Relationship of USDA marbling groups with palatability of beef longissimus muscle

A. J. Garmyn, G. G. Hilton, J. B. Morgan, and D. L. VanOverbeke

STORY IN BRIEF

The objective of this study was to evaluate the relationship between USDA quality grade and beef palatability by use of trained sensory panels and Warner-Bratzler shear force (**WBSF)**. Angus cattle from related herds in California, Iowa, and Oklahoma were utilized. Longissimus muscle samples (n = 1,715) were obtained and fabricated into steaks for evaluation by trained sensory panel and WBSF. Quality grade influenced WBSF and all trained sensory panel traits, except livery/metallic flavor. As quality grade increased, steaks were more tender, as evidenced by both WBSF and sensory panel tenderness ratings. Prime steaks were rated juiciest by panelists, while Select and Low Choice were similarly rated below Top Choice for sustained juiciness. Quality grade influenced beef flavor, but not in a linear fashion. The positive linear relationships between USDA quality grade and beef tenderness and juiciness suggest quality grade is still one of the most valuable tools available to predict beef palatability.

Key Words: beef, palatability, quality grade, trained sensory panel, tenderness

INTRODUCTION

Standards for the U.S. beef grading system were first implemented in 1927; however, subsequent amendments have been made, with the final revision occurring in 1997 (USDA, 1997). Quality grades are applied to segment carcasses into uniform groups to predict palatability by evaluating lean surface marbling, firmness, and texture in relation to the carcass maturity. However, variability still exists in tenderness among carcasses within a quality grade. Numerous attempts have been made to predict tenderness on-line through objective measures such as s.c. fat thickness, pH, and lean color, or combinations of multiple traits (Tatum et al., 1982; Jeremiah et al., 1991; Rust et al., 2008). Although some tools were promising, results have been variable. The objective of the current study was to re-examine the relationship of marbling groups with palatability of beef longissimus steaks by use of trained sensory panels and Warner-Bratzler shear force.

MATERIALS AND METHODS

Animal Resources. Three separate but related beef cattle resources were utilized in this study. The Iowa State University Research Herd has been selected for increased intramuscular fat (IMF) since 1996. A related herd exists in California that has been selected for increased IMF. Another related herd exists in Oklahoma that has been selected for increased IMF, ribeye area, and retail product, and decreased back fat since 1993.

Harvest and Data Collection. Cattle were harvested at commercial facilities in Iowa, California, Texas, or Colorado. Trained personnel obtained carcass measurements, including hot carcass

weight (**HCW**), ribeye area (**LMA**), marbling score (**MS**), percentage kidney, pelvic, and heart fat (**KPH**), fat thickness (**FT**), USDA calculated yield grade, and USDA quality grade.

Sample Collection and Preparation. Sample collection was unique in each plant. In Iowa, two rib sections were obtained from each carcass. Samples were fabricated at the Iowa State University Meat Laboratory (Ames) and transported frozen to Oklahoma State University (**OSU**) Food and Agricultural Products Center (**FAPC**) in Stillwater. In California, one rib section was removed from each carcass. Samples were collected, packaged, and transported to OSU FAPC for fabrication. In Texas, strip loins (IMPS #180) were collected, vacuum packaged, boxed, and transported to OSU FAPC. In Colorado, two rib sections were obtained from each carcass. Samples were collected and frozen at 14 d postmortem and shipped to OSU FAPC for fabrication. Two, 2.54 cm, steaks were removed for WBSF and trained sensory analysis. All steaks were vacuum packaged and frozen after aging for 14 d from the harvest date.

Warner Bratzler Shear Force. Steaks were broiled in an impingement at 200ºC to an internal temperature of 68ºC. Following cooking, steaks were allowed to cool before determining shear force values. Six 0.5-in cores were removed from each steak parallel to the muscle fiber orientation. The cores were sheared once by a Warner-Bratzler head attached to an Instron Universal Testing Machine (model 4502; Instron Corp., Canton, MA). Mean peak WBSF was then calculated by averaging the six cores.

