

**EFFECTS OF FREEZING AND LOCATION  
WITHIN THE BEEF *LONGISSIMUS* MUSCLE  
(STRIP LOIN STEAK) ON TENDERNESS**

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**Summary**

Twenty-four USDA Select strip loins (IMPS 180) were aged (32°F) until 14 days postmortem and fabricated into *longissimus* muscle (strip loin) steaks (1-in. thick). Then, steaks were either cooked or stored at -20°F for an additional 17 days before they were thawed and cooked. Cores and sensory panel samples were removed from the medial, center, and lateral sections of each steak and locational identify maintained. In addition, a random composite of cubes from an entire steak was used for a sensory panel evaluation. Previously frozen steaks had lower Warner-Bratzler shear force (WBSF) values, less cooking loss, and a shorter cooking time than fresh (non-frozen) steaks; however, no difference was found for combined thawing and cooking loss. Cores from the medial section of steaks had lower WBSF values than cores from the center section. A sensory panel found that the medial section was more tender than the lateral section and had less detectable connective tissue than the center or lateral sections or samples taken at random. The center and random treatments were juicier than the lateral section. Highest correlations between sensory panel tenderness and WBSF were obtained when the medial and lateral sections were averaged ( $r=-0.74$ ,  $r=-0.69$ ) and when all three sections were averaged ( $r=-0.70$ ,  $r=-0.69$ ) for fresh and frozen WBSF steaks, respectively. Freezing lowered WBSF values and the medial section of the steak was the most tender. An awareness of these results and potential procedural artifacts

must be considered when handling and sampling steaks, and interpreting results.

(Key Words: Beef, *Longissimus* dorsi, Freezing, Steaks, Tenderness.)

**Introduction**

Previous work in our laboratory has shown that pork tenderness can be improved by freezing. Additional benefits of freezing are longer storage periods, better product control, and more flexibility in inventory. Many researchers have found differences in tenderness between the lateral and medial sections of the *longissimus* muscle, but have disagreed which section is most tender. If such differences actually exist, they must be accounted for in order for tenderness measurements to be accurate. Our objectives were to determine effects of location within the *longissimus* muscle, and effects of freezing, on WBSF and sensory panel attributes.

**Experimental Procedures**

Twenty-four USDA Select strip loins (IMPS 180) from a commercial packing facility (2 days postmortem) were stored at  $32 \pm 2^\circ\text{F}$  until 14 days postmortem. Loins were trimmed of external fat, faced, and fabricated into seven 1-in.thick *longissimus* muscle steaks, starting at the anterior end. One steak was randomly assigned to fresh (non-frozen) WBSF, one to frozen WBSF, and five steaks to sensory panel evaluation. Steaks assigned to the fresh WBSF treatment were immediately weighed and cooked after aging. All

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other steaks were vacuum packaged and stored at  $-20^{\circ}\text{F}$  for 17 days until analysis. Frozen WBSF steaks were thawed for 27 hours at  $37^{\circ}\text{F}$  before they were weighed, removed from the bag, and reweighed to determine thawing loss. In addition, cooking time and weight after cooking were recorded and percentage of cooking loss for both WBSF treatments was calculated.

All steaks were cooked to  $158^{\circ}\text{F}$  internally in a Blodgett dual-air-flow convection gas oven preheated to  $325^{\circ}\text{F}$ . Steak temperature was monitored using a 30-gauge, type T thermocouple inserted into the geometric center of each steak. Steaks for WBSF were then stored overnight at  $37^{\circ}\text{F}$ . Following refrigeration, six  $\frac{1}{2}$ -in. diameter cores were taken parallel to muscle fibers. Two cores each were taken from the medial, center, and lateral portions of each steak. Cores were sheared perpendicular to muscle fiber orientation using an Instron Universal Testing Machine with a WBSF attachment.

