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# Investigation of Smoked Beef Brisket Palatability from Three USDA Quality Grades

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**Abstract:** The objective of this study was to investigate differences in smoked beef brisket palatability from 3 USDA quality grades (USDA Prime, average [middle 1/3] Choice, and Select). Briskets ($n = 54$; 18 per quality grade) were seasoned with a blend of 1:1 coarse salt/black pepper, and then cooked in a smoker to a final internal temperature of 93°C for approximately 6 to 7 h. For sensory analysis, briskets were separated into point (*pectoralis superficialis*) and flat (*pectoralis profundus*) portions and then sliced perpendicular to the muscle fibers. Consumer panelists ($N = 360$) evaluated palatability traits, acceptability of each trait, and willingness to pay (WTP). An interaction between quality grade and muscle was observed ($P \leq 0.03$) for all palatability traits, proportion of acceptable samples, and WTP. Consumers could not distinguish among quality grades of the point portions for tenderness, juiciness, flavor liking, and overall liking ($P > 0.05$). Point samples, regardless of quality grade, were scored greater ($P < 0.05$) than Prime flat samples for all palatability traits. Choice and Select flat samples were scored lesser ($P < 0.05$) than all other treatment combinations for tenderness, flavor liking, and overall liking. In alignment with palatability traits, consumers' WTP was greatest for point portions, regardless of quality grade ($P < 0.05$), followed by Prime flat portions. Choice and Select flat portions had the lowest WTP ($P < 0.05$). Consumer acceptability of cooked beef brisket generally followed similar trends as palatability scores. Quality grade had no effect on the eating quality of the point portions of smoked briskets, and point portions received superior palatability scores to flat portions. Prime flat portions had greater eating quality compared to that of Choice and Select flat portions, and consumers had greater WTP for what they perceived as superior eating quality.

**Key words:** brisket, consumer sensory, *pectoralis*, quality grade, smoked beef
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## Introduction

Beef chuck accounts for approximately 52% of the total carcass side weight, and historically, beef whole muscles from the chuck have been underutilized due to perceived lower eating quality in comparison to the loin and rib (Nyquist et al., 2018). This has resulted in chuck cuts commonly being marketed as ground products, roasts, or lower-quality steaks (Belew et al., 2003; Von Seggern et al., 2005; Lepper-Blilie et al., 2014, Nyquist et al., 2018). Specifically, the brisket has been overlooked as a marketable product from the chuck due to its unacceptability as a steak (Kukowski et al., 2004). With the current demand of beef brisket increasing due to barbecue enthusiasts, it is important for the beef industry to keep finding ways to add value to their products (Harris et al., 2017). Smoking briskets via the "low and slow" cooking method—whereby briskets are cooked at low temperatures ranging from 225°F (107°C) to 300°F (149°C) for several hours until reaching the desired well-done endpoint temperature for briskets of approximately 200°F (93°C) (Raichlen, 2016)—not only adds value to the carcass but provides a more enjoyable eating experience for consumers.

When using typical sensory evaluation cooking methods, such as steak grilling or roasting, the beef brisket is a muscle known for its toughness and high connective tissue content. The connective tissue in brisket samples remains insoluble during cooking resulting in a tough final product (Johnson et al., 1988; Belew et al., 2003; Jeremiah et al., 2003). Carmack et al. (1995) compared palatability attributes of 12 major muscles from beef carcasses, including the *pectoralis profundus*, or flat portion of the beef brisket; the *pectoralis profundus* was scored toughest of all the muscles and had undesirable beef flavor intensity. Additionally, Jeremiah et al. (2003) found that, out of 33 muscles or muscle group roasts, the flat and point portions of the brisket were the toughest or among the toughest both initially and overall and had the most perceivable connective tissue. With a combination of intense beef flavor and low flavor desirability, the flat and point portion of the brisket had 2 of the lowest overall palatability scores out of 33 major muscles.

Consumer perception of beef products is closely related to liking of specific palatability attributes, such as tenderness, juiciness, flavor, and overall liking (O'Quinn et al., 2018). Consumers have demonstrated a willingness to pay (WTP) a premium for a beef with greater eating quality (Miller et al., 2001; Kukowski et al., 2005). The impact of intramuscular fat content or USDA quality grade on beef tenderness, juiciness, flavor, and overall palatability has been well documented (Smith et al.,1985; O'Quinn et al., 2012; Emerson et al., 2013; Corbin et al., 2015; Nyquist et al., 2018), with increased eating quality observed in higher quality grades. While the majority of beef palatability research has focused on the *longissimus* muscle, some research has been conducted evaluating the impact of quality grade in other beef muscles (Jeremiah et al., 2003; Gruber et al., 2006; Hunt et al., 2014; Lepper-Blilie et al., 2014; Jung et al., 2016; Nyquist et al., 2018; Yeh et al., 2018). However, to our knowledge the impact of USDA quality grade on smoked beef brisket palatability has never been evaluated. The objective of this study was to determine the influence of USDA quality grade on smoked beef brisket palatability within the point and flat portions of the brisket. We expected that differences in palatability due to quality grade would possibly not be as pronounced in the brisket in comparison to the *longissimus* muscle. However, due to the expected higher amounts of collagen and fat of the point portions of the brisket, we hypothesized that consumers would prefer the point portions of the briskets compared to flat portions.

