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Factors associated with surface iridescence in fresh beef

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Abstract

The objective of this study was to investigate factors associated with surface iridescence in fresh beef. Eight muscles were evaluated for occurrence of surface iridescence: *Biceps femoris* (BF), *Gluteus medius* (GM), *Longissimus lumborum* (LD), *Psoas major* (PM), *Rectus femoris* (RF), *Semimembranosus* (SM), *Semitendinosus* (ST), and *Tensor fasciae latae* (TF). Incidence of surface iridescence was 91% for ST, 34% for SM, 27% for LD, 20% for GM, 12% for RF, 9% for BF, 8% for TF, and 6% for PM ($P<0.05$). Factors associated with surface iridescence in the ST were further examined because iridescence was observed to a much higher degree in the ST as compared with other muscles evaluated. Greater ST surface iridescence was associated with larger ribeye areas, more youthful lean maturity scores, higher L^*, a^* and b^* colorimeter values, lower ultimate pH values, and faster cooking ($P<0.05$).

Keywords: Beef; Color; Surface iridescence

1. Introduction

Color is probably the single greatest appearance factor that determines whether or not meat cuts will be purchased (Kropf, 1980). Thus, deviations from normal meat color may decrease the value of meat products and result in consumer dissatisfaction. One such problem is the natural occurrence of iridescence, which is a rainbow-like or multicolored appearance (Obuz & Kropf, 2002) sometimes found in fresh beef muscles and often present in cooked meats. Consumers may associate iridescent colors with chemical or bacterial contamination of meat products (Wang, 1991), which may result in consumer refusal of products. Swatland (1984) studied iridescence in cooked cured beef and reported that green iridescence was the most common color, which helps explain why consumers may confuse iridescence with spoilage of meat products.

Swatland (1984) determined that iridescence was a result of microstructural diffraction by myofibrils. Wang (1991) found that the presence of iridescence was affected by angles of lighting and observation and orientation of the meat. Swatland (1988) showed that the appearance of iridescence had little or no relationship with sarcomere length. Rather, Swatland (1988) concluded that iridescence was likely related to hydration state of the tissue. It has been shown that iridescence increases as water-holding capacity decreases (Wang, 1991). Considering the relative incidence and severity of iridescence in beef products, relatively little information on this phenomenon has been reported in the literature. Therefore, the objective of the current study was to further investigate factors associated with iridescence in fresh beef.

2. Materials and methods

2.1. Carcasses and muscle sampling

Sixty-four beef carcasses were selected at a commercial beef packing plant in Joslin, Illinois to represent a wide range in muscle color (see Wulf & Page, 2000 for more on carcass selection). The carcasses selected were all "Young" (61 carcasses with "A" maturity scores,

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three carcasses with "B" maturity scores), represented a somewhat narrow marbling range (35 carcasses with "small" marbling scores, 29 carcasses with "slight" marbling scores), represented both common sex classes (50 steer carcasses, 14 heifer carcasses), and included six "dark cutting" carcasses (USDA, 1997). Carcasses were held at 0–2 °C until fabrication. At 7 days postmortem, the following muscles were excised from one hindquarter of each carcass: *Biceps femoris* (BF), *Gluteus medius* (GM), *Longissimus lumborum* (LD), *Psoas major* (PM), *Rectus femoris* (RF), *Semimembranosus* (SM), *Semitendinosus* (ST), and *Tensor fasciae latae* (TF). Each muscle was then bisected perpendicular to the long axis of the muscle at the approximate mid point.

