

## Effect of Degree of Doneness, Quality Grade, and Time on Instrumental Color Readings from Beef Strip Loin Steaks Cooked to Six Degrees of Doneness

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### Abstract

The effect of quality grade and time after cooking on the instrumental color of beef steaks cooked to varying degrees of doneness was determined using 24 beef strip loins from 12 animals representing five quality treatments [Prime, Top Choice (Modest<sup>00</sup> – Moderate<sup>100</sup> marbling), Low Choice, Select, Select Enhanced (108%)]. Each steak was cooked to a peak internal temperature of very-rare (130°F), rare (140°F), medium-rare (145°F), medium (160°F), well-done (170°F), or very well-done (180°F). Each cooked steak was cut in half, perpendicular to the long axis of the steak, and lightness (L\*), redness (a\*), and yellowness (b\*) were evaluated on the internal face of the medial side at 0, 1, 2, 3, 6, 9, and 12 minutes post-cutting. There was an interaction ( $P < 0.05$ ) between quality treatment and time for L\* values. There was no difference ( $P > 0.05$ ) among quality treatments for L\* value at any time point, except at 12 minutes where Top Choice samples were lighter ( $P < 0.05$ ) than Select Enhanced samples. Additionally, there was an interaction ( $P < 0.05$ ) between time and degree of doneness for L\*, a\*, and b\*. The impact of time on cooked color was dependent on degree of doneness, with steaks cooked to lower degrees of doneness becoming lighter and more red in color with time and steaks cooked to higher degrees of doneness becoming darker. Quality grade had no impact ( $P > 0.05$ ) on cooked color measures of non-enhanced samples.

### Introduction

An increase in internal temperature results in greater myoglobin denaturation and a subsequent cooked-brown color. Previous research has demonstrated cooked color has a large impact on consumer perception. Therefore, the objective of this study was to determine the effect of quality grade and time after cooking on the instrumental color of steaks cooked to varying degrees of doneness.

### Experimental Procedures

Beef strip loins [n = 24, Institutional Meat Purchase Specifications #180; North American Meat Institute (2014)] from 12 animals representing five quality treatments

[Prime, Top Choice (Modest<sup>00</sup> – Moderate<sup>100</sup> marbling), Low Choice, Select, Select Enhanced (108%)] were collected from a Midwest beef processor and transported to the Kansas State University Meat Laboratory. Select Enhanced loins were enhanced with a solution of water, salt, and alkaline phosphate to 108% of raw weight. Sub-primals were cut into 1-in thick steaks and aged 21 days. Steaks were assigned to a degree of doneness so that each animal would be represented by a single steak within each degree of doneness. Steaks were stored at -40°F and thawed at 36–39°F for 24 hours prior to cooking. Each steak was cooked to a peak internal temperature of very-rare (130°F), rare (140°F), medium-rare (145°F), medium (160°F), well-done (170°F), or very well-done (180°F) on electric clamshell grills [Griddler; Cuisinart, Stamford, CT; NCBA (2008); AMSA (2015)]. Cooked steaks were rested for three minutes, then cut in half, perpendicular to the long axis of the steak. Color was immediately measured on the internal face of the medial side for lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 2.54-cm aperture, 10° observer; Hunter Associates Laboratory, Reston, VA) at three locations and averaged. Instrumental color was also evaluated at 1, 2, 3, 6, 9, and 12 minutes post-cutting. Statistical analysis was conducted in SAS (Version 9.4, SAS Inst. Inc., Cary, NC) using PROC GLIMMIX with  $\alpha = 0.05$ . Data were analyzed as a split-split-plot design with quality treatment as the whole plot factor, degree of doneness as the subplot factor, and post-cut time as a repeated sub-subplot measure.

## Results and Discussion

There was an interaction for  $L^*$  ( $P < 0.05$ ) between quality treatment and time (Table 1) due to Top Choice samples being lighter ( $P < 0.05$ ) than Select Enhanced samples at 12 minutes. There were no other differences ( $P > 0.05$ ) among any of the other quality treatments for  $L^*$  value at any other time point. Additionally, there was an interaction ( $P < 0.05$ ) between time and degree of doneness for  $L^*$ ,  $a^*$ , and  $b^*$ . Within very-rare, rare, and medium-rare steaks, internal color lightened ( $P < 0.05$ ) from time 0 to 2 or 3 minutes (Figure 1), while the internal color of well-done and very well-done steaks darkened ( $P < 0.05$ ) from time 0 to 2 minutes. The internal color of very-rare, rare, medium-rare, and medium steaks became more red ( $P < 0.05$ ) over time (Figure 2). However, time had only a minimal impact on redness changes in well-done and very well-done steaks. Steak internal yellowness values increased ( $P < 0.05$ ) within each degree of doneness. However, these changes were more prevalent at lower degrees of doneness, with increased ( $P < 0.05$ ) yellowness values at each successive time point within very-rare steaks, but no change ( $P > 0.05$ ) in yellowness from 6 to 12 minutes for well-done and very well-done steaks (Figure 3). Quality treatment had an effect on redness ( $P < 0.05$ ), with Select Enhanced steaks being less red than all treatments except Prime steaks (Table 2). Select Enhanced steaks were less yellow ( $P < 0.05$ ) than all other quality treatments.

