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ORIGINAL RESEARCH

Assessment of colour stability and palatability of beef top sirloin butts (*Gluteus medius*) muscle

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MJB, conceived idea, designed study, collected data & analysis, laboratory analysis, statistical analysis, preparation of manuscript; AJP, conceived idea, designed study; JZB, statistical analysis; SRG, collected data & analysis, laboratory analysis; KC, collected data & analysis, laboratory analysis

ABSTRACT

This study investigated the interactive effect of USDA quality and yield grades on color stability of beef top sirloin butt. Beef top sirloin butts (n = 48) were selected at a slaughter facility based on United States Department of Agriculture (USDA) quality grade (USDA Top Choice or USDA Select) and USDA yield grade category (yield grades 1 and 2 or 4 and 5) to measure the instrumental color variation within the *gluteus medius* (GM). After aging 14 days at 2°C, eight 2.54-cm thick steaks were cut from GM, with 2 steaks removed from the anterior (ANT), middle (MID) and posterior (POST) sections of GM. One steak was cut into 3 equal length steaks, designated as lateral (LAT), central (CENT), and medial (MED) portions and were placed onto foam trays over-wrapped with an oxygen-permeable film, and stored under simulated retail display conditions (2°C and white fluorescent lighting) for 7 d. The lateral and medial portions of Select steaks were lighter ($P < 0.05$) than the lateral and medial portions of Top Choice steaks while top Choice steaks were redder ($P < 0.05$) and more yellow ($P < 0.05$) than Select steaks each day of the 7 d simulated retail display period. This study will help consumers to assess visual appearance of meat product because it influences consumer`s buying decision

Keywords Beef Top sirloin butts; *Gluteus medius*; Colour stability; USDA grades; Instrumental assessment.

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INTRODUCTION

Meat color contributes to the overall quality, and any desirable color is associated with freshness of the meat. Any changes in the fundamental color or its consistency and stableness within *gluteus medius* (GM) may be related with post-mortem changes within the muscle. Faustman *et al.* (1990) reported that individual muscles vary in their relative color stability. For instance, *gluteus medius* was revealed to be less color stable than *longissimus* muscle (George-Evans *et al.,* 2004) Consequently, different muscle tissues may have variable potentialities of decreasing metmyoglobin (Hood, 1980). The most vital distinct factor in meat color stability seemed to be the intramuscular differences (Hunt *et al.*, 1991).

It is important that the meat industry produce beef of acceptable quality in order to satisfy consumers` preference and needs at the least costs. Beef top sirloin steak is commonly served in restaurants and bought in retail shops by households because it is a cost effective cut (National cattlemen`s Beef association, 2005). Therefore, it is important that ensuing research on beef top sirloin steak focus on strategies that would promote color stability in order to improve longevity of fresh beef color (Arnold *et al.,* 1992).

There are some variations in fiber and metabolism in muscles due to its difference in function in living animals (Kirchofer *et al.*, 2002). Nevertheless, meat shows a broad range of postmortem oxygen consumption rates and subsequent color stability. This is due to differences muscle origin, and existence of a contrary relationship between rate of discoloration and oxygen consumption rate (Seyfert *et al.*, 2006). Mitochondrial enzymes control meat oxygen consumption rates and pigment reduction, especially cytochrome C oxidase, which carry on consuming oxygen during postmortem (Tang *et al.*, 2005). Mitochondria utilize and decrease the amount of oxygen in meat which would otherwise be available to bind myoglobin and this leads to deoxymyoglobin instead oxymyoglobin formation (Richards *et al.*, 2002). Therefore, meat color is affected by several factors including the concentration of haem pigments especially myoglobin, chemical state of myoglobin, and physical attributes of meat (Jeong *et al.,* 2009). The objective of this research was to investigate the interactive effect of USDA quality and yield grades on color stability of beef top sirloin butt.

MATERIALS AND METHODS

Top sirloin butt selection and fabrication

Individually-identified top sirloin butts (n = 48) from the left sides of the carcass were obtained during carcass fabrication and were vacuum-packaged for further processing. Top sirloin butts were allowed to age at 2°C for 14 d before removal from vacuum-sealed packages. Beginning at posterior end of resulting *gluteus medius* (GM), eight 2.54-cm-thick steaks were cut as follows: 1) first and second steaks designated as posterior (POST) steaks; 2) third steak cut and discarded; 3) fourth and fifth steaks designated as middle (MID**)** steaks; 4) sixth steak cut and discarded; and 5) seventh and eighth steaks designated as anterior (ANT) steaks.