2.2. Measurements

Fresh cut surfaces of muscles were allowed to bloom for 90 min. A trained graduate student used a five-point scale to rate surface iridescence of fresh cut surfaces after bloom time had elapsed for each muscle (1 = no iridescence, 2 = slightly iridescent, 3 = moderately iridescent, 4 = very iridescent, 5 = extremely iridescent). The iridescence scoring was accomplished by changing the observation angle for each sample to that angle which resulted in the greatest iridescence. The size of the iridescence area and the intensity of the iridescence were both taken into account when assigning iridescence scores. Ultimate muscle pH was measured on the fresh cut muscle surface using a Meatcheck 160 pH meter (Sigma Electronic GmbH Erfurt, Erfurt, Germany) equipped with a puncture-type combination pH probe (LoT406-M6-DXK-S7/25, Mettler-Toledo GmbH, Urdorf, Switzerland). After the 90 min bloom time, colorimeter readings (CIE L^*, a^*, b^* values) were measured with a Minolta Chroma Meter CR-310 (Minolta Corp., Ramsey, NJ) with a 50-mm-diameter measurement area using a D65 illuminant. Subprimals were then vacuum-packaged and frozen at −26 to −30 °C.

Frozen subprimals were then cut into 2.5 cm-thick steaks for Warner-Bratzler shear force on a band saw, vacuum packaged, and placed back into frozen storage. Steaks for shear force were thawed for 24 h at 1–2 °C and cooked on a belt-fed impingement oven (model 1132-000-A, Lincoln Foodservice Products, Inc., Fort Wayne, IN). Preliminary test cooking was done to determine appropriate cooking times to reach 71 °C internal temperature. Cooking times and actual internal temperatures reached for each muscle were reported by Wulf and Page (2000). Cooked steaks were cooled to room temperature (≈21 °C) before six cores were removed parallel to the muscle fiber orientation and individually sheared once on a Warner-Bratzler shear machine (G-R Manufacturing Co., Manhattan, KS). An average Warner-Bratzler shear force was calculated and recorded for each steak.

2.3. Statistical analysis

Chi-square analysis was used to test for differences among muscles in surface iridescence scores. Simple correlations were calculated between ST surface iridescence, carcass traits, cooking traits, and Warner-Bratzler shear force. Data were also analyzed with PROC GLM (SAS Institute Inc., Cary, NC) using a one-way ANOVA to test for differences among ST iridescence scores (independent variable = ST iridescence score; dependant variables = carcass and muscle measurements) and to test for differences between sex classification, marbling score, and dark cutting status (independent variables = sex classification, marbling score, and dark cutting status; dependant variables = ST iridescence scores). Least squares means were separated using pairwise *t*-tests.

3. Results and discussion

Across all muscles, the incidence of iridescence scores was 74.0, 17.0, 7.6, 1.4, and 0.0% for scores 1, 2, 3, 4, and 5, respectively. Ranked from greatest to least muscle surface iridescence occurrence (percentage with iridescence scores of two or greater) were the ST (90.6%), SM (34.4%), LD (26.6%), GM (20.3%), RF (12.5%), BF (9.4%), TF (7.9%), and PM (6.3%) (Fig. 1).

Iridescence was observed to a much higher degree in the ST as compared with the other muscles investigated (Fig. 2). Wang (1991) found that ST muscles showed considerably more iridescence than BF muscles. Moreover, Lawrence, Hunt, and Kropf (2002) reported that iridescence intensity and percentage of iridescent area of cooked meat was greatest in the ST muscle, followed by the SM and BF.

Table 1
Correlation coefficients between *Semitendinosus* iridescence and carcass traits, colorimeter values, pH, cooking traits, and Warner-Bratzler shear force

Variable	Correlation	*P*
Skeletal maturity	−0.05	0.72
Lean maturity	−0.35	0.01
Overall maturity	−0.20	0.11
Marbling	−0.01	0.91
Hot carcass weight, kg	0.11	0.41
Fat thickness, mm	0.09	0.47
Ribeye area cm^2	0.30	0.02
Yield grade	−0.10	0.41
Semitendinosus L^*	0.40	0.01
Semitendinosus a^*	0.32	0.01
Semitendinosus b^*	0.37	0.01
Semitendinosus ultimate pH	−0.41	0.01
Semitendinosus final cooked temperature, °C	−0.28	0.02
Semitendinosus cooking loss	−0.03	0.82
Semitendinosus Warner-Bratzler shear force, kg	−0.06	0.64