Sensory Analysis. Steaks were broiled in an impingement at 200ºC to an internal temperature of 68ºC. Immediately after cooking, samples were uniformly cut from each steak and placed in a cup with the corresponding identification number. Samples were served warm to panelists. Sensory attributes were evaluated by an eight member, trained panel consisting of Oklahoma State University personnel. Samples were evaluated using a standard ballot from the American Meat Science Association (AMSA, 1995), consisting of the evaluation of initial (**IJ)** and sustained juiciness (**SJ**), initial (**IT**) and overall tenderness (**OT**) and connective tissue (**CT**) amount on eight point scales (8 = extremely juicy, tender, none, 1= extremely dry, tough, abundant). Three flavor attributes were evaluated and included beef flavor (**BF**), painty/fishy (**PFF**), and livery/metallic (**LMF**). Flavor intensity was scored on a 3-point scale [not detectable (1) to strongly detectable (3)].

Statistical Analysis. Data were edited by removing USDA Standard carcasses because sample size was insufficient for this quality grade. All statistical analyses were performed using SAS (SAS Inst. Inc., Cary, NC). Dependent variables were tested for significance by analysis of variance using PROC GLM. The statistical model included a fixed effect of USDA quality grade. Since the animals utilized in this study were finished at multiple feeding operations and all genders were not present or equally represented at each feeding location, carcass data were analyzed with feeding location and sex within feeding location included in the model.

Least squares means were computed and separated ($P < 0.05$) using the PDIFF option of GLM. The correlation procedure was used to generate Pearson phenotypic correlations to determine the relationship between WBSF and trained sensory panel traits.

RESULTS AND DISCUSSION

***Carcass Data*.** Carcass traits are in Table 1 by gender within feeding location, since all genders were not present or equally represented at each feeding location. Carcasses from steers fed in Colorado had heavier ($P < 0.05$) HCW than all other groups, whereas steers and heifers fed in Iowa produced lower ($P < 0.05$) HCW than all other groups. Fat thickness was impacted ($P < 0.05$) by gender within feeding location. Steers fed in Texas had significantly greater ($P < 0.05$) FT than all other feeding locations, whereas bulls fed in Iowa deposited the least backfat. Longissimus muscle area and KPH were influenced ($P < 0.05$) by gender within feeding location, but there were no clear patterns based on feeding location or gender for either trait. As seen with FT, USDA calculated yield grade was significantly higher ($P < 0.05$) for steers fed in Texas, while bulls produced carcasses with the lowest yield grade ($P < 0.05$). Bulls produced carcasses with the lowest marbling score when compared to all other groups, whereas steers and heifers in Iowa and steers in Texas had the highest quality grading carcasses ($P < 0.05$).

Table 1. Effect of feeding location[1] and gender on carcass traits of Angus cattle (n = 1,747)

	A	SEM[2]	B		SEM	C			SEM	D	SEM
Item	Steers		Steers	Heifers		Steers	Heifers	Bulls		Steers	
HCW, lb	739.1^{bc}	3.57	786.4^{a}	740.8^{b}	4.85	688.1^{d}	688.3^{d}	735.2^{c}	4.98	738.5^{c}	3.17
FT, in	0.52^{b}	0.01	0.46^{c}	0.54^{b}	0.01	0.44^{c}	0.45^{c}	0.36^{d}	0.01	0.70^{a}	0.01
LMA, in^2	12.34^{c}	0.06	11.92^{a}	12.97^{d}	0.08	11.85^{d}	11.87^{d}	12.88^{ab}	0.08	12.75^{b}	0.05
KPH, %	1.93^{b}	0.02	1.95^{b}	2.04^{a}	0.03	2.08^{a}	2.08^{a}	1.86^{c}	0.03	2.08^{a}	0.02
Calc.YG	3.05^{c}	0.03	2.87^{d}	3.26^{b}	0.04	2.82^{d}	2.86^{d}	2.44^{e}	0.04	3.38^{a}	0.03
MS[3]	5.95^{b}	0.05	5.95^{b}	5.92^{b}	0.07	6.29^{a}	6.31^{a}	5.35^{c}	0.07	6.29^{a}	0.05

