Technical Note: Use of belt grill cookery and slice shear force for assessment of pork longissimus tenderness[1]

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ABSTRACT: The present experiments were conducted to determine whether improved beef longissimus shear force methodology could be used to assess pork longissimus tenderness. Specifically, three experiments were conducted to: 1) determine the effect of belt grill (BG) cookery on repeatability of pork longissimus Warner-Bratzler shear force (WBSF), 2) compare the correlation of WBSF and slice shear force (SSF) with trained sensory panel tenderness ratings, and 3) estimate the repeatability of pork longissimus SSF for chops cooked with a BG. In Exp. 1 and 2, the longissimus was removed from the left side of each carcass (Exp. 1, n = 25; Exp. 2, n = 23) at 1 d postmortem and immediately frozen to maximize variation in tenderness. In Exp. 1, chops were cooked with either open-hearth electric broilers (OH) or BG, and WBSF was measured. Percentage of cooking loss was lower ($P <$ 0.001) and less variable for chops cooked with a BG (23.2%; SD = 1.7%) vs. OH (27.6%; SD = 3.0%). Estimates of the repeatability of WBSF were similar for chops cooked with OH (0.61) and BG (0.59). Although significant ($P < 0.05$), differences in WBSF (4.1 vs. 3.9 kg) between cooking methods accounted for less than 5% of the total variation in WBSF. In Exp. 2, the correlation of SSF (r = –0.72; $P < 0.001$) with trained sensory panel tenderness ratings was slightly stronger than the correlation of WBSF (r = –0.66; $P < 0.001$) with trained sensory panel tenderness ratings, indicating that the two methods had a similar ability to predict tenderness ratings. In Exp. 3, duplicate samples from 372 carcasses at 2 and 10 d postmortem were obtained, cooked with BG, and SSF was determined. The repeatability of SSF was 0.90, which is comparable to repeatability estimates for beef and lamb. Use of BG cookery and SSF could facilitate the collection of accurate pork longissimus tenderness data. Time and labor savings associated with BG cookery and the SSF technique should help to decrease research costs.

Key Words: Cooking, Longissimus, Pork, Shear Force, Tenderness

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Introduction

Recent genetic selection for increased swine lean growth rate has raised concerns about possible decreases in pork tenderness. Thus, there has been a recent research emphasis on the effects of genetics on pork quality (Mabry and Baas, 1998). To make substantial progress in determining the genetic sources of variation in pork tenderness requires evaluation of tenderness on a large number of observations. Traditional research techniques for measuring meat tenderness are highly labor intensive, which makes it very expensive to evaluate tenderness on large numbers of samples. We have developed procedures for cookery (Wheeler et al., 1998) and shear force (Shackelford et al., 1999a,b) that have facilitated evaluation of beef longissimus tenderness on large numbers of samples. Wheeler et al. (1998) found that when beef longissimus steaks were cooked for a constant amount of time using a belt grill (**BG**) rather than cooking to a constant endpoint temperature using open-hearth (**OH**) broilers, Warner-Bratzler shear force (**WBSF**) and trained sensory panel tenderness data were more repeatable. Also, we found that shear force data were more repeatable using the slice shear force (**SSF**) protocol that we developed for beef tenderness classification (Shackelford et al., 1999b), rather than the traditional WBSF protocol (Shackelford et al., 1999a). Therefore, the present experiments were conducted to determine whether these procedures could be adapted for use in pork tenderness research. Specifi-

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Table 1. Assignment of pork chops to cooking method for measurement of Warner-Bratzler shear force[a]

	Animal number	
Chop	Odd	Even
1	BG replicate A	OH replicate A
2	BG replicate A	OH replicate A
3	BG replicate B	OH replicate B
4	BG replicate B	OH replicate B
5	OH replicate A	BG replicate A
6	OH replicate A	BG replicate A
7	OH replicate B	BG replicate B
8	OH replicate B	BG replicate B

[a]BG = belt grill, and OH = Farberware open-hearth broiler (Bronx, NY).

cally, three experiments were conducted to: 1) determine the effect of BG cookery on repeatability of pork shear force data, 2) compare the correlation of WBSF and SSF with trained sensory panel tenderness ratings, and 3) estimate the repeatability of pork longissimus SSF for chops cooked with a BG.