# Materials and Methods

## Raw product collection and preparation

Beef briskets from the USDA Prime, average (middle 1/3) Choice, and Select quality grades ($n = 54$; 18 per quality grade) were collected at a commercial abattoir in Omaha, Nebraska. Briskets from average Choice carcasses will be simply referred to as "Choice" going forward. Carcasses were selected and verified by trained Texas Tech University personnel through visual appraisal of marbling and maturity (USDA, 1997) of the carcass at the time of selection. Carcass data, including beef carcass yield and quality grade traits and *longissimus* muscle pH (TPS Model WP-90 with pH sensor part #111227; TPS Pty Ltd., Brendale, QLD, Australia), were collected and recorded by trained personnel. Carcasses were fabricated after selection; briskets were collected, vacuum packaged, boxed, and transported (0°C to 1°C) to the Gordon W. Davis Meat Science Laboratory (Lubbock, Texas). Briskets were frozen (−29°C) at 5 d postmortem. Briskets were thawed for approximately 48 h before consumer service at 2°C to 4°C. Briskets were then unpackaged, surface fat was trimmed to 6 mm, and sternum fat was removed. A 5-cm sample weighing approximately 500 g was removed from both the brisket flat (*pectoralis profundus*) and point (*pectoralis superficialis*). These samples were vacuum packaged individually, labeled, and frozen at −29°C for subsequent compositional analysis. Briskets were seasoned with a blend of 1:1 coarse kosher salt (Morton Salt Inc., Chicago, IL) and coarse ground black pepper (McCormick & Co. Inc; Hunt Valley, MD). Each raw brisket was weighed (Ohaus Defender 3000 XtremeW, Parsippany, NJ), and the amount of salt and pepper were determined (0.05% total of the brisket raw weight). Seasoning was applied by hand to ensure even coverage on all sides of the brisket. Briskets were held at 2°C to 4°C for 12 h prior to cooking.

## Cooking

On each day of consumer testing ($n = 6$), 4 pellet grills (Jim Bowie Green Mountain Grills; Reno, NV) were preheated to 121°C. Nine test briskets were cooked on each testing day ($n = 3$ per quality grade), and 2 additional briskets unrelated to the treatment design were cooked for warm-up samples. Raw briskets were placed into grills after preheating. Only briskets of one quality grade were loaded in a grill (i.e., all Prime and only Prime were loaded in one grill on a

given test day; the same concept applied to Choice and Select briskets). Therefore, 3 grills were used to cook each of the 3 quality grades, and 1 grill was used to cook the warm-up sample briskets. The briskets were smoked in grills loaded with GMG Gold Blend (red oak, hickory, and maple wood) hardwood pellets (Green Mountain Grills, Reno, NV) at a pit temperature of 121°C for approximately 6 to 7 h. Each pellet grill was equipped with an internal temperature probe, which was used as a gauge for internal brisket temperature. Within each grill, brisket internal temperature was monitored using the internal temperature probe that was inserted into the thickest portion of the smallest brisket to determine temperature. When each brisket reached 63°C, as confirmed using a separate digital thermometer (Model Mk4, Thermoworks Thermapen, American Fork, UT), time and temperature were recorded. That brisket was removed from the smoker and double wrapped with heavy duty aluminum foil (Member's Mark, Bentonville, AR) before being placed back into the pellet grill. As briskets were removed for wrapping, the internal temperature probe was moved to the next smallest brisket until all briskets were wrapped. The internal temperature probe was then placed back in the original brisket, and a similar pattern was followed until all briskets were cooked. As each brisket reached 93°C, as verified by an external digital thermometer (Model Mk4, Thermoworks Thermapen, American Fork, UT), time and temperature were recorded, and that wrapped brisket was removed from the pellet grill and placed in an insulated container.

## Cooked sample preparation

Cooked briskets were held in an insulated container for approximately 2 h prior to sensory panels. Approximately 90 min before consumer service, sample preparation began. Each brisket was removed from the insulated cooler, aluminum foil was removed, and individual weights were recorded for the whole brisket and each portion of the brisket as they were separated into muscles (Ohaus Defender 3000 XtremeW, Parsippany, NJ). Brisket portions were then sliced (6 mm × 50 mm × cooked depth) perpendicular to the muscle fiber to obtain no fewer than 20 slices per portion for consumer evaluation. An initial cut was made at a 90° angle to the fiber direction to square off the leading edge prior to slicing. The slices were cut one at a time, and fiber direction was monitored. The leading edge was resurfaced if fiber direction changed. Slices were transferred into preheated rectangular stainless-steel pans (176 mm × 108 mm × 150 mm), which were maintained in insulated water bath warming units (Model W-3Vi; American Permanent Ware Company, Dallas, TX) that were maintained at approximately 60°C during preparation and throughout the test session.

## Sensory evaluation

The Texas Tech University Institutional Review Board approved procedures for use of human subjects for consumer sensory panel evaluations (IRB2017-598). Sensory sessions were conducted at the Animal and Food Sciences Building at Texas Tech University in Lubbock. Panelists ($n = 360$) were recruited from the Lubbock area and were provided with monetary compensation. A total of 6 panel sessions were conducted on 6 separate days with 60 consumers per session and each session lasting approximately 45 min. Panelists were seated individually in numbered booths in a large room under fluorescent lighting. Before each panel session, verbal directions were given in regard to filling out a demographics survey and sample questionnaire on a second-generation iPad (Apple, Cupertino, CA). Each consumer was given access to an iPad with questionnaires preloaded for the study. Questionnaires, including demographics and sensory evaluation, were developed and administered using Qualtrics XM survey building software (Qualtrics XM, Provo, UT, Seattle, WA). Panelists were provided with a fork and knife, a toothpick, and a napkin, as well as unsalted saltine crackers, diluted apple juice, a cup of water, and an expectorant cup. Panelists were served samples, which were identified using 4-digit numeric codes generated randomly, in a randomized and balanced order. Each consumer ($N = 360$) received one warm-up sample unrelated to the trial to acclimate consumers to the sample format and provide linkage across testing nights. Additionally, consumers received 6 test samples representing all quality grade × muscle combinations. In the questionnaires, consumers were asked to rate each individual sample based on palatability characteristics of tenderness, juiciness, flavor liking, and overall liking. These characteristics were evaluated on a 100-point sliding scale in which the zero-anchors represented not tender, not juicy, dislike extremely flavor, and dislike extremely overall. Anchors for 100 represented very tender, very juicy, like extremely flavor, and like extremely overall. Additionally, panelists were asked to determine whether samples were acceptable or unacceptable for each palatability characteristic. WTP was assessed on an individual sample basis. Consumers used a sliding scale that ranged from $0 to $40 per

