PALATABILITY OF BEEF TOP LOIN STEAKS SOURCED FROM THREE QUALITY GRADE GROUPS FROM TEXAS AND NORTHERN ESTABLISHMENTS

A Thesis

by

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ABSTRACT

Beef loin, strip loin steaks from Texas and northern states (Colorado, Kansas, and Nebraska) and from three quality grade groups were chosen for this study: (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select. There were no ($P > 0.05$) Warner-Bratzler shear force differences or differences in consumer panel ratings for common palatability attributes (tenderness, juiciness, and flavor) between Choice and Select Texas and northern beef. However, northern Top Choice was more ($P < 0.05$) tender and had higher ($P < 0.05$) consumer panelist ratings for tenderness and juiciness liking than Texas Top Choice. The shear force values and palatability ratings for all beef, whether from Texas or northern plants, mirrored those found in the latest National Beef Tenderness Survey -2015, which showed improvement in tenderness from the surveys of the past.

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NOMENCLATURE

WBS- Warner-Bratzler Shear

IMPS- Institutional Meat Purchase Specifications

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

There has been a long-held opinion by some that beef from Texas is not of the same quality as that from northern states. Over 20 years ago, Texas A&M University researchers Savell et al. (1996) conducted a study entitled "Texas Perception Study: Evaluating Beef Based on Geographic Origin." The study involved the collection of USDA Choice and Select beef from Texas Kansas, Colorado, and Nebraska, and a plant location by USDA Quality Grade interaction was identified. The study found Texas Choice and Texas Select had higher Warner-Bratzler Shear (WBS) force values than northern Choice and northern Select, respectively. Furthermore, Savell et al. (1996) found there was not a quality grade effect within location for Texas and northern establishments. Even though these findings helped allay some concerns about the quality of Texas beef compared to that from the northern states, this question still remains and is the focus for the current research.

Various factors determine the palatability of beef, such as tenderness, flavor, and juiciness (Smith, Carpenter, & Berry, 1974; Smith et al., 1985). The idea that beef from Texas is less palatable may have resulted from the higher percentage of *Bos indicus* influenced cattle in Texas (Zhang, Hagerman, & McCarl, 2012). The National Beef Quality Audit-2016 concluded that *Bos indicus* cattle had a mean marbling score of Slight^{82}, in comparison, Native cattle had a mean marbling score of Small^{69} (Boykin et al., 2017). Therefore, Texas beef has been perceived to lack palatability characteristics that northern beef possesses, perhaps due to the lower percentage of carcasses grading USDA Choice or the higher percentage of *Bos indicus* influenced cattle. Studies have shown that *Bos indicus* cattle do not have the same palatability traits that *Bos taurus* cattle possess (Wheeler, Cundiff, & Koch, 1994; Whipple, Koohmaraie, Dikeman, Crouse, Hunt, & Klemm, 1990). The lack of tenderness could be a result of *Bos indicus* cattle having a higher level of calpastatin, an enzyme that inhibits calpains (O'Connor, Tatum, Wulf, Green, & Smith, 1997). Calpains are theorized to be one of the main factors in post-mortem proteolysis (Aberle, Forrest, Gerrard, & Mills, 1989). Based on data from the United States Department of Agriculture–Agricultural Marketing Service (USDA), Texas beef grades 64.81% percent Choice, in comparison to 70.94% Choice in Nebraska, Kansas, and Colorado (USDA, 2018). A lower percentage of cattle grading Choice in Texas lends itself to higher percentage of Texas cattle grading Select, 29.69%, compared to 17.86% of carcasses grading Select in Nebraska, Kansas, and Colorado (USDA, 2018). Overall, there are multiple reasons why an implicit bias in the beef industry may occur, specifically, that beef from Texas may possess lower palatability ratings than beef from northern states.

Implicit bias is the discriminatory bias based on stereotypes, and this type of bias can be very problematic, if unfavorable, even in perception of beef in a marketplace (Greenwald & Krieger, 2006). The perception of Texas beef may be classified as an implicit bias; however, this bias is not just segmented to beef raised in Texas but also beef slaughtered in Texas (Savell et al., 1996). The consumer bias occurs at the market place where it is unknown if cattle are raised in Texas or only slaughtered in Texas. Therefore, this study focuses upon the slaughter facilities in Texas or northern states, not if cattle were raised in Texas or northern states.

