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Comparison of Warner-Bratzler shear force values between round and square cross-section cores for assessment of beef *Longissimus* tenderness

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ABSTRACT

The objective of this experiment was to determine whether there is a difference between Warner-Blatzler shear force values of round (WBSF) and square (WBsSF) cross-section cores for assessment of beef tenderness. To compare the effect of core sampling, *Longissimus thoracis* muscles were obtained from 43 beef carcasses at 1, 14, and 28 days postmortem. For each sample, tenderness was assessed by a trained sensory panel and by WBSF and WBsSF techniques. There was a strong and linear relationship ($R^2 = 0.77$) between WBSF and WBsSF, but the average shear force of square cores were ($P < 0.05$) greater than those of round cores. The WBsSF had greater repeatability (R = 0.85 vs 0.81) and explained slightly more of the variation in sensory panel perception of beef tenderness (76% vs 74%) than WBSF. The results indicate that WBsSF seems to be a more precise method of measuring shear force, being little more sensitive for detecting tenderness differences than WBSF.

1. Introduction

The difficulty of standardizing the tenderness evaluation is one of the main problems related to the beef quality. Therefore, researchers have systematically attempted to determine the most accurate and repeatable method to measure shear force and sensory tenderness of cooked meat.

Warner-Blatzler shear force has been the main instrumental method used to evaluate beef tenderness, being well correlated with consumer tenderness ratings (Destefanis, Brugiapaglia, Barge, & Dal Molin, 2008; Miller, Carr, Ramsey, Crockett, & Hoover, 2001). However, the method of sample presentation has a significant effect on both sensory and instrumental evaluation, and ultimately, on the magnitude of the correlation coefficient (Poste et al., 1993). Therefore, both shear force and sensory tenderness measurements would be standardized so that data collected by different researchers would be comparable.

Some of the parameters to be standardized in the shear force evaluation are related to the sample preparation, which for the most part involves cooking specifications such as temperature, method, portion size and end-point temperature, but also includes the fiber orientation and dimension of sub-sections or cores removed for testing (Holman, Fowler, & Hopkins, 2016). Of these factors, obtaining cores correctly oriented parallel to the long axis of the muscle fibers is imperative to obtain the most accurate and repeatable data (Wheeler, Koohmaraie, Cundiff, & Dikeman, 1994; Wheeler, Shackelford, & Koohmaraie, 1996), reducing the variation in shear force protocols.

Comparing Warner-Blatzler shear force measurements using round (WBSF) and square (WBsSF) cross-section cores, Silva et al. (2015) reported that the WBsSF method was technically simpler and allowed for easier recognition of muscle fiber orientation, thereby ensuring that samples were taken parallel to muscle fiber orientation. Besides being described as more rapid, accurate and technically less difficult technique than WBSF, the use of WBsSF should maximize the correlation between instrumental evaluation and tenderness perception, because cuboids samples are commonly used in sensorial protocols. According to Poste et al. (1993), when utilizing both sensory and instrumental analysis to predict tenderness, the correlations were likely to be the greatest when both sampling methods were identical.

This study was conducted to compare the use of WBSF and WBsSF protocols in assessment of beef tenderness and to determine if, and to what extent, the correlation between sensory meat tenderness scores and shear force values can be increased using square (WBsSF) cross-section cores rather than round cores (WBSF).

2. Material and methods

2.1. Meat source and sampling

Vacuum-packaged ribeye (*Longissimus thoracis* muscle, LT) beef cuts from 43 Tabapuã (Brazilian *Bos indicus* breed) animals were purchased at 1 day postmortem from a large commercial processor. Beef LT cuts (experimental units, EU) were transported to Meat Science Laboratory (LabCarnes), in the Department of Food Science (DCA) of the Federal University of Lavras (UFLA), and were randomly assigned to aging times of 1 (n = 11), 14 (n = 22) or 28 (n = 10) days at 1 °C to develop

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a wide range of possible tenderness differences. In order to provide sufficient material for all analyses, each LT cut was frozen (−20 °C) and six 2.54 cm thick steaks were obtained (from the caudal end) using a band saw and sequentially identified in the following manner: steaks #1 and #4 were used for sensory panel evaluation; steaks #2 and #5 were used for assessment of WBSF; and steaks #3 and #6 were used for assessment of WBsSF. After obtaining the sixth steaks, a small sample was also removed from each EU for the myofibril fragmentation index analysis.

2.2. Fragmentation index (FI)

The FI was determined in the frozen samples following the procedure of Davis, Dutson, Smith, and Carpenter (1980), with modifications described by Aroeira et al. (2016).

2.3. Cooking and shearing

Steaks were thawed (4 °C) for 24 h, weighed prior to cooking and grilled at 160–180 °C in a clam-shell grill (Mega Grill; Britain, Curitiba, PR, Brazil) until they reached an internal temperature of 71 °C, monitored by a digital thermometer (TD-880 with K-type thermocouple; ICEL, Manaus, AM, Brazil) inserted into the geometric center of each steak. The cooked steaks were cooled at room temperature for 2 h before weighing and sampling for shear force measurements. The cooking loss was determined by the difference in the weight of the steak before and after cooking, and the result was expressed in percentage.