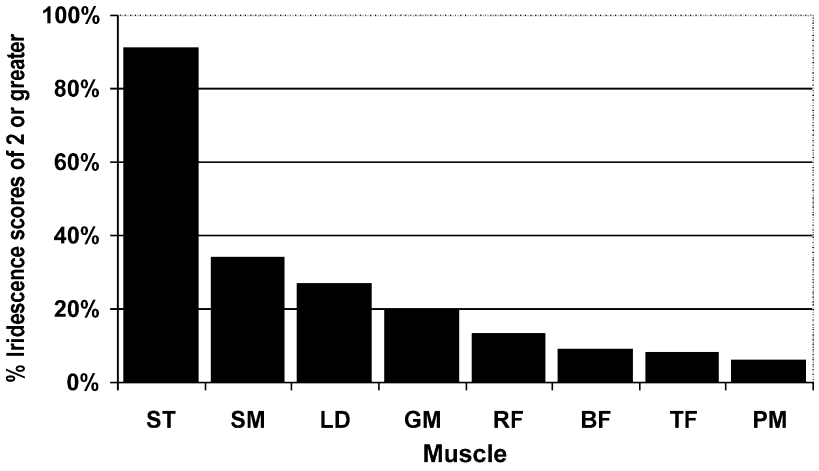

Fig. 1. Frequency of surface iridescence by muscle (1 = no iridescence, 2 = slightly iridescent, 3 = moderately iridescent, 4 = very iridescent, 5 = extremely iridescent) ($P < 0.05$).

Table 2
Least squares means of carcass traits, colorimeter values, pH, cooking traits, and Warner-Bratzler shear force with *Semitendinosus* iridescence

Variable	1 ($n = 6$)	2 ($n = 16$)	3 ($n = 35$)	4 ($n = 7$)	P
Skeletal maturity[a]	163±5.0	167±3.1	163±2.1	164±4.6	0.82
Lean maturity[a]	200g±12.8	172h±6.8	162h±2.6	159h±9.6	0.03
Overall maturity[a]	172±6.2	170±3.8	164±2.6	163±5.8	0.40
Marbling[b]	410±19.5	408±12.0	404±8.1	411±18.1	0.98
Hot carcass weight, kg	345±17.4	332±10.7	342±7.2	357±16.1	0.61
Fat thickness, mm	8±1.9	9±1.1	11±0.8	8±1.7	0.29
Ribeye area, cm^2	87g±4.1	84g±2.5	88g±1.7	99h±3.8	0.02
Yield grade	2.3±0.3	2.5±0.2	2.5±0.1	1.9±0.3	0.22
Semitendinosus L^*[c]	35g±1.6	39gh±1.0	41h±0.7	41h±1.5	0.01
Semitendinosus a^*[d]	21g±1.2	24h±0.7	25h±0.5	25h±1.1	0.03
Semitendinosus b^*[e]	8g±0.9	10h±0.5	11h±0.4	11h±0.8	0.01
Semitendinosus ultimate pH	5.9g±0.1	5.5h±0.0	5.5h±0.0	5.4h±0.1	0.01
Semitendinosus final cooking temp °C	71±1.5	68±0.9	67±0.6	67±1.4	0.11
Semitendinosus cooking loss[f]	27±0.7	27±0.4	28±0.3	27±0.6	0.39
Semitendinosus Warner-Bratzler shear force, kg	4.0±0.2	4.2±0.1	3.9±0.1	4.1±0.2	0.56

Means within a row lacking a common letter (g,h) differ ($P < 0.05$).
[a] 100 = A^{00}, 200 = B^{00}, etc.
[b] 300 = $Slight^{00}$, 400 = $Small^{00}$, etc.
[c] L^*: 0 = black, 100 = white.
[d] a^*: lower numbers = more green, higher numbers = more red.
[e] b^*: lower numbers = more blue, higher numbers = more yellow.
[f] Cooking loss as a percentage of the raw weight of the steak.