The steaks from each location pair were further divided into 3 equal length steaks designated as lateral (LAT), central (CENT), and medial (MED) portions. An approximately 2 g sample of GM was removed from each steak for pH measurement before each steak was placed onto foam trays with absorbent pads, over-wrapped with an oxygen-permeable, polyvinyl chloride film and stored under simulated retail display conditions (2°C and white fluorescent lighting) for 7 d.

Muscle pH

The 2 g of GM removed from each steak were homogenized in 20 ml of distilled, deionized water. Then, pH of the homogenate was measured with a pH meter equipped with a temperature-compensating combination pH electrode calibrated to both pH 4.0 and 7.0.

Instrumental color

Instrumental color readings of steaks (n = 432) were measured daily during the 7-days simulated retail display period using a Hunter Mini Scan calibrated against a standard white tile each day of data collection. The lightness (L*), redness (a*) and yellowness (b*) values of each steak in display were determined from average of 3 readings on the cut surface using illuminant A and a 10° standard observer. Chroma, ($\sqrt{a*^2+b*^2}$) and hue angle ($\tan^{-1}$[b*/a*]) were also calculated for each steak daily (AMSA, 1991). L* = a measured of darkness to lightness (a greater L* values indicates a lighter color); a* = a measure of redness (a greater a* value indicates a redder color); and b* = a measure a yellowness (a greater b* values indicates a more yellow color). Hue angle (reported in degrees) represents the change from the true red axis (a larger hue angle indicates a greater shift from red to yellow). Chroma, or saturation index, is a measure of the total color/vividness of color (a greater chroma value indicates greater total color/a more vivid color).

Statistical analyses

The general carcass data were analyzed using PROC MIXED of SAS (SAS 2002 Inst., Inc., Cary, NC, USA), with quality grade (QG) and yield grade (YG) categories, as well as the QG × YG interaction, included in the model as the fixed effects. The experiment was conducted as a split-split plot design, with QG and YG as the whole plot, steak location within the GM (POST, MID, or ANT) as the sub-plot, and the within steak position (LAT, CENT, and MED) as the sub-sub-plot. The analysis of variance for the instrumental color data was generated with PROC MIXED, and the fixed effects included in the statistical model included QG, YG, steak location (STK), within-steak position (WSP), and display day (instrumental color data only), whereas the random effects were QG × YG × top sirloin butt, and QG × YG × STK × WSP × top sirloin butt. Display day was the repeated variable in the analysis of the color data and subject of the repeated measures was STK × WSP × top sirloin butt. Least squares means were calculated for all main and interactive effects, and when significant ($P < 0.05$) *F* values were observed, least squares means were statistically separated with pair-wise *t*-tests PDIFF option).

RESULTS

Quality and yield grade effects

Muscle pH did not show any effect in either quality or yield grade category. Lightness (L*) values were significantly greater (P < 0.001) in steaks from USDA Select carcasses than USADA Choice while it was significantly greater (*P* < 0.001) in yield grade (YG) 4 and 5 carcasses than those from YG 1 and 2 carcasses. On the other hand, steaks from Top Choice carcasses were redder (greater a* values; P < 0.001) than steaks from Select carcasses. YG 4 and 5 steaks had greater (P < 0.001) a* values than steaks from YG 1 and 2 steaks. Steaks from top Choice carcasses, regardless of YG, were redder (lower hue angles; P < 0.05) than steaks from Select, YG 4 and 5 carcasses. Yellowness was greatest (P < 0.001)) in Top Choice steaks from YG 4 and 5 carcasses, whereas Select steaks from YG 4 and 5 carcasses were more (P < 0.05) yellow than both Top Choice steaks and Select steaks from YG 1 and 2 carcasses. An interaction for yield grade and quality grade for yellowness was observed (P < 0.001). Furthermore, chroma values were also greatest (P

< 0.05) in Top Choice steaks from, YG 4 and 5 carcasses; however, Top Choice steaks from YG 1 and 2 carcasses and Select steaks from YG 4 and 5 carcasses had more (*P* < 0.05) chroma values than Select steaks from YG 1 and 2 carcasses.