pound, with indicators every $5, to represent what the consumer would be willing to spend on a sample similar to the one they just tasted if they were to purchase that sample at retail. Consumers used their own knowledge of average brisket/beef prices and were not provided any reference prices or other information.

### Proximate analysis

The frozen samples of raw brisket portions were removed from frozen storage and held at 2°C to 4°C for 24 h prior to analysis. Each sample was removed from its packaging and trimmed of all remaining surface fat. Samples were then diced into symmetrical 2.5-cm cubes before being passed 3 times through a tabletop grinder (Cabela's Pro Series DC grinder; Sidney, NE) with a 4.5-mm grinding plate. Ground sample was plated into a 100- × 15-mm petri dish using a spatula before being placed into a FOSS NIR Food Scan (Hillerød, Denmark) for proximate analysis. Fat, moisture, protein, and collagen percentages were generated.

### Statistical analysis

The experimental design was completely randomized split plot arrangement of factors. Quality grade served as the main plot factor, and muscle was the subplot factor. Treatment comparisons were tested using the PROC GLIMMIX procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC) with $\alpha = 0.05$. Quality grade, muscle, and their interaction were used as fixed effects. For sensory data, the model included random effects of brisket identification (quality grade) and consumer identification (testing day). Acceptability data for each palatability trait were analyzed using a binomial model with the same fixed and random effects. Pearson correlation coefficients were determined among compositional data, consumer palatability traits, and WTP on a muscle basis via PROC CORR using a significance level of $P < 0.05$.

## Results

### Carcass data

Table 1 displays the effect of quality grade on carcass characteristics. Marbling and skeletal maturity (ossification) were the only 2 traits that differed ($P \leq 0.04$) because of quality grade. As expected, marbling score increased ($P < 0.05$) as quality grade increased, where Prime > Choice > Select. Additionally, Choice carcasses exhibited less ($P < 0.05$) skeletal ossification compared to Prime and Select carcasses, which were similar ($P > 0.05$). However, it should be noted that all carcasses were considered "A" maturity. All remaining carcass characteristics were similar among quality grades ($P > 0.05$).

**Table 1.** The effect of USDA quality grade on beef carcass characteristics ($n = 54$; 18/quality grade)

| Trait | Prime | Choice | Select | SEM[1] | *P* value |
|---|---|---|---|---|---|
| **12th Rib Fat, mm** | 17 | 16 | 13 | 1.5 | 0.17 |
| **12th Rib *Longissimus* Muscle Area, cm²** | 93.2 | 97.0 | 98.3 | 3.1 | 0.49 |
| **HCW, kg** | 427.6 | 436.1 | 401.2 | 10.7 | 0.07 |
| **KPH, %** | 2.3 | 2.2 | 2.1 | 0.1 | 0.59 |
| **Marbling[2]** | 746[a] | 542[b] | 335[c] | 7.8 | <0.01 |
| **Lean Maturity[3]** | 163 | 170 | 157 | 5.3 | 0.24 |
| **Skeletal Maturity[3]** | 176[a] | 155[b] | 180[a] | 7.1 | 0.04 |
| **pH** | 5.62 | 5.57 | 5.59 | 0.02 | 0.20 |

[1]Pooled (largest) SE of least-squares means.

[2]Slight[00] = 300, small[00] = 400, modest[00] = 500, moderate[00] = 600, slightly abundant[00] = 700, moderately abundant[00] = 800.

[3]A[00] = 100, B[00] = 200.

[a–d]Within a row, least-squares means without a common superscript differ ($P \leq 0.05$).

HCW, hot carcass weight; KPH, kidney, pelvic, and heart fat.

### Cooking characteristics

The data in Table 2 outline the main effect of quality grade on beef brisket cooking characteristics. Raw and cooked brisket weight was influenced ($P < 0.05$) by quality grade. Specifically, Select briskets were

**Table 2.** The effect of USDA quality grade on cooking characteristics of beef briskets ($n = 54$; 18/quality grade)

| Trait | Prime[1] | Choice[1] | Select[1] | SEM[2] | *P* value |
|---|---|---|---|---|---|
| **Raw Weight, kg** | 3.7[b] | 4.1[ab] | 4.4[a] | 0.35 | <0.01 |
| **Cooked Weight, kg** | 2.2[b] | 2.4[ab] | 2.6[a] | 0.21 | 0.02 |
| **Cook Yield, %** | 60.4 | 59.6 | 59.1 | 0.88 | 0.57 |
| **Cook Time, min** | 392.0 | 405.7 | 386.8 | 14.31 | 0.63 |
| **Cooked Flat Weight[3], kg** | 1.3 | 1.3 | 1.4 | 0.12 | 0.14 |
| **Cooked Point Weight[3], kg** | 0.9[b] | 1.1[a] | 1.2[a] | 0.18 | <0.01 |

[1]Prime = USDA Prime with marbling scores ranging from slightly abundant 0 to 100; Choice = average (middle 1/3) Choice with marbling scores ranging from modest 0 to 100; Select = USDA Select with marbling scores ranging from slight 0 to 100.