Table 3
Least squares means of *Semitendinosus* iridescence scores with sex classification, marbling, and dark cutting status

Variable	Sex Classification		P-value	Marbling		P-value	Dark cutting status		P-value
	Steer ($n = 50$)	Heifer ($n = 14$)		Slight ($n = 29$)	Small ($n = 35$)		Normal carcasses ($n = 58$)	Dark cutting carcasses ($n = 6$)	
Semitendinosus iridescence score[a]	2.3±0.2	2.4±0.2	0.76	2.4±0.2	2.2±0.2	0.27	2.7±0.1	1.9±0.3	0.02

[a] Five-point scale (1 = no iridescence; 5 = extremely iridescent).

Factors associated with surface iridescence in the ST were further examined because iridescence was observed to a much higher degree in the ST as compared with other muscles tested. Correlations of carcass traits, colorimeter values, pH, cooking traits and Warner-Bratzler shear force with surface iridescence of the ST were calculated (Table 1). Higher ST surface iridescence scores were associated with more youthful lean maturity scores, larger ribeye areas, higher L^*, a^*, and b^* colorimeter values, lower ultimate pH values, and faster cooking ($P < 0.05$). Table 2 presents least squares means for carcass traits, colorimeter values, pH, cooking traits, and Warner-Bratzler shear force with ST iridescence. Carcasses with ST muscles receiving iridescence scores of one had less ($P < 0.05$) youthful lean maturity values as compared with carcasses with ST muscles receiving