Texas Beef Genetics

The first cattle breed to be introduced to Texas was the Longhorn in the early 1800's. In the 19th century, Brahman, Shorthorn, Hereford, and Aberdeen-Angus cattle were introduced to Texas (TSHA, 2010). Later, in the early 20th century Santa Gertrudis cattle, a breed that is 3/8

Brahman and 5/8 Shorthorn were developed. Santa Gertrudis were bred to be hardy and able to thrive in land that is known for drought, disease, and insects (TSHA, 2010).

Cattle breeds in Texas were designed using genetics that could tolerate summer heat stress. *Bos indicus* influenced cattle were among the breeds adapted to hot and humid climates (Hammack, 2010; Zhang et al., 2012). Throughout history, *Bos indicus* cattle were not used primarily for production of favorable carcass traits, such as marbling.. However, their genetics were used to improve Continental and British breeds, making them more drought and disease tolerant. *Bos taurus* cattle such as Hereford, Charolais, and Angus originated from Europe. These breeds have strong maternal characteristics and favorable carcass traits such as a tendency to marble well. *Bos taurus* cattle did not thrive in the southern heat and could not withstand insects and disease. Therefore, *Bos indicus* cattle such as Brahman were used to create composite breeds due to heat tolerance and their resistance against disease, and pests. *Bos indicus* cattle have been bred with Hereford, Charolais, Angus, Simmental, as well as other cattle breeds to optimize hybrid vigor and create a more versatile breed (Hammack, 2010).

Although *Bos indicus* influence had a positive impact on the production and husbandry of cattle in Texas, it created a negative impact on the meat quality of Texas cattle. Multiple sources have shown that *Bos indicus* influence and beef tenderness and palatability have an inverse relationship; Stiffler, Griffin, Murphey, Smith, and Savell (1985) compared Hereford-Angus crossbred cattle and Brahman-Angus crossbred cattle of similar quality grade and concluded that the Brahman-Angus crossbred cattle had a higher WBS rating and well as lower tenderness and overall palatability consumer ratings. Moreover, as cattle have a higher percentage of *Bos indicus* influence, their tenderness decreases and WBS values increase (Johnson, Huffman, Williams, & Hargrove, 1990). The use of *Bos indicus* genetics in southern cattle operations to create hardier livestock has had a negative influence a on beef tenderness (Savell et al., 1996).

Factors Influencing Beef Palatability

Tenderness has been shown to be the most important factor when determining beef palatability; furthermore, flavor and juiciness also are major contributors to consumer acceptability and beef palatability (Lorenzen et al., 1999; Miller, Carr, Ramsey, Crockett, & Hoover, 2001; Neely et al., 1998; Smith et al., 1974; Smith et al., 1985). Belew, Brooks, McKenna, and Savell (2003) determined that four characteristics had the greatest effect on meat tenderness: postmortem proteolysis, intramuscular fat, connective tissue, and contractile state of a muscle.

Postmortem proteolysis or postmortem aging is not fully understood, however, several existing theories explain the importance of myofibrillar proteolysis. After death, calcium floods into the sarcoplasm and serves to activate proteolytic enzymes, principally, calpains which are responsible for the degradation of structural proteins, disrupting crosslinking, and ultimately, fragmentation of myofibrils (Huff-Lonergan, Mitsuhashi, Beekman, Parrish, Olson, & Robson, 1996; Koohmaraie, 1992; Koohmaraie, Schollmeyer, & Dutson, 1986). However, calpains are regulated by calpastatin, which inhibits enzymatic breakdown. Researchers have found that the percentage of *Bos indicus* influnce in cattle is related to the amount of calpastatin activity during postmortem proteolysis (Koohmaraie, 1992; O'Connor et al., 1997; Pringle, Williams, Lamb, Johnson, & West, 1997; Shackelford, Morgan, Cross, & Savell, 1991; Whipple et al., 1990). O'Connor et al. (1997) conducted a study with *Bos indicus* composite and *Bos taurus* cattle and measured 24 hr calpastatin activity. Cattle that were 3/8 *Bos indicus* had a higher amount of 24 hr calpastatin activity than *Bos taurus* cattle as well as lower panel tenderness ratings.