[2]Pooled (largest) SE of least-squares means.

[3]Flat = pectoralis profundus; Point = pectoralis superficialis.

[a–d]Within a row, least-squares means without a common superscript differ ($P \leq 0.05$).

**Table 3.** Demographic characteristics of all consumers ($N = 360$)

| Trait | Percentage, % |
|---|---|
| **Age** | |
| <20 y | 5.3 |
| 20–29 y | 24.7 |
| 30–39 y | 23.1 |
| 40–49 y | 20.6 |
| 50–59 y | 14.4 |
| >60 y | 11.9 |
| **Gender** | |
| Male | 48.6 |
| Female | 51.4 |
| **Occupation** | |
| Tradesperson | 9.2 |
| Professional | 29.2 |
| Administration | 20.0 |
| Sales and service | 15.3 |
| Laborer | 8.3 |
| Homemaker | 1.9 |
| Student | 7.5 |
| Currently not employed | 8.6 |
| **How Often Do You Eat Beef?** | |
| Daily | 19.2 |
| 4–5 times/wk | 32.5 |
| 2–3 times/wk | 34.4 |
| Weekly | 11.1 |
| Biweekly | 1.9 |
| Monthly | 0.8 |
| Never | 0.0 |
| **Household Size (Adults)** | |
| 1 | 14.5 |
| 2 | 57.5 |
| 3 | 16.1 |
| 4 | 9.4 |
| 5+ | 2.5 |
| **Household Size (Children)** | |
| 0 | 47.8 |
| 1 | 22.2 |
| 2 | 17.8 |
| 3 | 8.6 |
| 4+ | 3.6 |
| **Preferred Cooking Level** | |
| Blue | 0.8 |
| Rare | 5.8 |
| Medium rare | 38.3 |
| Medium | 26.1 |
| Medium well done | 22.8 |
| Well done | 6.1 |
| **Income Level** | |
| <$20,000/y | 9.7 |
| $20,000–50,000/y | 23.1 |
| $50,001–75,000/y | 21.4 |
| $75,001–100,000/y | 18.6 |
| >$100,000/y | 27.2 |
| **Education Level** | |
| Non-high school graduate | 6.7 |
| High school graduate | 15.3 |
| Some college/technical school | 38.6 |
| College graduate | 30.0 |
| Post graduate | 9.4 |
| **Cultural Heritage** | |
| African American | 1.9 |
| Asian | 0.6 |
| Caucasian/white | 53.3 |
| Hispanic | 39.4 |
| Mixed race | 2.5 |
| Native American | 0.8 |
| Other | 1.4 |

heavier ($P < 0.05$) than Prime briskets, but Choice brisket weight (raw and cooked) did not differ ($P > 0.05$) from Select or Prime. Despite differences in total brisket weight, when briskets were separated into muscles, the cooked weight of the flat portions did not differ ($P > 0.05$) because of quality grade. However, Choice and Select brisket point portions were heavier ($P < 0.05$) than Prime brisket point portions. All other cooking characteristics, including cook yield and cook time, were not affected by quality grade ($P > 0.05$). On average, cook yield was 59.7%, and total cooking time averaged 394 min (6.6 h) across all briskets.

## Demographic profile

Consumer demographic information is presented in Table 3. The majority of participants (68.4%) were between the ages of 20 and 49 years, and gender was evenly split between male and female participants. Additionally, most participants were employed full time (82%) or were students (7.5%). Participants identified predominately as Caucasian/white (53.3%) or Hispanic (39.4%) for their heritage. Additionally, the majority of participants had some college or technical school experience or were college graduates (68.6%). Household size most commonly consisted of 2 adults (57.5%), with 0 or 1 child (70%). The greatest percentage of participants in any one income bracket had a household income of >$100,000 per year (27.2%), but 63.1% of participants of had a household income level between $20,000 and $100,000 per year, with an even split among 3 income brackets. Most (66.9%) participants indicated that they eat beef weekly (2–5 times/wk). Lastly, most consumer-panel participants indicated that their preferred degrees of doneness

of beef steaks were medium rare, medium, and medium well done.

### Consumer sensory

Table 4 displays the effects of muscle and USDA quality grade on consumer sensory scores for tenderness, juiciness, flavor liking, and overall liking. An interaction between muscle and quality grade was observed for all palatability traits ($P < 0.05$). Consumers scored point portions similarly ($P > 0.05$) for all palatability characteristics, regardless of quality grade, and point portions were scored greater ($P < 0.05$) than all other treatment combinations. Next, Prime flat portions were scored greater ($P < 0.05$) for tenderness, flavor liking, and overall liking compared to Choice and Select flat portions ($P > 0.05$), which did not differ. However, juiciness differed across all 3 quality grades for the flat portions ($P < 0.05$), where Prime flat > Choice flat > Select flat.