Materials and Methods

Experiment 1: Comparison of Cooking Methods

At 1 d postmortem, the longissimus was removed from the left side of 25 pork carcasses and frozen (–20°C) to maximize variation in tenderness. Subsequently, eight 2.54-cm-thick chops were obtained from the center of each frozen loin. For samples cooked to a constant endpoint temperature using OH broilers, and for samples cooked for a constant amount of time using a BG, WBSF was measured in duplicate. The method of assignment of chops to their intended use is shown in Table 1.

Chops were thawed until an internal temperature of 5°C was reached. Belt grill cooking was conducted with a Magigrill (model TBG-60; MagiKitch'n Inc., Quakertown, PA). Belt grill settings (top heat = 163°C, bottom heat = 163°C, preheat = 149°C, height (gap between platens) = 2.16 cm, and cook time = 5.8 min) were designed to achieve a final internal temperature of 71°C for 2.54-cm-thick longissimus chops. After the chops exited the BG, a needle thermocouple probe was inserted into the geometric center of the chop and postcooking temperature rise was monitored with a handheld thermometer (Cole-Parmer, Vernon Hills, IL). The maximal temperature, which occurred about 2 min after the chop exited the BG, was recorded as the final cooked internal temperature.

Electric broiler cooking was conducted with an OH electric broiler (model 450N; Farberware, Bronx, NY). Chops were turned after reaching 40°C and removed from the grill after reaching 71°C internal temperature. Temperature was monitored with iron constantan thermocouple wires that were inserted into the geometric center of each steak and attached to a Beckman Industrial data logger (model 205; Beckman Industrial, San Diego, CA).

Cooked chops were cooled for 24 h at 4°C before removal of three 1.27-cm diameter cores from each chop parallel to the longitudinal orientation of the muscle fibers. Each core was sheared once with a WBSF attachment using an electronic testing machine (model 4411; Instron Corp., Canton, MA). The crosshead speed was set at 200 mm/min.

To help ensure repeatable WBSF data, we typically obtained six cores per sample; however, in the case of pork longissimus, two chops are usually needed to obtain six cores, with three cores coming from each chop. Thus, the experimental unit was the average WBSF value for the six cores from a set of two consecutive chops. Repeatability of WBSF was calculated as the proportion of the total variance that could be attributed to animal variance: repeatability = $\sigma^2_{\text{animal}}/(\sigma^2_{\text{animal}} + \sigma^2_{\text{error}})$. Variance components were estimated with the MIVQUEO option of the VARCOMP procedure of SAS (SAS Inst., Inc., Cary, NC).

Experiment 2: Comparison of Shear Force Methods

At 1 d postmortem, the longissimus was removed from the left side of 23 pork carcasses and frozen (–20°C) immediately to maximize variation in tenderness. Subsequently, seven 2.54-cm-thick chops were obtained from the center of each frozen loin. Two chops were used for measurement of WBSF as before, four chops were used for trained descriptive attribute sensory panel assessment of tenderness (Wheeler et al., 2000), and one chop was used for measurement of SSF. Immediately after cooking, sensory panel chops were trimmed free of epimysium and sliced into 1.3 cm × 1.3 cm × cooked steak thickness cubes. All the cubes from the four chops were mixed and three cubes were randomly assigned to each of the eight trained (Cross et al., 1978) panelists. Panelists evaluated the cubes for tenderness on an eight-point scale (8 = extremely tender and 1 = extremely tough). Immediately after cooking, SSF was determined using the protocol developed for assessment of beef longissimus tenderness (Shackelford et al., 1999a,b). Immediately after cooking, a 1-cm-thick, 5-cm-long slice was removed from each steak parallel to the muscle fibers. The slice was acquired by first cutting across the width of the longissimus at a point approximately 2 cm from the lateral end of the muscle. Using a sample sizer, a cut was made across the longissimus parallel to the first cut at a distance 5 cm from the first cut. Using a knife that consisted of two parallel blades spaced 1 cm apart, two parallel cuts were simultaneously made through the length of the 5-cm-long steak portion at a 45° angle to the long axis of the longissimus and parallel with the muscle fibers. Each sample was sheared once with a flat, blunt-end blade (Shackelford et al., 1999b) using an electronic testing machine (model 4411; Instron Corp.). As with beef (Shackelford et al., 1999a,b), the crosshead speed