Intramuscular fat is the amount of marbling found in a beef carcass and is evaluated at the cut surface of the ribeye in-between the 12th and 13th ribs. These flecks of fat deposited within the muscle are theorized to stretch the cells in the muscle and spread apart the connective tissue found within the muscle (Cover & Hostetler, 1960). The amount of marbling is quantified by a marbling score, then balanced with the maturity of the carcass to determine a quality grade. There are ten marbling degrees (Practically Devoid, Traces, Slight, Small, Modest, Moderate, Slightly Abundant, Moderately Abundant, Abundant, and Very Abundant) and five maturity groups (A, B, C, D, E). After balancing the marbling degree and determining maturity, the carcass is assigned one of eight (USDA Prime, USDA Choice, USDA Select, USDA Standard, USDA Commercial, USDA Utility, USDA Cutter, and USDA Canner) grades. Smith et al. (1987) used beef loin steaks of various quality grades to determine that as the quality grade increased, the WBS values decreased. In other words, as the quality grade improved, so did the tenderness, resulting in lower WBS force values.

The amount of connective tissue does not significantly relate to tenderness ratings of beef, however, a higher percentage of soluble collagen found in the muscle does significantly correlate to the decrease of tenderness ratings in beef (Cross, Carpenter, & Smith, 1973). Connective tissue amount is dependent on the type, animal age, and breed type (Brady, 1937; Brooks & Savell, 2004; Lawrie, 1985; Purslow, 1999, 2004). However, the method of cooking can affect the tenderness of meat and help solubilize connective tissue. Bratzler (1971) and Lorenzen et al. (1999) both discussed the need for method of cooking to correlate with the amount of connective tissue; muscles with small amounts of connective tissue should be cooked using dry heat, whereas muscles with heavy amounts of connective tissue should be cooked with moist heat over a long period of time to soften the collagen in the muscle.

Another factor of beef tenderness is the contractile state of myofibrillar proteins during postmortem chilling. If the temperature of the muscle decreases rapidly during chilling, cold shortening may occur. Cold shortening results in toughening of the muscle and a decrease in tenderness. Cold shortening is attributed to the buildup of calcium in the muscle because of a lack of affinity of the sarcoplasmic reticulum to the ion. Next, ATP is flooded in the muscle resulting in intense contraction (Savell, Mueller, & Baird, 2005). While the muscle is in contraction, the overlapping of filaments results in a larger muscle fiber diameter and a decrease in tenderness.

Beef Palatability Analysis

Common tests to determine palatability attributes are consumer sensory panels and trained sensory panels. Consumer sensory panels are subjective and able to determine like or dislike of tenderness, flavor, and juiciness; however, trained sensory panels are more objective and are not used to determine liking of a certain attribute of a product (Miller et al., 2001). How the public will perceive or like a product can be determined by using a consumer panel. Consumer satisfaction of a product is known to be a large driver of repeat sales and new customers (Miller et al., 2001). A consumer study gives a larger certainty that the consumer will respond well to certain variables and factors of the product and help ensure a higher acceptability by the consumer (Resurreccion, 2004).

WBS force analysis and slice shear force (SSF) analyses measure beef tenderness, although these methods are not able to determine the flavor or juiciness of the product. Objective measures lack the ability to test preference or acceptance of one product over another (Destefanis, Brugiapaglia, Barge, & Dal Molin, 2008). Furthermore, Destefanis et al. (2008)

compared consumer sensory panel tenderness ratings and WBS force values of beef strip steaks. The majority of consumers in the study were not able to determine the steak's WBS force value category. According to Huffman, Miller, Hoover, Wu, Brittin, and Ramsey (1996), a difference in WBS force ratings must have a change in 1 kg (9.81 N), or more to be detectable to a consumer. Therefore, WBS force can be used for a very precise rating of tenderness, but, the differences may not be detectable to consumers.

CHAPTER II

MATERIALS AND METHODS

Product Collection

Beef from Texas and northern states (Colorado, Kansas, and Nebraska) from three USDA (2016) quality grade groups were chosen for this study: (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.