[1]A = California; B = Colorado; C = Iowa; D = Texas.
[2] Standard error of the means pooled for each feeding location.
[3] Marbling Score = MS (3.0 = traces; 4.0 = slight; 5.0 = small; 6.0 = modest; 7.0 = moderate; 8.0 = slightly abundant; 9.0 = moderately abundant).
^{abcd} Within a row, means without a common superscript differ ($P < 0.05$).

Tenderness. Quality grade influenced ($P < 0.05$) WBSF and all trained sensory panel traits, except LMF (Table 2). As USDA quality grade increased, steaks were more tender ($P < 0.05$). Warner-Bratzler shear force values were lowest for USDA Prime steaks. Low Choice steaks were tougher than Top Choice (upper two-thirds USDA Choice) steaks, which were both more tender than Select. A similar pattern was observed for trained sensory panel tenderness traits, as Prime steaks were rated higher than all other grades for IT, OT, and CT ($P < 0.05$). Panelists did not initially detect a difference ($P > 0.05$) in tenderness between Low Choice and Select, as they were both rated lowest for IT. However, panelists detected the greatest amount of connective tissue in Select steaks, resulting in the lowest overall tenderness ratings.

Smith et al. (1985) reported steaks from carcasses with higher marbling scores had lower ($P < 0.05$) shear force values and higher ($P < 0.05$) sensory panel ratings than steaks with lower marbling scores, which supports the current results. Wheeler et al. (1994) determined steaks decreased in shear force as marbling increased from traces to small; however, there was no difference in shear force values for steaks within the USDA Choice grade (small, modest, and moderate), which contradicts the present findings. Furthermore, Lorenzen et al. (2003) examined the effect of quality grade on trained and consumer sensory panel ratings, but did not include USDA Prime in that evaluation. Nonetheless, Lorenzen et al. (2003) reported USDA Select were less tender than USDA Choice, but did not detect differences in WBSF, muscle fiber tenderness, or connective tissue amount between Top Choice and Low Choice top loin steaks, which contradicts the current findings.

Juiciness. Prime steaks were rated the juiciest ($P < 0.05$) both initially and overall by trained sensory panelists. Panelists initially rated Top Choice and Select steaks as the least juicy ($P <$

0.05), below Low Choice; however, when panelists evaluated sustained juiciness, they rated Select and Low Choice below Top Choice for SJ. The results for sustained juiciness are in accordance with Lorenzen et al. (2003) that reported that trained sensory panelist rated Top Choice steaks juicier than Low Choice or Select steaks.

Table 2. Least squares means for USDA quality grade effect on Warner-Bratzler shear force (WBSF) and trained sensory panel traits of beef longissimus muscle

	USDA quality grade				
Item	Select	Low Choice	Top Choice[1]	Prime	SEM[2]
N	160	772	683	123	
WBSF, lb	8.64[a]	8.27[b]	7.89[c]	7.21[d]	0.093
Initial juiciness[3]	5.41[b]	5.27[c]	5.45[b]	5.65[a]	0.071
Sustained juiciness[3]	4.97[c]	4.89[c]	5.06[b]	5.30[a]	0.030
Initial tenderness[3]	5.66[c]	5.74[c]	5.90[b]	6.09[a]	0.035
Overall tenderness[3]	5.56[d]	5.73[c]	5.87[b]	6.07[a]	0.036
Connective tissue amount[4]	5.63[d]	5.86[c]	5.93[b]	6.10[a]	0.036
Beef flavor[5]	2.47[b]	2.52[a]	2.49[b]	2.45[b]	0.014
Painty/Fishy flavor[5]	1.17[a]	1.10[b]	1.15[a]	1.17[a]	0.010
Livery/Metallic flavor[5]	1.12	1.10	1.10	1.11	0.008

