Use of the *Longissimus* Muscle to Predict Carcass Tenderness

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Background

Tenderness is measured by a number of objective and subjective procedures in research settings: Warner-Bratzler shear force, slice shear force, star-probe, trained sensory panels and untrained consumer panels. An understanding of the relationships among these procedures is important for interpreting the data in the literature.

In general, there is a moderate to strong relationship among the measures of Warner-Bratzler shear force (WBSF), slice shear force (SSF), and sensory panel ratings in beef. Correlations between WBSF and trained sensory panel overall tenderness ranged from -.18 to -.85 (Otremba et al., 1999; Rhee et al., 2004). Ortembra et al. (1999) reported higher correlations between WBSF and the semitendinosus than for WBSF and longissimus where Rhee et al. (2004) reported much higher correlations (-.45 to -.85) for all 11 muscles studied. Correlations between WBSF and consumer panel tenderness ratings ranged from -.16 to -.72 (Lorenzen et al., 2003; Destefanis et al., 2008). Lorenzen et al. (2003) reported a correlation between WBSF and longissimus consumer sensory rating of -.26 compared to the -.72 reported by Destefanis et al. (2008).

The relationship between WBSF and SSF is well established. Correlations between these two methods of tenderness measurements range from .65 to .80 in beef (Shackelford et al., 1999). Reported correlations between SSF and trained sensory panels range from -.58 to -.76 in beef longissimus (Shackelford et al., 1999; Wheeler et al., 2000a). Shackelford et al. (2004) reported a correlation between SSF and trained sensory panel in pork longissimus to be -.72. For both beef and pork, SSF had higher correlations with trained sensory panel tenderness ratings than WBSF (Shackelford et al., 1999; Shackelford et al., 2004). A comparison of SSF to untrained or consumer beef panel revealed a strong correlation of .92 (Wheeler et al., 2004).

Lonergan et al. (2001) investigated the relationship between the star-probe attached to an Instron Universal Testing Machine, WBSF, and trained sensory panel in pork. They reported a correlation of .68 between WBSF and star-probe. Additionally, there was a correlation of -.55 between WBSF and sensory panel and -.54 between star-probe and sensory panel. Two additional studies investigated the relationship between star-probe and sensory panel; Huff-Lonergan et al. (2002) and Lonergan et al. (2007) both reported a moderate correlation of -.54 between these two measures of tenderness.

There are several factors that affect tenderness, but four are considered the most important: postmortem proteolysis, intramuscular fat, connective tissue, and contractile state of the muscle (Belew et al., 2003). While no one procedure can accurately evaluate all of these factors, WBSF, SSF and star-probe seem to be moderately good indicators of human perception of tenderness.

Comparison of Longissimus to Other Muscles in the Carcass

While many researchers have looked at multiple muscles, few have compared the muscles to other muscles in the carcass. Belew et al. (2003) compared the WBSF of 40 different beef muscles. This produced 800 muscle to muscle comparisons, 60% of which produced moderate to high correlations (Belew et al., 2003). Of the correlations reported, 166 ranged from .70 to .99, 314 ranged from .50 and .69, and 173 ranged from .30 and .49 (Belew et al., 2003). There were 26 negative correlations in this data set (Belew et al., 2003) and 121 correlations were not reported. This indicates that some muscles might be better predictors of overall carcass tenderness than others. Simoes et al. (2005) compared nine muscles in an attempt to identify one muscle as an indicator for the other muscles. This study took an interesting approach to identifying the indicator muscle; they had a combined mean of all the muscles and then looked for the individual muscle that was not statistically different from the combined mean. This work pointed to the biceps femoris as the preferred indicator muscle (Simoes et al., 2005).

The longissimus muscle is the most studied muscle in meat science, and current grading techniques in beef expose the longissimus muscle before fabrication. From a practicality stand point this makes the longissimus muscle the most desirable candidate for comparison with other muscles. Table 1 summarizes the relationship between the longissimus muscle and other muscles in the carcass across specie and measurement methods from published data sets. The correlations are made within the same aging time and a combination of quality grades unless otherwise noted in the table. While many of the correlations presented in Table 1 are highly significant, they are all in the low to moderate range. There is a tendency for the correlations between the longissimus and muscles of the beef round to have higher magnitude correlations than some of the other muscle groups. Additionally, the relationships between the muscles in beef do not seem to be the same in the other species, but there was only one data set for pork used in this review.