## Implications

The impact of time on internal cooked color was dependent on degree of doneness, with steaks cooked to lower degrees of doneness becoming lighter and more red in color with time and steaks cooked to higher degrees of doneness becoming darker. Additionally, quality treatment had no impact on cooked color measures of non-enhanced steaks.

These results provide insight into cooked beef color changes related to time and how this might impact degree of doneness perceptions by consumers.

## References

- AMSA. 2015. Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of meat. 2 ed. American Meat Science Association, Champaign, IL.
- NCBA. 2008. Beef steak color guide. National Cattlemen's Beef Association, Centennial, CO.
- North American Meat Institute. 2014. The meat buyer's guide. 8th ed. North American Meat Institute, Washington D.C.

**Table 1. Least squares means for the interaction ( $P = 0.02$ ) between quality treatment and time on L\*<sup>1</sup> of beef steaks from five quality grades**

Bloom time, minutes	Quality treatment				
	Select Enhanced <sup>2</sup>	Select	Low Choice	Top Choice	Prime
0	50.80	50.40	50.81	51.35	51.12
1	51.02	51.03	51.33	51.74	51.46
2	50.84	51.16	51.37	52.00	51.69
3	51.08	51.64	51.62	52.25	51.75
6	51.05	51.50	51.66	52.31	51.70
9	50.75	51.44	51.26	52.05	51.58
12	50.40 <sup>b</sup>	51.34 <sup>ab</sup>	51.30 <sup>ab</sup>	52.13 <sup>a</sup>	51.75 <sup>ab</sup>
Standard error	0.58	0.59	0.61	0.61	0.58
$P$ – value	0.02	0.02	0.02	0.02	0.02

<sup>ab</sup>Within a row, means without a common superscript differ ( $P < 0.05$ ).

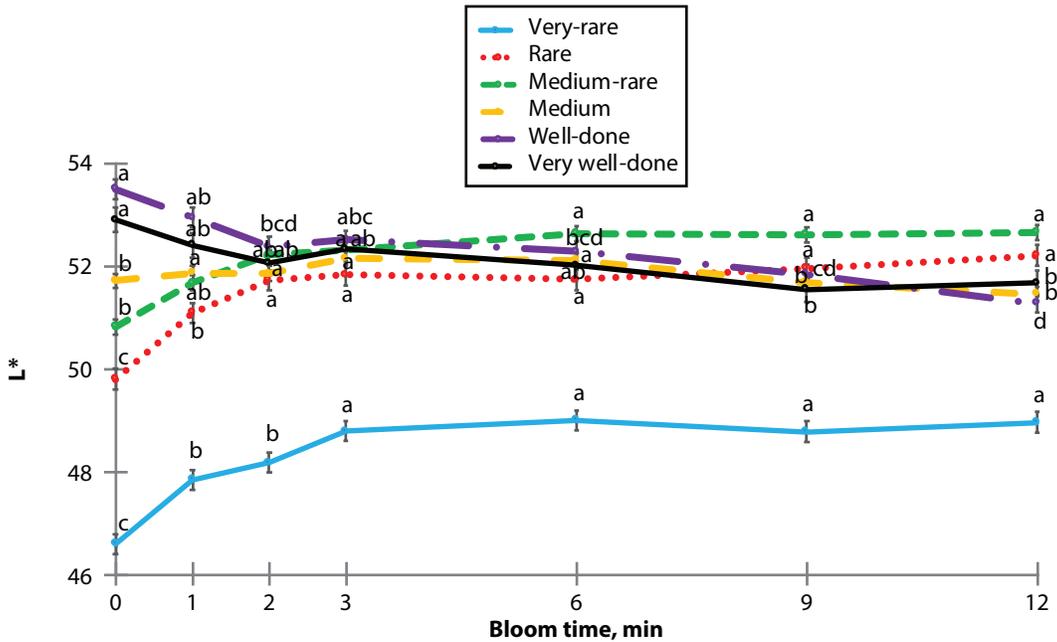
<sup>1</sup>L\*: 0 = black, 100 = white.

<sup>2</sup>Enhanced to 108% of raw weight with water, salt, and alkaline phosphate solution.