[1] Top Choice = upper two-thirds USDA Choice.
[2] Pooled standard error of the treatment means.
[3] 1 = extremely dry, extremely tough; 8 = extremely juicy, extremely tender.
[4] 1 = abundant; 8 = none.
[5] 1 = not detectable; 3 = strong.
[abcd] Within a row, means without a common superscript differ ($P < 0.05$).

Flavor. Quality grade significantly ($P < 0.05$) impacted longissimus beef flavor and painty/fishy flavor; however, there was no clear pattern based on USDA quality grade. Panelists rated Low Choice steaks higher ($P < 0.05$) than all other grades for BF and lower ($P < 0.05$) than all other grades for PFF, with no other differences between quality grades. Finally, LMF was not influenced ($P > 0.05$) by USDA quality grade. Lorenzen et al. (2003) reported a lower cooked beef flavor intensity in Low Choice steaks when compared to Top Choice, which both had higher beef flavor intensity than Select. This does not support the current findings.

Correlations. Descriptive statistics were generated for WBSF and sensory traits (data not shown in tabular form). Average WBSF value was 3.67 (range 2.12 to 8.47). From the initial rating of juiciness, sustained juiciness dropped from 5.38 to 5.00. The average panelist rating for IT (5.82; range 3.37 to 7.63) and OT (5.78; range 3.00 to 7.38) was slightly tender, while panelists detected a slight amount (5.88; range 3.13 to 7.25) of connective tissue on average. The beef flavor intensity average was 2.50. The average PFF and LMF were 1.30 and 1.04, respectively.

Table 3. Pearson correlations between Warner-Bratzler Shear force (WBSF) and trained sensory traits of beef LM[1] (n = 1,715)

Trait	IJ	SJ	IT	OT	CT	BF	PFF	LMF
WBSF, kg	**-0.14**	**-0.12**	**-0.62**	**-0.63**	**-0.61**	**-0.05**	**0.01**	**-0.08**
Initial juiciness (IJ)		**0.89**	**0.37**	**0.30**	**0.19**	-0.04	**0.12**	**0.11**
Sustained juiciness (SJ)			**0.35**	**0.31**	**0.22**	**-0.07**	**0.08**	**0.10**
Initial tenderness (IT)				**0.95**	**0.86**	-0.02	0.04	**0.09**
Overall tenderness (OT)					**0.92**	-0.01	-0.01	**0.08**
Connective tissue (CT)						0.02	**-0.07**	**0.07**
Beef flavor (BF)							**-0.47**	**-0.15**
Painty/fishy flavor (PFF)								**-0.06**

[1]Significant correlations are shown in bold ($P < 0.05$).

Pearson correlations between WBSF and sensory traits are in Table 3. There were strong positive correlations ($P < 0.05$) between IT, OT, and CT, with the largest between initial and overall tenderness (r = 0.95). The sensory tenderness traits (IT, OT, and CT) had moderately strong associations ($P < 0.05$) with WBSF in the negative direction. This is in accordance with Shackelford et al. (1995), who found a strong relationship between peak load and overall tenderness for the longissimus dorsi when they compared instrumental tenderness and trained sensory panel tenderness scores. Furthermore, Shackelford et al. (1999) reported a strong negative correlation between WBSF and trained sensory panel (r = -0.72), and Rhee et al. (2004) reported strong negative correlations between WBSF and overall sensory panel tenderness (r = -0.74) and connective tissue (r = -0.65). There was a strong positive correlation ($P < 0.05$) between IJ and SJ (r = 0.89). Beef flavor was significantly correlated ($P < 0.05$) with PFF (r = -0.47) and LMF (r = -0.15), but the relationship with LMF was relatively weak.