Wheeler et al. (2000a) implemented a tenderness classification system to examine the relationship between classifying the longissimus muscle and the tenderness of the gluteus medius, semimebranosus, and biceps femoris using a trained sensory panel. Data adapted from that study is presented in Table 2. Tenderness classification into tender, intermediate and tough categories based on longissimus muscle slice shear force successfully sorted the longissimus, semimembranosus, and biceps femoris into the three categories. The tenderness classification system used sorted the tough gluteus medius muscles from the tender and intermediate muscles.

Conclusion

There is a moderate and significant relationship between tenderness in the longissimus muscle and other muscles in the carcass for beef. Tenderness classification based on the longissimus muscle can segment other muscles into those same classifications. **Muscles from a carcass with a tender longissimus are more tender than their counterpart muscles in a carcass with a tough longissimus muscle.** Because of current beef grading activities and practicality in an industrial setting, the longissimus muscle is the logical muscle in which to predict tenderness of a carcass.

Table 1: Comparison of correlations between *longissimus* muscle tenderness and other muscles[1] of the carcass

Study	Specie	Measure[2]	AD	BF	GM	IS	PM	QF	RF	SM	SS	ST	TB
Shackelford et al., 1995	Beef	WBSF	-	.43**	.40**	-.03	.12	.33*	-	.26	.42**	.13	.56***
Wheeler et al., 2000a	Beef	Sensory	-	.43*	.68**	-	-	-	-	.58**	-	-	-
Wheeler et al., 2000a	Beef	SSF to Sensory	-	-.41*	-.31*	-	-	-	-	-.47*	-	-	-
Wheeler et al., 2000b	Pork	Sensory	-	.17	-	-	-	-	-	.54**	-	.34	.36
Rhee et al., 2004	Beef	WBSF	.05	.54**	.53*	-.02	.44*	-	.43*	.51**	.56**	.26	.50**
Rhee et al., 2004	Beef	Sensory	.38*	.55**	.73***	.32	.54**	-	.46**	.51**	.32	.31	.42*
Gruber et al., 2006[3]	Beef (Upper $^{2}/_{3}$ Choice)	WBSF	-	-.04	.26	.09	.19	-	.42*	.37*	.10	.29	.28
Gruber et al., 2006[3]	Beef (Select)	WBSF	-	.02	.39*	-.05	.07	-	.17	.30†	.05	.12	-.07

[1]AD = adductor, BF = biceps femoris, GM = gluteus medius, IS = infraspinatus, PM = psoas major, QF = quadriceps femoris, SM = semimembranosis, SS = supraspinatus, ST = semitendiosus, TB = triceps brachii

[2]WBSF = Warner-Bratzler shear force, Sensory = trained sensory panel, SSF = slice shear force

[3]Adapted from these data sets, correlations provided by authors

†*P*<0.10

**P* < 0.05

***P* <0.01

****P* < 0.001

Table 2: Trained sensory descriptive attribute ratings for tenderness[a] (Mean $\pm$ SEM) by tenderness class and muscle with 14 d postmortem aging[1]

Tenderness classification[b]	*Longissimus*	*Gluteus medius*	*Semimembranosus*	*Biceps femoris*
Tender	7.7 $\pm$ 0.20[c]	6.8 $\pm$ 0.18[c]	6.4 $\pm$ 0.18[c]	5.9 $\pm$ 0.16[c]
Intermediate	7.1 $\pm$ 0.11[d]	6.5 $\pm$ 0.10[c]	5.8 $\pm$ 0.10[cd]	5.4 $\pm$ 0.09[d]
Tough	6.3 $\pm$ 0.27[e]	5.8 $\pm$ 0.25[d]	5.1 $\pm$ 0.25[e]	4.8 $\pm$ 0.21[e]
Unsorted	7.1 $\pm$ 0.09[d]	6.5 $\pm$ 0.08[e]	5.8 $\pm$ 0.08[d]	5.4 $\pm$ 0.07[d]

[1]Adapted from Wheeler et al., 2000a

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

[b]Based on 2 d postmortem longissimus slice shear force: tender = < 26 kg, intermediate = 26 to 42 kg, tough = > 42 kg, and unsorted = all 98 samples

[c,d,e]Means lacking a common superscript letter differ ($P < 0.05$)

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