Sensory panel steaks were thawed for 24 to 36 hours at  $37^{\circ}\text{F}$  and cooked using the same procedures as for WBSF steaks. Cooked steaks were trimmed of epimysial connective tissue and any remaining external fat, cut into  $\frac{1}{2} \times \frac{1}{2}$  in.  $\times$  steak thickness cubes and placed in pre-heated double boilers. The random treatment contained a composite of random cubes from an entire steak. The medial, center, and lateral sections from four steaks were identified and separated. The center portion consisted of a 2-in. section centered at the point where the medial and lateral muscle fibers conjoin.

Sensory evaluation was conducted in individual booths having a mixture of red and green lighting. Duplicate samples for each treatment were presented to experienced panelists in a statistically randomized order. All treatments within a single loin were evaluated during a session. Samples were evaluated for five sensory

attributes using an eight-point numerical scale and scored to the nearest 0.5. Traits assessed were: myofibrillar tenderness (1 = extremely tough, 8 = extremely tender), juiciness (1 = extremely dry, 8 = extremely juicy), beef flavor intensity (1 = extremely bland, 8 = extremely intense), connective tissue amount (1 = abundant, 8 = none), and overall tenderness (1 = extremely tough, 8 = extremely tender).

All data were analyzed as a randomized complete block design in which loin served as the blocking factor. Data for WBSF were analyzed in a split plot design with fresh and frozen treatments as the main plots and location within the *longissimus* (random, medial, center, and lateral) as the subplots. Means were separated by least significant differences when respective F-tests were significant, using appropriate error terms for split plot analyses (Mixed procedures of SAS, 2000). Mixed procedures of SAS (2000) were used to determine sensory panel treatment differences and means were separated ( $P < 0.05$ ) using least significant differences. Correlations were determined using the Corr procedure of SAS (2000).

## Results and Discussion

Previously frozen steaks had lower ( $P < 0.05$ ) WBSF values, less cooking loss, and a shorter cooking time than fresh (non-frozen) steaks (Table 1). However, no difference ( $P = 0.95$ ) was found for total loss (combination of cooking loss and drip loss). The improved tenderness due to freezing may be attributed to ice crystal formation causing myofibrils to rupture, connective tissue to stretch, and/or some proteolysis. The shorter cooking time for previously frozen steaks may be because drip loss was removed prior to cooking, resulting in less evaporative loss during cooking.

The medial section had lower ( $P < 0.05$ ) WBSF values than the center section and tended to have lower ( $P = 0.09$ ) WBSF values than the lateral section (Table 2). Further-

more, sensory panel myofibrillar and overall tenderness scores were higher (more tender;  $P < 0.05$ ) for the medial section than the lateral section. Connective tissue amount scores were also higher (less detectable connective tissue;  $P < 0.05$ ) for the medial section compared to the center section, lateral section, and random treatment. Also, the center section had higher ( $P < 0.05$ ) connective tissue scores than the lateral section. *Longissimus* muscle juiciness scores were higher (more juicy;  $P < 0.05$ ) for the center and random treatments when compared to the lateral section. Differences in tenderness between the medial and lateral sections of the *longissimus* may be partially attributed to the muscle's shape, chill rate, and function. Typically, the medial section of the *longissimus* steak is wider and has more mass than the lateral section. During carcass chilling, the lateral section may chill faster than the medial, causing slower glycolysis, as evidenced by occasional occurrences of cold toughening. Also during cooking, the narrower lateral section may reach a higher endpoint cooking temperature than the wider medial section.

Fresh WBSF values were correlated to sensory panel overall tenderness scores for the medial ( $r = -0.66$ ), center ( $r = -0.52$ ), lateral ( $r = -0.73$ ), and an average of medial and lateral ( $r = -0.74$ ) locations. Average fresh WBSF values were also correlated to overall tenderness scores ( $r = -0.70$ ). Frozen WBSF values were also correlated to overall tenderness scores ( $r = -0.62$ ,  $-0.58$ ,  $-0.69$ ,

$-0.69$ ) for medial, lateral, average of medial and lateral, and average of all three locations, respectively. For the random treatment, fresh WBSF was not correlated to sensory panel overall tenderness for many locations or location combinations within the *longissimus*, but all locations of frozen WBSF were moderately correlated (ranging from  $r = -0.47$  to  $r = -0.54$ ) to sensory panel overall tenderness.