Table 2. Simple statistics, repeatabilities, and correlations for Experiments 1 and 2

Trait	Cooking method	n	Mean	SD	Minimum	Maximum	Repeatability	Correlation to tenderness rating
Experiment 1								
Cooked temperature, °C	Belt grill	25	71.1b	2.1	67.3	75.4		
Cooked temperature, °C	Open hearth	25	71.0^{b}	0.0	71.0	71.0		
Cooking loss, %	Belt grill	25	23.2^{c}	1.7	19.1	25.6	0.51	
Cooking loss, %	Open hearth	25	27.6^{b}	3.0	22.1	34.1	0.00	
Warner-Bratzler shear force, kg	Belt grill	25	3.9^{c}	0.6	2.6	5.0	0.59	
Warner-Bratzler shear force, kg	Open hearth	25	4.1^{b}	0.7	2.3	6.3	0.61	
Experiment 2								
Warner-Bratzler shear force, kg	Belt grill	23	3.5	0.7	2.5	5.6		–0.66***
Slice shear force, kg	Belt grill	23	18.9	6.0	10.6	36.8		–0.72***
Tenderness rating[a]	Belt grill	23	6.4	1.1	3.4	7.5		

***P < 0.001.
[a]1 = extremely tough, and 8 = extremely tender.
[b,c]Within a trait, means that do not have a common superscript letter differ.

was set at 500 mm/min. Simple correlations were calculated using SAS.

Experiment 3: Repeatability of Slice Shear Force for Belt Grill Cooked Chops

The right loin was obtained from 372 pork carcasses. At 2 d postmortem, the loins were divided at the 10th rib, and both the anterior and posterior sections were deboned and completely trimmed. Anterior and posterior sections were frozen at 2 and 10 d postmortem, respectively. Subsequently, adjacent 2.54-cm-thick chops were obtained from the 9th-rib region of the frozen anterior section, and two adjacent chops were obtained from the last rib region of the frozen posterior section. Chops were thawed and cooked with BG as described for Exp. 1. Slice shear force was measured as described for Exp. 2.

Aging time differed to create greater variation in tenderness for the evaluation of the repeatability of SSF and was not a factor in the statistical model. Samples obtained at different aging times were treated as completely independent samples. Repeatability of SSF was calculated as the proportion of the total variance that could be attributed to sample (a given carcass at a given number of days postmortem) variance:

$$R = \sigma^2_{\text{sample}}/(\sigma^2_{\text{sample}} + \sigma^2_{\text{error}})$$

Variance components were estimated with the MIVQUEO option of the VARCOMP procedure of SAS.

Results

Experiment 1: Comparison of Cooking Methods

As reported for beef and lamb (Wheeler et al., 1998; Shackelford et al., 2004), percentage of cooking loss was lower (P < 0.001), less variable, and more repeatable for chops cooked with a BG vs. OH (Table 2). Estimates of the repeatability of WBSF were similar for chops cooked with OH and BG. Although significant (P < 0.05), differences in WBSF between cooking methods accounted for less than 5% of the total variation in WBSF. This result suggests that replacement of OH cookery with the less labor-intensive BG method will have little impact on the magnitude or repeatability of pork longissimus WBSF values.

Experiment 2: Comparison of Shear Force Methods

In agreement with our evaluation of SSF as an objective assessment of beef tenderness (Shackelford et al., 1999a), the correlation of pork longissimus SSF with sensory panel tenderness rating was slightly stronger than the correlation of WBSF with tenderness rating (Table 2). Also in agreement with our findings for beef (Shackelford et al., 1999a), the CV of SSF (32%) was larger than the CV of WBSF (19%).