USDA quality grade influenced beef palatability traits, including WBSF and trained sensory panel ratings for tenderness, juiciness, and flavor. Several studies have shown similar results; however, results from this study showed differences within USDA Choice for tenderness and juiciness that other researchers have failed to detect. The positive linear relationships between quality grade and tenderness and juiciness may suggest USDA quality grade is still one of the most valuable tools available to predict beef palatability.

LITERATURE CITED

AMSA. 1995. Research Guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of fresh meat. National Live Stock and Meat Board. Chicago, IL.

Belk, K. E., M. H. George, J. D. Tatum, G. G. Hilton, R. K. Miller, M. Koohmaraie, J. O. Reagan, and G. C. Smith. 2001. Evaluation of the Tendertec beef grading instrument to predict the tenderness of steaks from beef carcasses. J. Anim. Sci. 79:688-697.

Jeremiah, L. E., A. K. W. Tong, and L. L. Gibson. 1991. The usefulness of muscle color and pH for segregating beef carcasses into tenderness groups. Meat Sci. 30:97-114.

Lorenzen, C. L., R. K. Miller, J. J. Taylor, T. R. Neely, J. D. Tatum, J. W. Wise, M. J. Buyck, J.

O. Reagan, and J. W. Savell. 2003. Beef Customer Satisfaction: Trained sensory panel ratings and Warner-Bratzler shear force values. J. Anim. Sci. 81:143-149.

Rhee, M. S., T. L. Wheeler, S. D. Shackelford, and M. Koohmaraie. 2004. Variation in palatability and biochemical traits within and among eleven beef muscles. J. Anim. Sci. 82:534-550.

Rust, S. R., D. M. Price, J. Subbiah, G. Kranzler, G. G. Hilton, D. L. VanOverbeke, and J. B. Morgan. 2008. Predicting beef tenderness using near-infrared spectroscopy. J. Anim. Sci. 86:211-219.

Shackelford, S. D., T. L. Wheeler, and M. Koohmaraie. 1995. Relationship between shear force and trained sensory panel tenderness ratings of 10 major muscles from *Bos indicus* and *Bos taurus* cattle. J. Anim. Sci. 79:3333-3340.

Shackelford, S. D., T. L. Wheeler, and M. Koohmaraie. 1999. Evaluation of slice shear force as an objective method of assessing beef longissimus tenderness. J. Anim. Sci. 77:2693-2699.

Smith, G. C., Z. L. Carpenter, H. R. Cross, C. E. Murphy, H. C. Abraham, J. W. Savell, G. W. Davis, B. W. Berry, and F. C. Parrish, Jr. 1985. Relationship of USDA marbling groups to palatability of cooked beef. J. Food Quality. 7:289-308.

Tatum, J. D., G. C. Smith, and Z. L. Carpenter. 1982. Interrelationships between marbling, subcutaneous fat thickness cooked beef palatability. J. Anim. Sci. 54:777-784.

USDA. 1997. Official United States Standards for Grades of Carcass Beef. Agric. Marketing Serv., USDA, Washington, DC.

Wheeler, T. L., D. Vote, J. M. Leheska, S. D. Shackelford, K. E. Belk, D. M. Wulf, B. L. Gwartney, and M. Koohmaraie. 2002. The efficacy of three objective systems for identifying beef cuts that can be guaranteed tender. J. Anim. Sci. 80:3315-3327.

Wheeler, T. L., L. V. Cundiff, and R. M. Koch. 1994. Effect of marbling degree on beef palatability in *Bos taurus* and *Bos indicus* cattle. J. Anim. Sci. 72:3145-3151.

ACKNOWLEDGEMENTS

The authors would like to thank Jim Reecy and J.R. Tait for their collaboration with this project, as well as all involved with carcass data collection and sample transportation. This research was supported by Pfizer Animal Genetics.