Even though redness (a*) values decreased (*P* < 0.05) progressively from day 1 to day 5 of display (Figure 1), top Choice steaks were redder (greater a* values; *P* < 0.05) than Select steaks each day of simulated retail display. There was also a significant interaction (P < 0.001) between quality grade and day of simulated display; (Table 1). On day 4 of display, top Choice steaks had similar a* values to Select steaks displayed only for 2 days, whereas, a* values of top Choice steaks displayed for 5 days were similar (P > 0.05) to Select steaks after only 3 days of display.

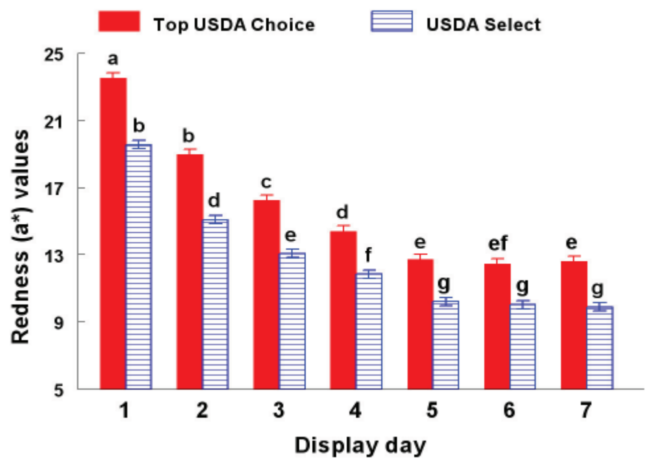

Figure 1. Interactive effect of quality grade category and display duration on redness (a*) values of *gluteus medius* steaks.Bars lacking common letters are different (P < 0.05).

Hue angle increased (P < 0.05) progressively from day 1 to day 5 of simulated retail display (Figure 2) and there was no (P > 0.05) difference in hue angles between day 5 and day 7 of display (Table 1). Moreover, the color of Top Choice steaks was closer (P < 0.05) to the true red axis than Select steaks, as evidenced by lower hue angles, each day of stimulated display (Table 1). On the other hand, chroma values decreased (P < 0.05) from the highest mean value on day 1 to the lowest values on days 5 through 7 of display (Figure 3). And similar to the previous quality grade × day of simulated display (P < 0.001) interactions, steaks from Top Choice carcasses were more (P < 0.05) vivid in color than those from Select carcasses every day of simulated retail display. Moreover, Top Choice steaks scored the lowest chroma values by the fifth day of display, whereas Select steaks had similar (P > 0.05) chroma values on day 3 of display.

Location variation within the gluteus medius

There was no (P > 0.05) interactive effect of steak location and within-steak position on muscle pH, but anterior and middle GM steaks had greater (P < 0.01) pH values than posterior steaks. Steaks from the lateral and central steak positions had greater (P < 0.01) pH values than steaks located in the medial portion of GM steaks (Table 2)

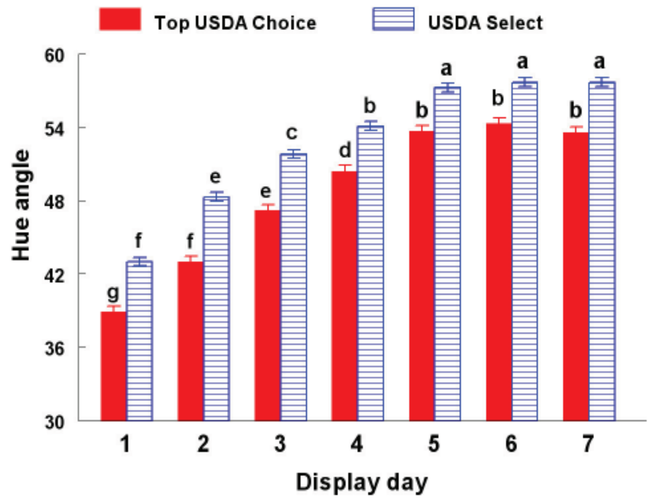

Figure 2. Interactive effect of quality grade category and display duration (P <0.027) on calculated hue angle values of *gluteus medius* steaks. [a-g] Bars lacking common letters are different (P < 0.05)

