Sampling Methodology for Relating Sarcomere Length, Collagen Concentration, and the Extent of Postmortem Proteolysis to Pork Longissimus Tenderness,

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Introduction

Samples used for measuring meat tenderness and the associated biochemical traits have generally come from different chops. Samples have been taken from locations 15 cm or more from the location for tenderness measurements (McKeith et al, 1985; DeVol et al., 1988; Wheeler et al., 2000). It seems that measuring these traits on samples from the same location and treated in the same manner would improve evaluations of the relationship between tenderness and other traits. Thus, the objective of this study was to determine whether a greater proportion of the variation in tenderness could be explained by sarcomere length, collagen concentration, and protein degradation measured on the same cooked meat used for shear force determination rather than on a separate raw sample.

Materials and Methods

The Roman L. Hruska U.S. Meat Animal Research Center **(USMARC)** Animal Care and Use Committee approved the use of animals in this study. Pork carcasses were chilled for 24 h at 0°C following humane slaughter at a commercial facility.

The caudal portion of each loin (taken from a point 4 cm caudal to the 10^{th} rib) was vacuum-packaged, stored at 2°C until 7 d postmortem, and then frozen before five 2.54-cm thick chops were removed. From the cranial end, chops one and two were used for slice shear force,

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chops three and four were used for trained sensory evaluation, and chop five was used for raw biochemical trait measurements. Measurements of biochemical traits on cooked sample were made on the slice shear force samples.

For measurements on raw samples, three cubes representing the lateral, central, and medial locations within the chop five were removed for sarcomere length measurement according to the methods of Koolmees et al. (1986). For cooked pork, (chops one and two), two cubes (7 x 7 x 7 mm) were cut from each half of the slice shear force slice (n = 4) after shearing and prepared in the same manner. From each cube, sarcomere length of eight fibers per sample was determined (24 [raw], 32 [cooked] total measurements per chop) as described by Cross et al. (1981). The remainder of the raw and cooked sample was trimmed and powdered for protein degradation and collagen concentration determinations. Total collagen concentration was calculated from HPLC measurement of hydroxyproline as described by Wheeler et al., (2000). Degradation of the myofibrillar protein, desmin, was measured as described by Wheeler and Koohmaraie (1999). Each sample was compared to an at-death standard measured in triplicate.

Slice shear force of pork longissimus was determined on two chops with the average value being reported. However, to simplify interpretation of the data, slice shear force values were converted to Warner-Bratzler shear force values based on an equation from 1561 observations (our unpublished data). An eight-member trained descriptive attribute panel evaluated cooked steaks or chops as described by Wheeler et al. (1998).

Data were analyzed by analysis of variance for a completely randomized design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC). The main effect was cook state. The CORR procedure of SAS was used for simple correlations. The RSQUARE procedure of SAS was used for multiple linear regression of biochemical traits on measures of tenderness.

Results and Discussion

Means and variability in tenderness and biochemical traits are shown in Table 1. Tenderness variation in these samples was relatively large for aged pork and should be sufficient for studying factors potentially associated with that variation. Collagen concentration and desmin degradation were lower and sarcomere length was longer in raw than in cooked samples. The simple correlation coefficients between measurements on raw and cooked samples were low and not significant for sarcomere length, but moderate and significant for all other traits (Table 2). Simple correlation coefficients between biochemical traits and measures of tenderness ranged from low to high. In seven of eight instances, desmin degradation was significantly correlated to measures of tenderness regardless of whether measured on raw or cooked sample. Measurements of collagen concentration in pork were not significantly correlated with measures of tenderness. Measurements of sarcomere length were not significantly correlated with measures of tenderness. In nine of the twelve comparisons of the correlations between raw and cooked measurements to tenderness, the magnitude of the correlations was greater for cooked measurements than for raw, but only two of the comparisons between raw and cooked were significant.

A three-variable model including sarcomere length, collagen concentration, and desmin degradation explained more of the variation in tenderness rating and shear force value when these traits were measured on the cooked samples used to make the shear force determination than when measured on a separate raw sample (Table 3). Although, correlations between measures of tenderness and these individual traits were generally higher for tenderness rating than for shear force, the three-variable model explained more of the variation in shear force than it did the variation in tenderness rating. This difference in the magnitude of correlations with

tenderness rating compared to shear force is likely to be because the cooked sample for the biochemical measurements came from the samples used for shear force measurement and tenderness rating was measured on a separate steak/chop.

Implications

In experiments designed to determine the contribution of various biochemical traits to tenderness variation, the cooked sample used to make tenderness measurements also could be used for biochemical measurements with improved results relative to using a separate raw sample for biochemical measurements.

Literature Cited

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Table 1. Means and variability for meat quality traits for beef and pork longissimus

Trait	N	Mean	SD	Minimum	Maximum	CV, %
Raw	20					
Sarcomere length, µm		1.69[b]	0.07	1.57	1.87	4.1
Collagen, mg/g		4.6[b]	0.7	3.5	6.1	15.2
Desmin, % degraded		83.5[b]	12.3	57.8	97.4	14.7
Cooked						
Sarcomere length, µm	20	1.49[b]	0.07	1.34	1.58	4.7
Collagen, mg/g		5.2[b]	0.8	4.2	6.9	15.4
Desmin, % degraded		91.4[b]	7.3	75.5	99.5	8.0
Warner-Bratzler shear force, kg		3.5	0.9	2.9	4.9	25.7
Tenderness rating[a]		6.0	0.8	4.1	7.4	13.3

[a]1 = extremely tough, 8 = extremely tender.

[b]Means within species differ between raw and cooked state ($P < 0.05$).

Table 2. Simple correlation coefficients between measurements on raw and cooked samples and between meat quality traits and measures of tenderness for pork longissimus by cook state

Trait	Raw vs Cooked	Slice shear force, kg		Tenderness	
		Raw	Cooked	Raw	Cooked
Sarcomere length, µm	0.11	-0.40	-0.08	0.14	0.15
Collagen, mg/g	0.59*	-0.12	0.18	-0.38	-0.33
Desmin, % degraded	0.76**	-0.44	-0.61**	0.53*	0.67**

*P < 0.05.
**P < 0.01.
***P < 0.001.

Table 3. Coefficients of determination for explaining variation in measures of tenderness for pork longissimus by cook state using a three-variable model including sarcomere length, collagen concentration, and desmin degradation

Cook state	Slice shear force, kg	Tenderness
Raw	0.48	0.26
Cooked	0.57	0.42