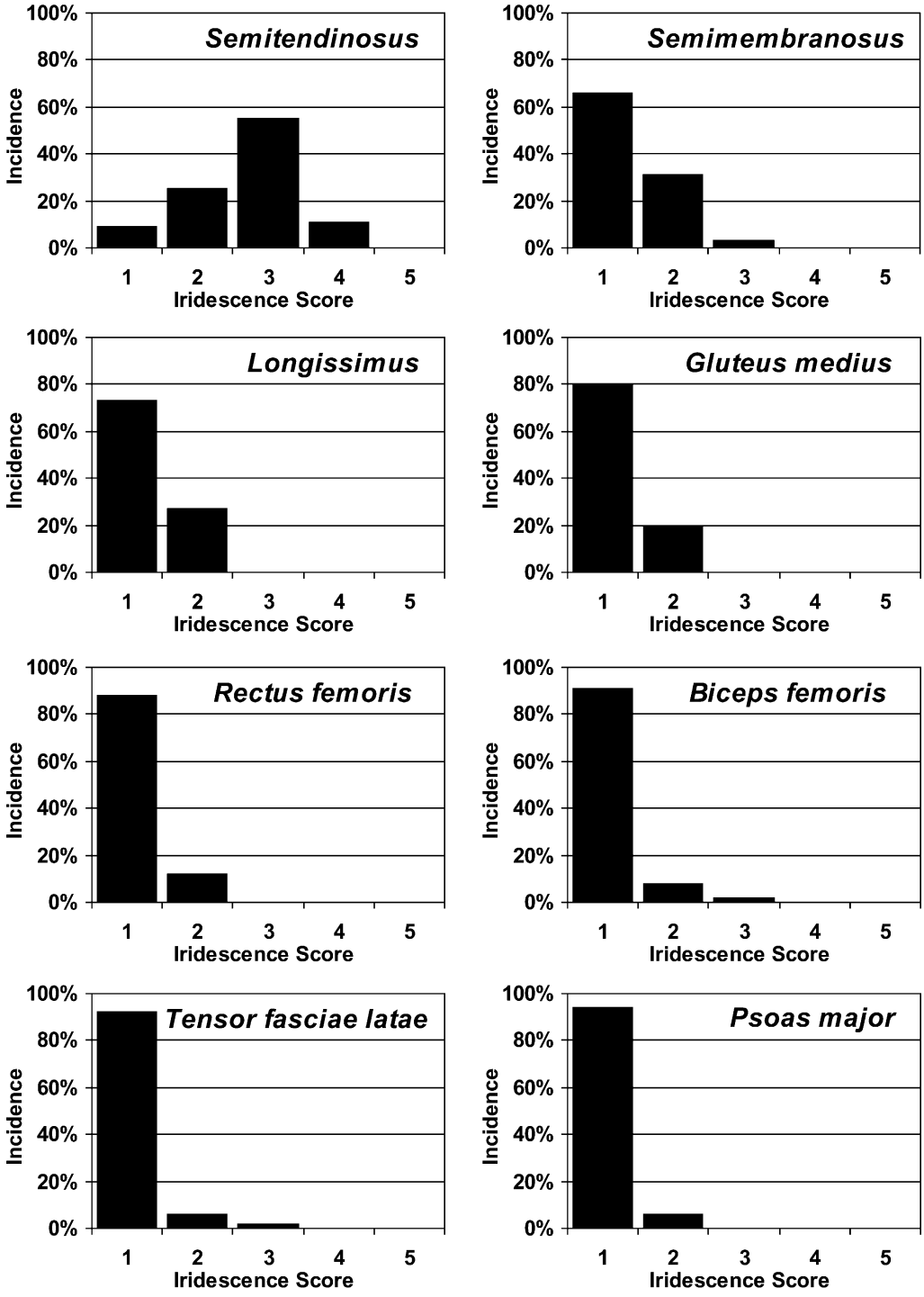

Fig. 2. Distribution of surface iridescence scores for various beef muscles (1 = no iridescence, 2 = slightly iridescent, 3 = moderately iridescent, 4 = very iridescent, 5 = extremely iridescent) ($P < 0.05$).

iridescence scores of 2, 3, and 4. Carcasses with ST muscles receiving iridescence scores of four had larger ($P < 0.05$) ribeye areas as compared with carcasses with ST muscles receiving iridescence scores of 1, 2, and 3. *Semitendinosus* muscles with iridescence scores of one had lower ($P < 0.05$) L^* values as compared with ST muscles with iridescence scores of 3 and 4. *Semitendinosus* muscles with iridescence scores of one had lower ($P < 0.05$) a^* and b^* values as compared with ST muscles with iridescence scores of 2, 3, and 4. *Semitendinosus* muscles with iridescence scores of one had higher ($P < 0.05$) ultimate pH values as compared with ST muscles with iridescence scores of 2, 3, and 4. Surface iridescence had no effect ($P > 0.05$) on cooking loss or Warner-Bratzler shear force values of the ST.

Table 3 presents least squares means of *Semitendinosus* iridescence scores with sex classification, marbling, and dark cutting status. Sex classification had no effect ($P > 0.05$) on surface ST iridescence. Marbling score also had no effect ($P > 0.05$) on surface ST iridescence. In contrast, Wang (1991) found that the incidence of iridescence in fresh beef ST muscles increased as fat content decreased. Dark cutting carcasses, which are characterized by high pH and high water-holding capacity (Lawrie, 1998), had lower ($P < 0.05$) mean ST surface iridescence scores. The current findings agree with Wang (1991), whom demonstrated that iridescence in fresh beef ST muscles increased as water-holding capacity decreased.

Wang (1991) found that iridescence was affected by angle of cutting across muscle fibers, with the greatest iridescence occurring when the cut was made perpendicular (90° angle) to the muscle fibers. In our study, the ST was cut perpendicular to the muscle fibers which could possible explain the high incidence of surface iridescence in the ST; however, the PM was also cut perpendicular to the muscle fibers and had the lowest incidence of surface iridescence. The reason for the difference in iridescence between the ST and PM may be due to pH (average ultimate pH: 5.60 for ST, 5.74 for PM; data not presented in tabular form).

4. Conclusions

This study found the amount of surface iridescence on fresh beef differed greatly among muscles with *Semitendinosus* muscles having the greatest occurrence of surface iridescence of those investigated. Higher surface iridescence scores for the *Semitendinosus* were associated with larger ribeye areas, more youthful lean maturity scores, higher L^*, a^* and b^* colorimeter values, and lower ultimate pH values.

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