As seen in Table 4, an interaction between quality grade and muscle was also detected ($P < 0.05$) for acceptability of all palatability traits and overall acceptability. A greater percentage of consumers found tenderness acceptable for all point portions of the brisket, regardless of quality grade, compared to Choice and Select flat portions ($P < 0.05$). Prime flat portions, however, had a similar proportion of consumers indicate that samples were acceptable for tenderness compared to Choice and Prime point portions ($P > 0.05$). A greater ($P < 0.05$) proportion of consumers found juiciness acceptable for all point portions, regardless of quality grade, compared to the remaining treatment combinations. A greater percentage of consumers found juiciness acceptable for Prime and Choice flat portions, which were similar ($P > 0.05$), compared to Select flat portions ($P < 0.05$). A greater ($P < 0.05$) proportion of consumers found flavor acceptable for the Select point compared to the Choice flat and Select flat. However, the Select point had similar ($P > 0.05$) flavor acceptability as the Prime flat, Choice point, and Prime point. Lastly, more ($P < 0.05$) consumers believed that the Select point, Choice point, and Prime flat—which were all similar ($P > 0.05$)—were more acceptable overall compared to the Choice flat and Select flat.

WTP was influenced by the interaction between quality grade and muscle ($P = 0.02$; Table 4). Consumers were willing to pay more ($P < 0.05$) for point portions, regardless of quality grade, compared to flat portions. Much like the scoring of overall liking, consumers were willing to pay more ($P < 0.05$) for Prime flat portions of briskets compared to Choice and Select flat portions, which had similar WTP ($P > 0.05$), and consumers were willing to pay the least for those samples.

**Table 4.** The interactive effects of USDA quality grade[1] and muscle[2] on consumer palatability traits of beef briskets ($N = 360$)

| | Prime | | Choice | | Select | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Trait | Flat | Point | Flat | Point | Flat | Point | SEM[3] | Grade *P* value | Muscle *P* value | Interaction *P* value[4] |
| **Tenderness**[5] | 64.5$^{b}$ | 85.0$^{a}$ | 57.0$^{c}$ | 81.9$^{a}$ | 54.3$^{c}$ | 80.1$^{a}$ | 1.9 | <0.01 | <0.01 | <0.01 |
| **Juiciness**[5] | 60.6$^{b}$ | 66.2$^{a}$ | 55.7$^{c}$ | 65.8$^{a}$ | 53.8$^{d}$ | 66.0$^{a}$ | 1.9 | <0.01 | <0.01 | <0.01 |
| **Flavor Liking**[5] | 51.4$^{b}$ | 79.0$^{a}$ | 43.8$^{c}$ | 74.6$^{a}$ | 38.1$^{c}$ | 74.7$^{a}$ | 1.8 | 0.23 | <0.01 | 0.02 |
| **Overall Liking**[5] | 60.3$^{b}$ | 67.8$^{a}$ | 54.5$^{c}$ | 68.1$^{a}$ | 50.1$^{c}$ | 68.1$^{a}$ | 1.9 | 0.09 | <0.01 | <0.01 |
| **Tenderness Acceptability, %** | 93.5$^{b}$ | 95.6$^{ab}$ | 86.8$^{c}$ | 96.3$^{ab}$ | 81.9$^{c}$ | 97.5$^{a}$ | 2.9 | 0.55 | <0.01 | <0.01 |
| **Juiciness Acceptability, %** | 82.2$^{b}$ | 96.0$^{a}$ | 77.5$^{b}$ | 96.8$^{a}$ | 63.9$^{c}$ | 96.5$^{a}$ | 3.8 | 0.20 | <0.01 | 0.03 |
| **Flavor Acceptability, %** | 91.0$^{ab}$ | 88.9$^{abc}$ | 85.6$^{bc}$ | 89.9$^{ab}$ | 83.4$^{c}$ | 91.9$^{a}$ | 2.6 | 0.62 | 0.01 | 0.01 |
| **Overall Acceptability, %** | 89.8$^{ab}$ | 88.0$^{bc}$ | 83.3$^{cd}$ | 91.4$^{ab}$ | 78.3$^{d}$ | 93.0$^{a}$ | 3.0 | 0.82 | <0.01 | <0.01 |
| **Willingness to Pay**[6]**, $0.45/kg** | 8.43$^{b}$ | 9.87$^{a}$ | 7.24$^{c}$ | 9.86$^{a}$ | 6.76$^{c}$ | 9.58$^{a}$ | 0.42 | 0.07 | <0.01 | 0.02 |

[1]Quality grade: Prime = USDA Prime with marbling scores ranging from slightly abundant 0 to 100; Choice = average (middle 1/3) Choice with marbling scores ranging from modest 0 to 100; Select = USDA Select with marbling scores ranging from slight 0 to 100.

[2]Muscle: flat = pectoralis profundus; point = pectoralis superficialis.

[3]Pooled (largest) SE of least-squares means.

[4]Observed significance levels for interaction of quality grade × muscle.

[5]Consumer tenderness, juiciness, flavor liking recorded on anchored 100-mm line scale, 0 = not tender, not juicy, and dislike extremely of flavor or overall; 100 = very tender, very juicy, and like extremely of flavor or overall.

[6]Consumer willingness to pay recorded on an anchored line scale in US dollars ranging from $0 to $40 per pound with notation every $5.

[a–d]Within a row, least-squares means without a common superscript differ ($P \leq 0.05$).

