foodservice steaks stratified by USDA quality grade group

| USDA quality grade group | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prime | 39 | 7.0 | (±0.3) | 7.3 | (±0.3) | 7.0 | (±0.3) | 6.8 | (±0.3) | 6.3 | (±0.4) |
| Top Choice | 36 | 6.5 | (±0.3) | 6.7 | (±0.4) | 6.4 | (±0.4) | 6.6 | (±0.4) | 5.8 | (±0.4) |
| Low Choice | 46 | 6.8 | (±0.3) | 7.2 | (±0.3) | 7.2 | (±0.3) | 6.9 | (±0.3) | 6.2 | (±0.4) |
| Select | 14 | 6.9 | (±0.5) | 7.1 | (±0.6) | 6.9 | (±0.6) | 7.1 | (±0.6) | 6.5 | (±0.7) |
| *P* value | | 0.7542 | | 0.6915 | | 0.4608 | | 0.8089 | | 0.7171 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

**Table 13.** Least-squares means ± SE for sensory panel ratings[1] for top sirloin foodservice steaks stratified by USDA quality grade group

| USDA quality grade group | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prime | 29 | 7.1 | (±0.3) | 7.6 | (±0.4) | 7.3 | (±0.4) | 7.4 | (±0.4) | 6.1 | (±0.4) |
| Top Choice | 43 | 7.2 | (±0.3) | 7.3 | (±0.3) | 7.3 | (±0.3) | 7.1 | (±0.3) | 6.7 | (±0.4) |
| *P* value | | 0.8808 | | 0.5534 | | 0.8500 | | 0.5728 | | 0.2720 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

**Table 14.** Least-squares means ± SE for sensory panel ratings[1] for tenderloin foodservice steaks stratified by USDA quality grade group

| USDA quality grade group | $n^2$ | Overall like/dislike | | Tenderness like/dislike | | Tenderness level | | Flavor like/dislike | | Juiciness like/dislike | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prime | 39 | 7.9 | (±0.3) | 7.6 | (±0.3) | 7.5 | (±0.3) | 7.6 | (±0.3) | 7.2 | (±0.4) |
| Top Choice | 49 | 7.4 | (±0.3) | 7.1 | (±0.3) | 6.8 | (±0.3) | 7.3 | (±0.3) | 6.9 | (±0.3) |
| Low Choice | 45 | 7.0 | (±0.3) | 7.4 | (±0.3) | 7.2 | (±0.3) | 6.6 | (±0.3) | 6.2 | (±0.3) |
| Select | 43 | 7.1 | (±0.3) | 7.1 | (±0.3) | 6.8 | (±0.3) | 7.3 | (±0.3) | 6.8 | (±0.3) |
| *P* value | | 0.1354 | | 0.5170 | | 0.2567 | | 0.0902 | | 0.1823 | |

[1]Sensory panel ratings: overall like/dislike (10 = like extremely; 1 = dislike extremely), tenderness like/dislike (10 = like extremely; 1 = dislike extremely), tenderness level (10 = like extremely; 1 = dislike extremely), flavor like/dislike (10 = like extremely; 1 = dislike extremely), and juiciness like/dislike (10 = like extremely; 1= dislike extremely).

[2]Number of steaks.

there were no ($P > 0.05$) USDA quality grade effects on consumer ratings for overall like/dislike, tenderness like/dislike, tenderness level, flavor like/dislike, or juiciness like/dislike. Guelker et al. (2013) reported a lack of differences in sensory panel ratings among Prime, Top Choice, Low Choice, and Select foodservice steaks, and Voges et al. (2007) only showed significant differences for flavor like/dislike where Select steaks received higher ($P < 0.05$) ratings than Prime, Top Choice, and Low Choice steaks. Martinez et al. (2017) noted that Prime ribeye and top loin steaks received higher ($P < 0.05$) tenderness like/dislike and tenderness level ratings than Top Choice, Low Choice, or Select ribeye steaks. It is interesting that so many of these surveys have shown little to no differences in sensory panel ratings for foodservice steaks when stratified by USDA quality grade group when the financial values in the marketplace vary so greatly among them.

## Conclusions

There was an increase in the number of packages with brands or claims on the retail steak labels from the past 3 surveys. This may be due to retail customers being more interested in where their food comes from, which may influence their purchasing decisions. Additionally, this increase may relate to the fact that there are more branded/certification programs available than there were 5 y ago.

In general, most retail steaks evaluated in the 2022 survey were considered "very tender," and all retail cuts numerically decreased in WBS force values compared to Guelker et al. (2013) and Martinez et al. (2017). Although the ribeye and top loin foodservice steaks showed a numerical increase in WBS force values when compared to Martinez et al. (2017), this increase did not impact consumer sensory ratings of the product.

Similar WBS values and consumer sensory panel ratings for foodservice steaks across USDA quality grades could be attributed to Low Choice and Select steaks performing quite well, instead of Prime and Top Choice steaks underperforming. Foodservice steaks receiving high consumer sensory ratings and WBS values deemed to be tender, regardless of USDA quality grade, is an outcome that benefits many sectors of the beef industry.

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