Products were selected to conform with the Institutional Meat Purchase Specifications (IMPS) as described in The Meat Buyer's Guide (NAMI, 2014). Beef loin, strip loin, boneless (IMPS 180) were collected from foodservice wholesale/purveying and retail case-ready establishments based on processing establishment number to be sorted by plant origin to represent the three quality grade groups from processing establishments from Texas or from northern states. For Texas, Top Choice (n = 174), USDA Choice (n = 180), and USDA Select (n = 168) steaks were collected, and for the northern plants, Top Choice (n = 180), USDA Choice (n = 156), and USDA Select (n = 174) steaks were collected.

The strip loins were collected, removed from their package, the anterior portion was faced, and three steaks (2.54-cm thick) from the anterior end were obtained to create strip loin, center-cut, boneless (IMSA 1180A) steaks. Products were packaged temporarily at the respective foodservice and retail facility and transported in insulated coolers with refrigerant material to Texas A&M University Rosenthal Meat Science and Technology Center (College Station, TX). Upon arrival, steaks were packaged individually in 2.0 mil Sealed Air Food Care vacuum bags (Item No. B2470, Sealed Air, Charlotte, NC) with an OTR of 3 to 6 [(cm^3 (STP/(m^2-24 hr-atm)) @ 0% RH, 4.4 C] and sealed using an Ultravac Double Chamber Vacuum Packaging Machine (MODEL 2100-D; Kansas City, MO). Steaks were frozen (-40 °C) until sensory analysis. Then, of the three steaks from each subprimal, one steak was allocated to WBS force evaluation and two steaks to consumer sensory panel and were distributed equally within source and quality grade.

Cooking Method

Steaks were thawed at approximately 4 °C for 48 h before cooking. Steaks were weighed, and initial internal temperatures were recorded before being cooked on grated, open-hearth, non-stick electric grills (Hamilton Beach ™ Indoor/Outdoor Grill, Southern Pines, NC) preheated to approximately 177 °C. A thermocouple reader (Omega™ HH506A, Stanford, CT) was used to monitor internal steak temperature with a 0.02-cm diameter, copper constantan Type-T thermocouple wire (Omega). Steaks were flipped upon reaching an internal temperature of 35 °C and were removed when a final internal temperature of 70 °C was reached. Thermocouples were removed from each steak and cook times and steak weights were recorded. Weights and cooking data are reported in Tables 1, 2, 3, and 4. Cooked steaks destined for WBS force evaluation were covered with PVC and chilled for 16 to 18 h at approximately 2 to 4 °C. Cooked steaks assigned to sensory evaluation were placed in a food warmer and held at 60 °C (Alto-Shaam, Model 750-TH-II, Milwaukee, Wisconsin) for no longer than 20 min before serving panelists.

Consumer Panel

Consumer panel procedures were approved by the Texas A&M Institutional Review Board (Protocol Number: IRB2016-0328M). Consumer panelists (*n* = 335) were recruited from the Bryan/College Station area using an existing database and email list serves. Consumer panelists' demographic information and consumption patterns are reported in Tables 5 and 6, respectively.

Steaks were thawed and cooked as previously described, cut into cuboidal portions (approximately 1.27 cm × 1.27 cm × steak thickness) and served warm to consumer panelists in individual booths equipped with red theater gel lights. Each panel consisted of 24 panelists, and each panelist received six samples. On average, each sample was evaluated by four panelists. Samples were served in a random order and identified with random three-digit codes. Panelists were provided Nabisco Unsalted Tops Premium Saltine Crackers (Kraft Foods Global, Inc., East Hanover, New Jersey) and double-distilled, deionized water to use as palate cleansers between samples. Panelists were asked to characterize steak sample attributes using 9-point scales: overall liking (1 = dislike extremely; 9 = like extremely), flavor liking (1 = dislike extremely; 9 = like extremely), juiciness liking (1 = dislike extremely; 9 = like extremely), and tenderness liking (1 = dislike extremely; 9 = like extremely).

Warner-Bratzler Shear Force

Chilled steaks were allowed to equilibrate to room temperature (approximately 30 min) before being trimmed of visible fat and heavy connective tissue to expose muscle fiber orientation. From each steak, six 1.3-cm cores were removed parallel to the muscle fibers using a hand-held coring device. Cores were sheared once, perpendicular to the muscle fibers, using a United Testing machine (United SSTM-500, Huntington Beach, CA) at a cross-head speed of 200 mm/min using a 10.0-kg load cell, and a 1.02-cm thick V-shape blade with a 60° angle and a half-round peak. The peak shear force was recorded, and the mean peak shear force values were used for statistical analysis.