### Proximate analysis

An interaction ($P \leq 0.02$) between quality grade and muscle was detected for the percentages of moisture, fat, and protein (Table 5). However, collagen was independently influenced by muscle and quality grade ($P < 0.01$; data not shown in tabular form). Within the Prime and Select briskets, flat portions had greater ($P < 0.05$) protein percentage than point portions; however, protein did not differ ($P > 0.05$) between point and flat portions of Choice briskets. Select and Choice briskets generally had greater protein percentage compared to Prime briskets, regardless of muscle portion. Within each quality grade, point portions had greater ($P < 0.05$) fat percentage than flat portions. Within each muscle portion, Prime samples had greater ($P < 0.05$) fat percentage than Choice or Select, which did not differ ($P > 0.05$). Fat content was greatest in Prime point samples ($P < 0.05$), nearly double the fat percentage of the next closest treatment combination (Prime flat). Fat percentage was lower ($P < 0.05$) in Choice and Select flat samples compared to all other treatment combinations; however, Choice flat and Select point had similar ($P > 0.05$) fat percentage. Prime point portions had lower ($P < 0.05$) moisture percentage than any other treatment combination due to the elevated fat in those samples. Within Prime samples, flat portions had greater ($P < 0.05$) moisture percentage than point portions; however, there were no differences ($P > 0.05$) in moisture percentage between the muscle portions within Choice samples and within Select samples. Select and Choice briskets generally had greater moisture percentage compared to Prime briskets, regardless of muscle portion.

Lastly, regardless of muscle portion, Prime (2.6%) samples had greater ($P < 0.05$) collagen percentage than Choice (2.0%) or Select (1.7%) samples, which did not differ ($P > 0.05$). Point portions had greater ($P < 0.05$) collagen percentage than flat portions, regardless of quality grade (2.5% vs. 1.8%, respectively).

### Correlations

Table 6 displays Pearson correlation coefficients among sensory traits, WTP, and compositional traits for the brisket flat and shows that all traits were correlated ($P < 0.01$). In Table 7, Pearson correlation coefficients among sensory traits, WTP, and compositional traits for the brisket point are displayed. Regardless of muscle portion, tenderness, juiciness, and flavor liking were positively related ($P < 0.01$) to each other and to overall liking. Flavor liking clearly had the strongest relationship to overall liking ($r = 0.89$), but coefficients among tenderness, juiciness, and overall liking were much stronger for flat than point portions. WTP was also positively correlated ($P < 0.01$) to all palatability traits and overall liking for both muscle portions. In the flat portions, fat and collagen percentage were positively associated ($P < 0.01$) with tenderness, juiciness, flavor liking, and overall liking. Conversely, moisture and protein percentages were negatively associated ($P < 0.05$) with palatability traits. In the point portions, collagen was positively linked ($P < 0.05$) with juiciness but did not have a linear relationship to any other palatability trait ($P > 0.05$). Fat percentage was positively associated ($P < 0.05$) with tenderness and juiciness of point portion samples, whereas moisture was negatively correlated ($P < 0.05$) with tenderness and juiciness. Protein percentage of point samples was not associated ($P > 0.05$) with eating quality. Flavor liking and overall liking of point samples were not related ($P > 0.05$) to any of the compositional traits.

**Table 5.** The effects of USDA quality grade[1] and muscle[2] on the composition of beef briskets ($n = 54$; 18/quality grade)

| | Prime | | Choice | | Select | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Trait | Flat | Point | Flat | Point | Flat | Point | SEM[3] | Grade *P* value | Muscle *P* value | Interaction *P* value[4] |
| **Protein, %** | 24.2$^{bc}$ | 21.7$^{d}$ | 24.9$^{ab}$ | 24.5$^{bc}$ | 25.7$^{a}$ | 21.7$^{c}$ | 0.34 | <0.01 | <0.01 | <0.01 |
| **Fat, %** | 7.7$^{b}$ | 14.7$^{a}$ | 4.9$^{cd}$ | 7.6$^{b}$ | 3.6$^{d}$ | 6.6$^{bc}$ | 0.89 | <0.01 | <0.01 | 0.02 |
| **Moisture, %** | 69.4$^{b}$ | 65.0$^{c}$ | 71.1$^{ab}$ | 69.6$^{b}$ | 71.8$^{a}$ | 70.7$^{ab}$ | 0.63 | <0.01 | <0.01 | 0.01 |

[1]Quality grade: Prime = USDA Prime with marbling scores ranging from slightly abundant 0 to 100; Choice = average (middle 1/3) Choice with marbling scores ranging from modest 0 to 100; Select = USDA Select with marbling scores ranging from slight 0 to 100.

[2]Muscle: flat = pectoralis profundus; point = pectoralis superficialis.

[3]Pooled (largest) SE of least-squares means.

[4]Observed significance levels for interaction of quality grade × muscle.

[a–d]Within a row, least-squares means without a common superscript differ ($P \leq 0.05$).

**Table 6.** Pearson correlation coefficients for the relationships among consumer sensory scores and muscle compositional traits for the flat (*pectoralis profundus*) portion of the beef brisket

| | Tenderness | Juiciness | Flavor Liking | Overall Liking | WTP | Collagen | Fat | Moisture |
|---|---|---|---|---|---|---|---|---|
| **Juiciness** | 0.73** | | | | | | | |
| **Flavor Liking** | 0.67** | 0.69** | | | | | | |
| **Overall Liking** | 0.73** | 0.76** | 0.89** | | | | | |
| **WTP** | 0.43** | 0.45** | 0.47** | 0.54** | | | | |
| **Collagen** | 0.13** | 0.16** | 0.10** | 0.14** | 0.08* | | | |
| **Fat** | 0.13** | 0.18** | 0.09** | 0.13** | 0.10** | 0.73** | | |
| **Moisture** | −0.11** | −0.15** | −0.08** | −0.11** | −0.07* | −0.67** | −0.93** | |
| **Protein** | −0.10** | −0.17** | −0.07* | −0.12** | −0.09** | −0.42** | −0.63** | 0.47** |

*Significant correlation ($P \leq 0.05$).

**Significant correlation ($P \leq 0.01$).

WTP, willingness to pay.