Experiment 3: Repeatability of Slice Shear Force

This experiment was conducted to obtain an accurate estimate of the repeatability of SSF using a large (n = 744) data set that contained a substantial amount of variation in tenderness. Although this data set contained less variation (SD = 5.0 kg) in SSF than the data sets that we used to evaluate this technique in beef (SD = 7.5 kg) and lamb (SD = 13.4 kg), the estimated repeatability (0.90; Figure 1) was comparable to repeatability estimates that we have obtained for SSF for beef and lamb (0.91 and 0.95, respectively; Shackelford et al., 1999a, 2004).

Discussion

Compared with cooking chops or steaks to a constant endpoint temperature with OH broilers, which requires monitoring of the endpoint temperature of steaks/chops with thermocouple wires (AMSA, 1995), cooking for a

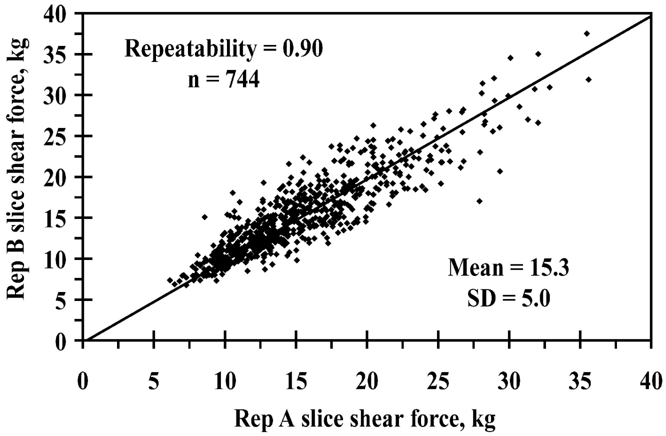

Figure 1. Repeatability of slice shear force of pork longissimus chops cooked with belt grill.

constant amount of time with a BG has numerous advantages. For beef, BG cooking resulted in a substantial improvement in the repeatability of WBSF (0.85 vs. 0.64) and trained sensory panel tenderness ratings (0.87 vs. 0.71; Wheeler et al., 1998). Although there was not a difference in repeatability of pork WBSF between chops cooked using BG and OH in the present study, there are numerous other advantages that dictate that this cooking method should be used for pork palatability research. These include: 1) lower and less variable cooking loss, 2) decreased labor required for cooking, and 3) greater predictability of cooking time, which eliminated the need to hold cooked samples before serving to a sensory panel. For beef, it was hypothesized that the lower and less variable cooking loss of BG vs. OH contributed to the greater repeatability of WBSF and sensory panel tenderness ratings (Wheeler et al., 1998). Yet, in the current study with pork, cooking loss was lower and less variable for BG compared with OH, but repeatability of WBSF did not differ between cooking methods. This contradiction of results may simply be a function of the low level of inherent variation in tenderness in these pork longissimus samples.

As we have discussed in detail previously (Shackelford et al., 1999a), SSF is a much less laborious and technically less difficult procedure than WBSF. The process of slice acquisition is completed in a few seconds rather than the approximately 5 min/sample that is required to determine fiber angle and obtain six “good” cores for WBSF. The present finding that SSF will provide a highly repeatable measurement of pork longissimus tenderness indicates that researchers can make use of this tool in pork tenderness research and substantially decrease research costs. The advantages of this technique are more substantial in large-scale experiments in which tenderness evaluations must be conducted on a large number of animals.

Implications

Belt grill cookery and the slice shear force technique can be used to accurately assess pork longissimus tenderness. Use of these technologies could decrease the labor required for pork tenderness research and might facilitate tenderness evaluation in experiments with a large number of samples. Thus, use of belt grill cookery and the slice shear force technique should decrease research costs and permit in-depth evaluation of the sources of genetic variation in pork tenderness.

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