Statistical Analysis

Data were analyzed using JMP, Version 13.1.0 (SAS Institute Inc., Cary, NC), where main effects and significant two-way interactions were included in the model. An analysis of variance was preformed to determine the potential differences between Texas and northern beef stratified by Quality Grade. Least squares means were calculated and where appropriate, means were separated with an $\alpha < 0.05$.

CHAPTER III

RESULTS AND DISCUSSION

Consumer Sensory Evaluation

Northern Top Choice received higher ($P < 0.05$) consumer ratings for tenderness liking, and juiciness liking in comparison to Texas Top Choice (Table 9). Having a greater amount of *Bos indicus* influence in Texas cattle could explain the difference in tenderness and juiciness (Zhang et al., 2012). Pringle et al. (1997), O'Connor et al. (1997), and Sherbeck, Tatum, Field, Morgan, and Smith (1996) found lower (P <0.05) panel tenderness ratings for *Bos indicus* influenced cattle than *Bos taurus*. Furthermore, northern Top Choice had higher ($P < 0.05$) flavor and juiciness liking ratings than Texas Select and northern Select. Previous research found the same difference in tenderness panel ratings between Top Choice and Select (Smith et al., 1985). However, there was no difference ($P > 0.05$) found between Texas Top Choice, Choice, and Select for overall liking, flavor, and juiciness liking. Similarly, Wheeler et al. (1994) did not find differences in flavor or juiciness panel ratings of *Bos indicus* influenced beef of USDA Choice and Select.

Warner-Bratzler Shear Force

Texas Top Choice, Texas Select, and northern Select had higher ($P < 0.05$) mean WBS force values than northern Top Choice, northern Choice, and Texas Choice (Table 7). Savell et al. (1996) evaluated WBS force for Choice and Select strips from Texas, Kansas, Nebraska, and Colorado, and reported no difference between Texas Choice and Select. Moreover, Savell et al. (1996) concluded that northern Choice was more tender than Texas Choice, and reported no differences between northern Choice and northern Select. Therefore, the WBS values from the current study show a 45.3% improvement in Texas Choice as well as 31.8% improvement in

Texas Select. Furthermore, the current values show a difference *($P < 0.05$)* between Choice and Select for both Texas and northern States. Also, northern choice showed a 40.6% improvement and northern select had a 29.1% improvement in tenderness since 1996.

Tenderness thresholds developed by Shackelford et al. (2014) and Belew et al. (2003) were used to categorize steaks into "very tender", "tender", "intermediate", and "tough" based on WBS results (Table 8). Texas Top Choice had the lowest percentage (86.4) of steaks in the "very tender" category and the greatest percentage (11.36) of steaks in the "tender" category. Texas Select had the greatest percentage (3.6) of steaks in the "intermediate" category and northern Select had the greatest percentage (1.2) of steaks in the "tough" category. northern Choice had the greatest percentage (100.0) of steaks in the "very tender" category.

CHAPTER IV

CONCLUSIONS

Tenderness has been found to be the most important palatability characteristic in consumer acceptance, and Texas beef has been perceived to be less tender than beef from northern states. This study concluded there were no WBS force differences or differences in consumer panel ratings for common palatability attributes (tenderness, juiciness, and flavor) between Choice and Select Texas and northern beef. However, northern Top Choice was more tender and had higher consumer panelist ratings for tenderness and juiciness liking than Texas Top Choice.

The WBS values and palatability ratings for all beef, whether from Texas or northern plants, mirrored those found in the latest National Beef Tenderness Survey -2015 which shows improvement in tenderness from the surveys of the past century (Martinez et al., 2017). All beef has improved, but there still remains a difference in Top Choice beef from Texas compared to beef of other major beef producing states.

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APPENDIX

TABLES

Table 1.

Least squares means for panel cook yields and times stratified by plant location[1] x quality grade group[2].