**Table 7.** Pearson correlation coefficients for the relationships among consumer sensory scores and muscle compositional traits for the point (*pectoralis superficialis*) portion of the beef brisket

| | Tenderness | Juiciness | Flavor Liking | Overall Liking | WTP | Collagen | Fat | Moisture |
|---|---|---|---|---|---|---|---|---|
| **Juiciness** | 0.66** | | | | | | | |
| **Flavor Liking** | 0.47** | 0.54** | | | | | | |
| **Overall Liking** | 0.51** | 0.57** | 0.89** | | | | | |
| **WTP** | 0.27** | 0.33** | 0.50** | 0.54** | | | | |
| **Collagen** | 0.02 | 0.07* | −0.03 | −0.05 | −0.01 | | | |
| **Fat** | 0.08** | 0.13** | 0.05 | 0.03 | 0.06 | 0.58** | | |
| **Moisture** | −0.08* | −0.13** | −0.05 | −0.03 | −0.06 | −0.56** | −0.98** | |
| **Protein** | −0.02 | −0.06 | 0.01 | 0.03 | 0.02 | 0.02** | −0.67** | 0.64** |

*Significant correlation ($P \leq 0.05$).

**Significant correlation ($P \leq 0.01$).

WTP, willingness to pay.

# Discussion

An increase in beef quality grade typically results in a concurrent increase in intramuscular fat, depending on the muscle (Wahrmund-Wyle et al., 2000). In the current findings, there were more apparent differences in fat percentage between muscles (point and flat portions) than among quality grades. For example, within every quality grade, point portions had greater fat percentage than flat portions. Prime samples did have greater fat percentage than Choice or Select, but Choice and Select had similar fat percentage when comparing within muscle. Previously, Johnson et al. (1988) showed there were vast differences in the composition of the *pectoralis profundus* and *pectoralis superficialis*. Specifically, the *pectoralis superficialis* had greater fat (12.1% vs. 6.3%) and collagen (11.05 mg/g vs. 5.95 mg/g) coupled with less moisture (66.6% vs. 70.1%) and protein (19.9% vs. 22.0%) compared to the *pectoralis profundus*. These samples were derived from 16 carcasses with marbling scores ranging from slight to modest, so the range in carcass quality was condensed compared to the current study. Von Seggern et al. (2005) also illustrated the compositional differences between the *pectoralis profundus* and *pectoralis superficialis* by evaluating muscles from 142 carcasses ranging in quality grade from Select to upper 2/3 Choice—again a narrower range in carcass quality grade than the current study. Much like previous findings, the *pectoralis superficialis* had greater fat (10.66 mg/g vs. 5.49 mg/g) and collagen (16.16 mg/g vs. 8.47 mg/g) along with less moisture (69.79 mg/g vs. 72.66 mg/g) compared to the *pectoralis profundus*. In the findings of both Johnson et al. (1988) and Von Seggern et al. (2005), fat and collagen were nearly doubled in the *pectoralis superficialis* compared to the *pectoralis profundus*. Although absolute values differed among studies, a similar finding was observed in the current study wherein the fat percentage of the point portions was greater across all quality grades and

nearly twice that of the flat portions within Prime and Select.

Muscles from the chuck typically have poor palatability outcomes, especially when they have been cooked using dry heat cookery methods that heat samples relatively rapidly (McKeith et al., 1985; Belew et al., 2003). In fact, Kukowski et al. (2004) found that consumers rated the deep pectoral the toughest, driest, and blandest of the muscles tested from the chuck and rib, which resulted in the lowest WTP. The *complexus*, *serratus ventralis*, *supraspinatus*, *triceps brachii*, *longissimus thoracis*, and the deep pectoral were cooked as steaks (Kukowski et al., 2004). Due to variation in composition, more specifically a higher collagen content (Johnson et al., 1988), utilizing a low and slow cookery method should allow for the solubilization of collagen, resulting in a more tender product.

Palatability differences were observed between muscles in the current study, which was likely influenced by compositional differences. Harris et al. (2017), who similarly utilized a low and slow cookery method for briskets, also detected some differences between point and flat portions; however, those differences were not all consistent with the current findings. In agreement with the current results, juiciness was greater in point than flat portions in all 3 sets of comparisons (7- vs. 21-d, 21- vs. 35-d, and 7- vs. 35-d postmortem aging), which were each designed to compare 2 postmortem aging periods. In contrast to the current findings, flavor liking was greater in the flat than point portions in 1 out the 3 sets, and overall liking was greater in the flat than point portions in 2 out the 3 sets. Tenderness like did not differ between muscle portions (Harris et al., 2017). Harris et al. (2017) believed consumers may actually prefer samples from the leaner flat portion, despite greater juiciness in the point portions, thus resulting in greater overall like for the flat portions. Most other studies that have compared the palatability—or more specifically tenderness, as measured using Warner-Bratzler shear force—utilized dry heat cookery methods. Previous reports have shown that *pectoralis profundus* had greater Warner-Bratzler shear force values than the *pectoralis superficialis* when using dry heat (Johnson et al., 1988; Von Seggern et al., 2005), moist heat (Von Seggern et al., 2005), and low and slow (Harris et al., 2017) cookery methods. Warner-Bratzler shear force analysis was not conducted in the current study; however, despite the utilization of the low and slow cooking method, consumers were still able to detect tenderness differences between the point and flat portions within each quality grade.