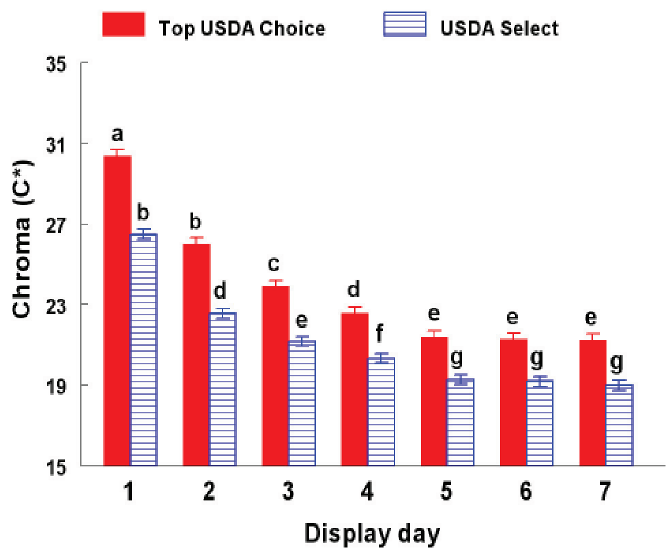

Figure 3. Interactive effect of quality grade category and display duration on chroma (C*) values of *gluteus medius* steaks.Bars lacking common letters are different (P < 0.05)

Even though neither a* nor chroma values differed (P > 0.05) among steak locations or within-steak position, the hue angle of anterior steaks was less ($P < 0.05$) than either middle or posterior steaks (Table 2).

DISCUSSION

Little work has been done to describe beef color characteristics of within muscle, particularly for *gluteus medius*. Most of the work done on this muscle focused on biochemical profiling and tenderness. Therefore, the results from this study on GM color stability may provide a valuable insight of the lateral and medial effects of the muscle that would benefit marketing of the product.

Quality and yield grade effects

The important finding of the present research is that neither quality nor yield grade designation is affected by pH. The top Choice steaks were maintaining the redness since they had lower values of hue angle as compared to Select steaks. This will have a negative effect on the Select grading system due to the shift of red color to yellowness. Hue angles were great ($P < 0.05$) for steaks from USDA Select, YG 1 and 2 carcasses, indicating a color that was closer to the true yellow axis (90°) than the true red axis (0°).

However, on the first day of retail display Select steaks were lighter but appeared darker on the last days of display. At the same time overall redness was declining progressively from day 1, this is despite the fact that Top Choice steaks were redder than Select steaks indicating some variations within the muscle. The darkness of steaks was a result of the presence oxygen which causes changes on meat surface. This is in agreement with work by Gill and McGinnis (1995) who observed that *psoas major* had least color stability since discoloration developed rapidly even in less oxygen concentrations.

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Location variation within the gluteus medius

The results on instrumental color (L*, a* and b* values) showed some variations from one steak location to another and from steak position to another. For instance, steaks centrally located within Top Choice were lighter than either that from lateral or medial positions. More yellowness appeared in the lateral, medial and central steaks located within Top Choice versus Select steaks.

It is expected that these variations to occur within this muscle, since it happened in other muscles such as *semimembranosus* (Sammel *et al.*, 2002) where variations occur between the inner and outer portions of the muscle. Chilling rate influenced the color variations of different steaks within the muscle. This is consistent with study by MacDougall, (1982) who reported that slow-chilling in large muscles is likely to have a higher scattering coefficients and unlocked structure, which in the long run produce a paler appearance. In view of the color behavior of GM, L*, a* and b* values of all steaks within GM muscle showed incremental decreases with increasing days of retail display, indicative of meat aging. Hue angle increased with increasing days of retail display.