Plant location	Quality grade group	Cook yield (%)	SEM	Cook times (s)	SEM
Texas plants	Top Choice	83.5a	0.5	1073.8d	37.0
Northern plants	Top Choice	83.6a	0.5	1153.3cd	36.4
Texas plants	Choice	82.3ab	0.5	1140.0cd	39.3
Northern plants	Choice	80.7c	0.5	1224.6bc	39.1
Texas plants	Select	82.0bc	0.5	1362.9a	37.6
Northern plants	Select	82.9ab	0.5	1310.3ab	37.0
P-value		0.0004		<0.0001	

Means within a column and lacking a common letter (a, b) differ ($P < 0.05$).

[1]Location where product was processed, from either Texas or northern states (Colorado, Kansas, and Nebraska).

[2]Quality grade group= USDA (2016): (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.

Table 2

Least squares means for WBS[1] cook yields and times stratified by plant location[2] x quality grade group[3].

Plant location	Quality grade group	Cook yield (%)	SEM	Cook times (s)	SEM
Texas plants	Top Choice	85.1ab	0.5	1153.8b	41.7
Northern plants	Top Choice	84.1a	0.5	1121.3b	41.0
Texas plants	Choice	83.6b	0.5	1210.1b	38.7
Northern plants	Choice	82.9b	0.6	1188.5b	44.1
Texas plants	Select	83.7ab	0.5	1367.0a	42.7
Northern plants	Select	82.7b	0.5	1449.7a	41.7
P-value		0.0222		<0.0001	

Means within a column and lacking a common letter (a, b) differ ($P < 0.05$).

[1]WBS=Warner-Bratzler Shear force values

[2]Location where product was processed, from either Texas or northern states (Colorado, Kansas, and Nebraska).

[3]Quality grade group=USDA (2016): (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.

Table 3

Means and standard deviations for weights, cook yield, temperatures, and cook duration for panel steaks.

Parameter	n[1]	Mean	SD
Raw weight (kg)	503	357.0	59.0
Cooked weight (kg)	503	294.4	49.7
Cook yield (%)	503	82.5	4.6
Initial raw temperature (°C)	503	10.5	1.4
Final cooked temperature (°C)	503	70.0	3.1
Cook duration (s)	503	1210.7	357.7

[1]Number of steaks evaluated

Table 4

Means and standard deviations for weights, cook yield, temperatures, and cook duration for WBS[1] force steaks.

Parameter	n^2	Mean	SD
Raw weight (kg)	526	360.0	59.5
Cooked weight (kg)	527	300.9	51.3
Cook yield (%)	526	83.7	5.1
Initial raw temperature (°C)	527	9.7	1.8
Final cooked temperature (°C)	527	70.1	0.3
Cook duration (s)	526	1246.8	405.0

[1]WBS=Warner-Bratzler Shear force

[2]Number of steaks evaluated

Table 5

Demographic attributes of consumer panelists.

Item	n[1]	%
Gender		
Male	142	42.5
Female	192	57.5
Age, yr		
< 20	37	11.0
21 to 25	107	31.9
26 to 35	83	24.8
36 to 45	29	8.7
46 to 55	39	11.6
56 to 65	20	6.0
≥ 66	20	6.0
Working status		
Not employed	21	5.8
Full-time	145	39.9
Part-time	57	15.7
Student	140	38.6
Income, US$		
< 25,000	91	27.2
25,000 to 49,999	78	23.3
50,000 to 74,999	53	15.8
75,000 to 99,000	47	14.0
≥ 100,000	66	19.7
Food allergy		
No	317	94.9
Yes	17	5.1
Food manufacturer		
No	333	99.4
Yes	2	0.6
Ethnicity		
Caucasian	249	72.6
Hispanic	42	12.2
Asian or Pacific	25	7.3
Black	18	5.2
American Indian	4	1.2
Other	5	1.5

[11]Number of responses.

Table 6

Consumption patterns of consumer panelists.