Increased marbling level in the *longissimus* muscle is related to increased beef tenderness, juiciness, flavor, and overall palatability ratings in both trained and consumer sensory panels (Smith et al., 1985; Platter et al., 2003; Garmyn et al., 2011; O'Quinn et al., 2012; Emerson et al., 2013; Corbin et al., 2015; Nyquist et al., 2018). However, the effect of marbling on tenderness is more apparent in middle meats than certain end cuts (Nelson et al., 2004; Hunt et al., 2014). Beef palatability research has historically focused on the *longissimus* muscle cooked as unseasoned steaks, leaving a large gap in knowledge of other muscles, especially when cooked and/or served in alternative forms, such as the low and slow cookery method with the addition of salt and pepper in the current study. Despite compositional differences among the quality grades, consumers scored tenderness, juiciness, flavor liking, and overall liking similar for point portions. Prime point samples had nearly double the fat percentage as Choice or Select point samples, suggesting that fat percentage may not be as important a factor to palatability scores in beef briskets. Moreover, Prime flat samples had similar fat percentage as Choice and Select point samples, yet they were consistently scored less tender and juicy and were less liked for their flavor and overall. This theory that fat percentage may not be as important a factor to palatability scores in beef briskets is supported by the low correlation coefficient ($r = 0.13$) between fat percentage and overall liking of the flat portions and the nonsignificant coefficient for the point portions. Samples from the flat portions were differentiated by consumers based on their quality grade. Prime flat samples were always scored more favorably than Choice or Select flat samples; however, Choice and Select flat samples were often scored similarly. The one exception to that trend was juiciness, for which there was a distinct difference between each grade.

Flavor seemed to be the biggest driver in consumer overall liking scores as flavor liking had the strongest correlation. The current results were not unexpected as the previous reports of beef eating quality for US consumers align with these coefficients for the *longissimus* (Hunt et al., 2014; Corbin et al., 2015) and other muscles (Hunt et al., 2014; Crownover et al., 2017; Garmyn et al., 2020a, 2020b). Kukowski et al. (2004) reported strong positive relationships between palatability traits and overall like, but tenderness was the trait with the highest correlation to overall like, suggesting that consumers found tenderness as the most important palatability for the muscles in the rib and chuck. Felderhoff et al. (2020) showed that flavor was the largest contributor to beef consumer satisfaction,

representing 59% of the satisfaction rating, followed by tenderness and juiciness. O'Quinn et al. (2018) determined the relative contribution of each trait to overall liking using multivariate regression, ultimately suggesting that flavor contributed the most (49.4%), followed by tenderness (43.4%) and juiciness (7.4%). Despite the discrepancy in relative contribution, beef palatability was still dependent upon the acceptance of all 3 traits. However, it appears that flavor liking's contribution to overall liking in the current study aligns more closely to the findings of Felderhoff et al. (2020) than to those of O'Quinn et al. (2018). Even so, the current findings also support the relationship of tenderness, flavor, and juiciness conjointly contributing to the consumer perception of overall liking as these traits were highly correlated to each other (Kukowski et al., 2004; Hunt et al., 2014; Corbin et al., 2015; Crownover et al., 2017; Garmyn et al., 2020a, 2020b). Tenderness, juiciness, and flavor liking were all highly correlated with WTP. WTP and overall liking were also highly correlated, but the relationships among eating quality traits and WTP were somewhat diminished compared to those among eating quality traits and overall liking. A similar observation was made by Kukowski et al. (2004), who believed that consumers could be influenced by some factors other than tenderness, juiciness, and flavor when determining WTP or price for the samples.

Approximately 30.3 million briskets are produced in a year according to AMS-USDA (2019) market reports. In this study, consumers were willing to pay more for samples that they perceived as having greater eating quality, which in fact were derived from carcasses with greater quality grades. With an average hot carcass weight of 363 kg, the brisket primal accounts for 4.95% of the carcass yield (AMS-USDA, 2020a). The remaining brisket subprimal (Institutional Meat Purchase Specification #120) has a 64.34% yield resulting in an average brisket weight of 5.79 kg (AMS-USDA, 2020b). Since consumers have indicated that they are willing pay for quality, specifically in smoked beef briskets, this provides the beef industry with an opportunity to merchandise smoked products, differentiating by quality grade and capturing premiums for higher quality grades.

## Conclusions

When smoked briskets were prepared using a low and slow cookery method, an interaction between quality grade and muscle was observed for all palatability traits, acceptability, and WTP. Specifically, consumers scored point portions similarly for all quality grades, and point portions received superior palatability scores to flat portions, but consumers could differentiate among quality grade of flat portions. Prime flat portions were juicier and more tender, with greater flavor and overall liking, compared to Choice and Select flat portions. Previous research has shown that both the brisket point and brisket flat portions are very tough cuts/muscles with high perceivable connective tissue when cooked using a dry heat cookery method. However, this study showed that there was an advantage to preparing briskets using a low and slow cookery method, in which briskets were cooked at low temperatures for long durations of time, because tenderness acceptability did not drop below 85% for any of the treatment combinations. In fact, it was very challenging for consumers to classify a point sample as unacceptable for tenderness, regardless of the quality grade (>95% acceptability).

WTP differences aligned with overall liking scores, suggesting that consumers were willing to pay more for what they perceived as superior eating quality. Considering that briskets are typically sold whole at retail, average WTP by quality grade in the current study was $9.55/lb, $8.55/lb, and $8.17/lb for Prime, Choice, and Select, respectively. Therefore, marketing and soliciting premiums at retail based on quality grade could be a viable option. However, consumers' WTP was no greater for point portions among the different quality grades. Alternatively, there could be value in marketing the flat and point portions separately, as consumers were willing to pay more for point than flat portions, regardless of the quality grade.

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