Location within the *longissimus* is important when correlating sensory panel tenderness and WBSF, because of tenderness variability. Overall, highest correlations between sensory panel and fresh WBSF values were obtained when the medial and lateral sections were averaged, with the center portion excluded, or when all three sections were averaged. This trend was also found when sensory panel tenderness and WBSF values of steaks that were previously frozen were correlated, although some correlations were lower. Because of tenderness variation within a steak, random location source of cubes during sensory panels resulted in lower correlations between WBSF and sensory panel tenderness. To achieve high correlations between sensory panel tenderness and WBSF, steaks should be divided into specific sections and values for all sections averaged. This study confirms the importance of location identification of samples and uniform handling throughout the course of any experiment.

**Table 1. Effects of Freezing on Warner-Bratzler Shear Force (WBSF), Cooking Loss, Drip Loss, Total Loss, and Cooking Time for Longissimus Muscle Steaks**

Item	Fresh <sup>a</sup>	Frozen <sup>b</sup>	SE
WBSF, kg	4.37 <sup>z</sup>	3.83 <sup>y</sup>	0.21
Cooking loss, %	27.65 <sup>z</sup>	24.70 <sup>y</sup>	0.69
Drip loss, %	-----	2.98	-----
Total loss, %	27.65	27.71	0.71
Cooking time, min	31.25 <sup>z</sup>	28.21 <sup>y</sup>	1.07

<sup>a</sup>Steaks were cooked at 14 days postmortem

<sup>b</sup>Steaks were frozen at 14 days postmortem and stored for an additional 17 days before cooking

<sup>yz</sup>Means within a row with different superscript letters differ (P < 0.05)

**Table 2. Effects of Location Within the Longissimus Muscle on Warner-Bratzler Shear Force (WBSF) Force and Sensory Panel Attributes**

Trait <sup>b</sup>	Location <sup>a</sup>				SE
	Medial	Center	Lateral	Random <sup>c</sup>	
WBSF, kg	3.84 <sup>y</sup>	4.34 <sup>z</sup>	4.11 <sup>yz</sup>	-----	0.22
Myofibrillar	5.74 <sup>z</sup>	5.54 <sup>yz</sup>	5.31 <sup>y</sup>	5.54 <sup>yz</sup>	0.15
Connective Tissue	6.61 <sup>z</sup>	6.42 <sup>y</sup>	6.23 <sup>x</sup>	6.37 <sup>xy</sup>	0.11
Juiciness	5.62 <sup>yz</sup>	5.68 <sup>z</sup>	5.43 <sup>y</sup>	5.63 <sup>z</sup>	0.08
Flavor Intensity	5.82	5.88	5.79	5.86	0.05
Overall Tenderness	5.93 <sup>z</sup>	5.69 <sup>yz</sup>	5.45 <sup>y</sup>	5.69 <sup>yz</sup>	0.15

<sup>a</sup>Steaks were divided into medial, center, and lateral locations

<sup>b</sup>Sensory traits were evaluated on an eight-point scale; (myofibrillar tenderness, 1=extremely tough, 8=extremely tender; connective tissue amount, 1=abundant, 8=none; juiciness, 1=extremely dry, 8=extremely juicy; flavor intensity, 1=extremely bland, 8=extremely intense; overall tenderness, 1=extremely tough, 8=extremely tender)

<sup>c</sup>Cubes were randomly chosen from the entire steak

<sup>xyz</sup>Means within a row with different superscript letters differ (P < 0.05)