Item	*n*	%
Consume meat		
No	1	0.3
Yes	334	99.7
Meat types consumed		
Chicken	328	25.8
Pork	310	24.4
Beef	334	26.3
Fish	297	23.4
Overall beef consumption		
Daily	22	6.5
5 or more times per wk	47	13.9
3 or more times per wk	165	49.0
1 time per wk	88	26.1
1 time every 2wks	13	3.9
Less than once every 2 wks	2	0.6
At home beef consumption		
0 times per wk	22	6.6
1 time per wk	96	28.8
2 times per wk	105	31.5
3 times per wk	73	21.9
4 times per wk	12	3.6
5 or more times per wk	25	7.5
In restaurant beef consumption		
0 times per wk	17	3.84
1 time per wk	179	40.41
2 times per wk	126	28.44
3 times per wk	77	17.38
4 times per wk	17	3.84
5 or more times per wk	27	6.09
Degree of doneness		
Rare	12	3.5
Medium rare	142	41.9
Medium	83	24.5
Medium well	74	21.8
Well done	28	8.3
Purchase tendencies		
Grass-fed	66	16.2
Traditional	277	72.5
Aged	21	5.5
Organic	22	5.8

[1]Number of responses.

Table 7

Least squares means of WBS[1] force stratified by plant location[2] x quality grade group[3].

Plant location	Quality grade group	WBS (N)	SEM
Texas plants	Top Choice	23.2a	0.6
Northern plants	Top Choice	20.2b	0.6
Texas plants	Choice	20.3b	0.6
Northern plants	Choice	18.9b	0.6
Texas plants	Select	22.6a	0.6
Northern plants	Select	22.5a	0.6
P-value			0.0324

Means lacking a common letter (a, b) differ ($P < 0.05$).

Means within a column and lacking a common letter (a, b) differ ($P < 0.05$).

[1]WBS=Warner-Bratzler Shear force values

[2]Location where product was processed, from either Texas or northern states (Colorado, Kansas, and Nebraska).

[3]Quality grade group=USDA (2016): (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.

Table 8

Percentage distribution of steaks stratified by plant location[1] x quality grade group[2] (Belew et al., 2003).

Plant location	Quality grade group	Very tender, WBS[3] < 31.4 N	Tender, 31.4 N < WBS < 38.3 N	Intermediate, 38.3 N < WBS < 45.1 N	Tough, WBS > 45.1 N
Texas plants	Top Choice	86.4	11.4	1.1	1.1
Northern plants	Top Choice	97.8	2.2	-	-
Texas plants	Choice	95.0	4.0	1.0	-
Northern plants	Choice	100.0	-	-	-
Texas plants	Select	94.0	2.4	3.6	-
Northern plants	Select	89.5	8.1	1.2	1.2

[1]Location where product was processed, from either Texas or northern states (Colorado, Kansas, and Nebraska).
[2]Quality grade group=USDA (2016): (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.
[3]WBS=Warner-Bratzler Shear force values.

Table 9

Least squares means of consumer panelist scores[a] for beef palatability stratified by plant location[1] x quality grade group[2].

Plant Location	Quality grade group	Overall Like	SEM	Flavor Like	SEM	Tenderness Like	SEM	Juicy Like	SEM
Texas plants	Top Choice	6.2	0.1	6.3	0.1	6.1c	0.1	6.1b	0.2
Northern plants	Top Choice	6.7	0.1	6.5	0.1	6.8a	0.1	6.5a	0.2
Texas plants	Choice	6.6	0.1	6.4	0.1	6.7ab	0.2	6.3ab	0.2
Northern plants	Choice	6.5	0.1	6.3	0.1	6.7a	0.2	6.0b	0.2
Texas plants	Select	6.3	0.1	6.2	0.1	6.4abc	0.1	6.0b	0.2
Northern plants	Select	6.2	0.1	6.2	0.1	6.3bc	0.1	6.1b	0.2
P-value		0.0533		0.3079		0.0070		0.0478	

Means within a column and lacking a common letter (a, b, c) differ ($P < 0.05$).

[a] Consumers used the following 9-point scales: overall liking (1=dislike extremely; 9=like extremely), flavor liking (1=dislike extremely; 9=like extremely), juiciness liking (1=dislike extremely; 9=like extremely), and tenderness liking (1=dislike extremely; 9=like extremely)

[1]Location where product was processed, from either Texas or northern states (Colorado, Kansas, and Nebraska).

[2]Quality grade group=USDA (2016): (1) Top Choice (Modest and Moderate marbling scores and representative of the upper 2/3's Choice grade), (2) Choice, and (3) Select.