This supports the work by Boles *et al* (1998) who reported that redness values dropped more quickly because of an increased rate of myoglobin formation at higher temperatures in all meat types. Redness is used as a good assessor of color acceptability so it has an influence on quality grade with low choice, and eventually having greater values than high choice and select steaks (Behrends *et al.,* 2003). However, top USDA Choice steaks had consistently high a* and b* values than USDA Select steaks throughout the period of simulated display, but lost certain percentage of color everyday due to display activity which was due to discoloration. It was reported by Gill, (1996) that discoloration of meat is affected by avoiding the production of brown metmyoglobin on the surface of the meat. Furthermore, pH values were noticed to be greater in anterior and middle GM steaks than posterior steaks, but on the other hand, lateral and central position steaks had higher pH values than medial located steaks. Gariepy *et al.* (1990) also reported differences in pH within a certain muscle and between muscles. This difference in muscle pH seemed to be due to closeness to bone Gariepy *et al.* (1990). It was suggested that the rise in pH could be caused by neutralization of lactic acid by calcium carbonate in the bone, as well as differences in the connective tissues Gariepy *et al.* (1990). The increase in muscle pH was also found to be associated with an increase in quality grade, which was observed in Select to Top Choice (Von Seggern *et al*., 2005). This observation was also reported by McKenna *et al.* (2005) who noticed that variations in muscle pH escalated roughly 0.1 units from day zero to day five.

CONCLUSION

It was found that anterior and middle GM steaks have higher values of pH than posterior steaks, but lateral steaks also had greater pH values than medial located steaks. All these differences observed in the GM steaks are related to average rated color stability characteristics. There is not much information available to describe biochemical variations within *gluteus medius* as well as sensory characteristics. Therefore, there is need for further investigations on this muscle in order to provide a detailed profile which would be helpful in improving the marketing aspects in meat industry.

Table 1 Effects of display duration on instrumental color of *gluteus medius* steaks

	Display day								$P > F$[1]		
Variable	1	2	3	4	5	6	7	SE	D	Q × D	Y × D
Lightness (L*)[2]	40.8^{v}	40.3^{w}	39.2^{xy}	39.6^{x}	39.3^{xy}	39.2^{xy}	39.0^{y}	0.24	***	NS	NS
Redness (a*)[2]	21.6^{v}	17.0^{w}	14.7^{x}	13.1^{y}	11.5^{z}	11.2^{z}	11.2^{z}	0.19	***	***	NS
Yellowness (b*)[2]	18.5^{v}	17.2^{w}	17.1^{wx}	16.9^{xy}	16.8^{yz}	16.8^{yz}	16.6^{z}	0.11	***	***	NS
Hue angle[3]	40.9^{z}	45.6^{y}	49.5^{x}	52.2^{w}	55.5^{v}	56.0^{v}	55.6^{v}	0.29	***	*	NS
Chroma[4]	28.4^{v}	24.3^{w}	22.5^{x}	21.4^{y}	20.3^{z}	20.2^{z}	20.1^{z}	0.19	***	***	NS

[1] Probability value of the main effect of display day (D) and the interactive effects with quality grade (Q) and yield grade (Y) categories.
[v,w,x,y,z] Within a row, least squares means lacking common superscript letter differ ($P < 0.05$).

Table 2 Main effects of steak location (S) and within steak position (P) on pH, instrumental color characteristics of *gluteus medius* steaks

	Steak location[1]				Within steak position[2]				$P > F$[3]		
Variable	ANT	MIDD	POST	SE	LAT	CENT	MED	SE	S	P	S × P
Muscle pH	5.43^{x}	5.42^{x}	5.40^{y}	0.009	5.40^{y}	5.41^{y}	5.43^{x}	0.009	**	**	NS
Lightness (L*)[4]	38.5^{y}	40.1^{x}	40.2^{x}	0.25	39.8^{x}	40.3^{x}	38.7^{y}	0.25	***	***	NS
Redness (a*)[4]	14.5	14.3	14.2	0.19	14.4	14.2	14.4	0.19	NS	NS	NS
Yellowness (b*)[4]	16.9^{y}	17.3^{x}	17.2^{xy}	0.12	17.2	17.1	17.1	0.12	0.052	NS	**
Hue angle[5]	50.3^{y}	51.1^{x}	51.0^{x}	0.28	50.6	51.0	50.7	0.28	*	NS	NS
Chroma[6]	22.4	22.6	22.4	0.20	22.5	22.4	22.5	0.20	NS	NS	0.058

[1] Steak location: ANT = anterior; MIDD = middle; and POST = posterior.
[2] Within steak position: LAT = lateral; CENT = central; and MED = medial.
[3] Probability value of the main and interactive effects included in the statistical model.
[x,y,z] Within a row and main effect, least squares means lacking common superscript letters differ ($P < 0.05$).

Conflict of interest None

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