Shear force measurements were conducted in cylinder (1.27 cm in diameter round cross-section) and cuboid (1.0 cm × 1.0 cm square cross-section) cores according to the Warner-Bratzler Shear Force (WBSF) and Warner-Bratzler square Shear Force (WBsSF) protocols, respectively (Silva et al., 2015). Five to six cores were obtained from each steak in the muscle fiber direction and sheared transversely (across the predominant muscle fiber orientation) at 200 mm/min by a Warner-Bratzler blade coupled to a TA.XTplus texturometer (Stable Micro Systems Ltd., Godalming, Surrey, UK). The average peak shear force (N) of the five cores was used for the statistical analyses.

2.4. Sensory analysis

Steaks were thawed (4 °C) for 24 h and grilled (Mega Grill; Britain, Curitiba, PR, Brazil) until an internal temperature of 72 °C was reached. Immediately after cooking, steaks were sliced and served to an 11-member sensory panel. Members of the sensory panel (age ranging from 23 to 33, being 63.63% female and 37.37% male) were selected and trained according to Cross, Moen, and Stanfield (1978). Each panelist received three random cuboid cores (1.0 cm × 1.0 cm × cooked steak thickness), obtained parallel to the predominant muscle fiber orientation, from each sample. Sensory panelists scored steaks for tenderness on an 8-point scale (1 = extremely tough and 8 = extremely tender).

2.5. Statistical analysis

The data were arranged in a completely randomized design (CRD) and the analysis of variance (ANOVA) for unbalanced data was conducted to determine the effects of aging time. When significant ($P < 0.05$) the means were separated by the Tukey test.

Correlation coefficients among FI, cooking loss, WBSF, WBsSF, and sensory panel tenderness were calculated using SAS System for Windows 9.2 (Statistical Analysis System - SAS Institute Inc., Cary, NC, USA), and the coefficients were tested by the Student *t*-test. Variance components (σ^2) were estimated with the MIVQUEO option of the VARCOMP procedure of SAS. For each muscle, repeatability (R) was calculated as:

$$R = \frac{\sigma^2_{animal} + \sigma^2_{aging}}{\sigma^2_{animal} + \sigma^2_{aging} + \sigma^2_{error}}$$

Linear regression analysis with the WBSF as dependent variable and the WBsSF as independent variable and with the sensory panel tenderness rating as dependent variable and the WBSF and WBsSF as independent variables were carried out to estimate the prediction equation and coefficient of determination (R^2).

Table 1
Simple statistics, repeatabilities, and correlations of experiment traits.

Trait	Aging time (days)	n	Mean	SD	Minimum	Maximum	Repeatability	Correlation to tenderness
MFI	1	11	520,58^a	45,59	448,27	617,54		
	14	22	385,59^b	94,39	239,36	610,20		
	28	10	308,51^c	44,89	253,44	375		
Cooking loos (%)	1	11	25,31^a	1,93	21,62	27,65		
	14	22	21,83^b	3,38	15,07	26,59		
	28	10	21,89^b	1,84	18,17	24,11		
WBSF (N)	1	11	81,72^a	18,05	47,87	103,40		
	14	22	55,43^b	13,54	35,22	76,81		
	28	10	42,67^b	8,24	29,04	56,41		
WBsSF (N)	1	11	100,36^a	17,06	81,91	127,43		
	14	22	66,81^b	16,48	42,58	96,04		
	28	10	49,05^c	10,40	34,92	71,32		
Tenderness rating[1]	1	11	6,24^a	0,64	5,23	7,14		
	14	22	4,83^b	0,91	3,09	6,18		
	28	10	3,67^c	0,83	2,23	5,36		
Means								
MFI		*43*	*402,20*	*106,23*	*239,36*	*617,54*	–	0.63*
Cooking loos (%)		*43*	*22,73*	*3,11*	*15,07*	*27,66*	0.38	0.53*
WBSF (N)		*43*	*59,23*	*19,75*	*29,05*	*103,54*	0.81	−0.86*
WBsSF (N)		*43*	*71,35*	*24,05*	*34,99*	*127,58*	0.85	−0.87*
Tenderness rating[1]		*43*	*4,92*	*1,22*	*2,23*	*7,14*	0.80	–

MFI = myofibril fragmentation index; WBSF = Warner-Bratzler shear force (use of round cross-section cores); WBsSF = Warner-Bratzler square shear force (use of square cross-section cores); SD = standard deviation.
[1] Scores on a scale from 1 (extremely tough) to 8 (extremely tender).
* $P < 0.001$.
[a–c] Within a trait, means followed by the same letter in a given row are not different ($P < 0.05$) by Tukey's test.