**Table 2. Effect of quality grade on a\* and b\* instrumental color of beef steaks**

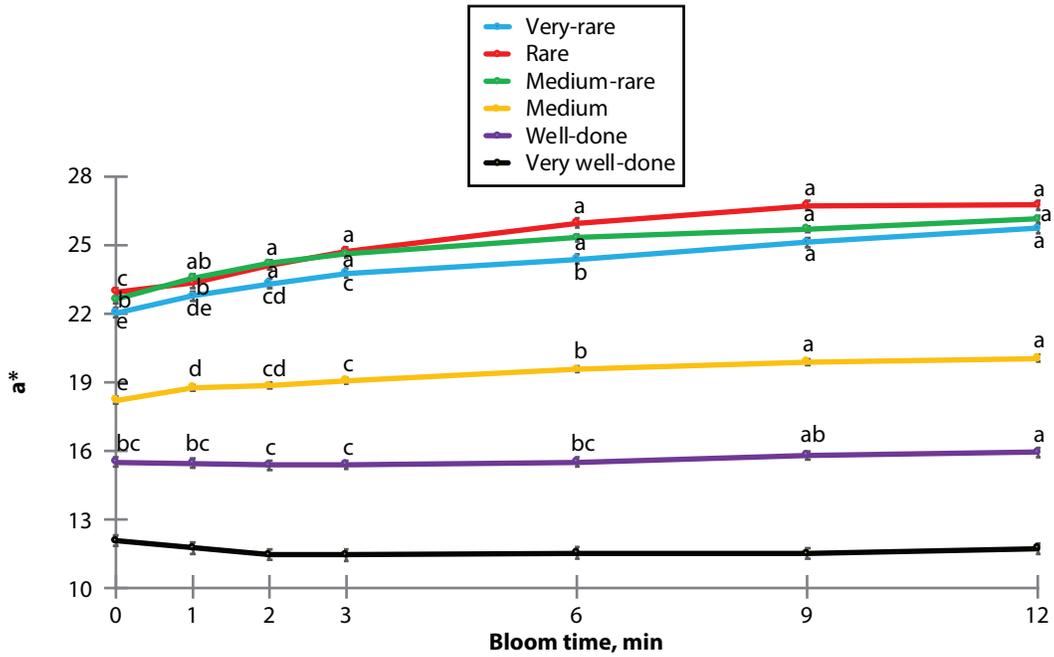
Quality treatment	Instrumental color	
	a* <sup>1</sup>	b* <sup>2</sup>
Select Enhanced <sup>3</sup>	19.05 <sup>b</sup>	17.61 <sup>b</sup>
Select	20.47 <sup>a</sup>	19.24 <sup>a</sup>
Low Choice	20.50 <sup>a</sup>	19.39 <sup>a</sup>
Top Choice	20.06 <sup>a</sup>	19.26 <sup>a</sup>
Prime	19.82 <sup>ab</sup>	19.30 <sup>a</sup>
Standard error	0.35	0.21
P – value	0.02	< 0.01

<sup>ab</sup>Within a column, means without a common superscript differ ( $P < 0.05$ ).  
<sup>1</sup>a\*: -60 = green, 60 = red.  
<sup>2</sup>b\*: -60 = blue, 60 = yellow.  
<sup>3</sup>Enhanced to 108% of raw weight with water, salt, and alkaline phosphate solution.



**Figure 1. Least squares means for the interaction ( $P < 0.01$ ) between time and degree of doneness on L\*<sup>1</sup> color readings of beef steaks.**

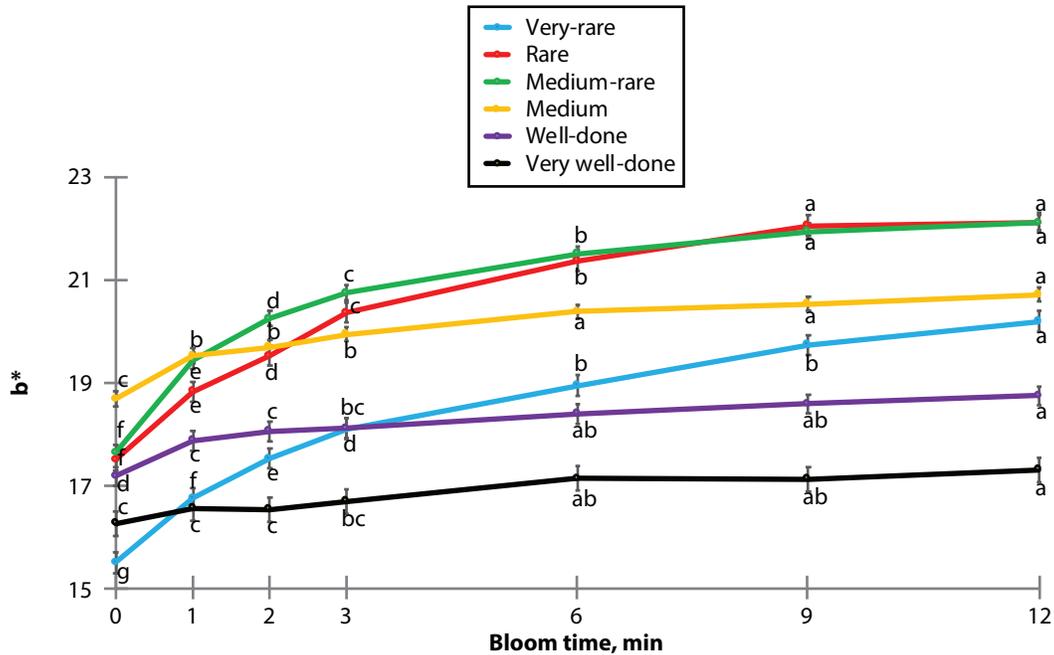
<sup>1</sup>0 = black, 100 = white.  
<sup>abcd</sup>Means within a degree of doneness without a common superscript differ ( $P < 0.05$ ).



**Figure 2.** Least squares means for the interaction ( $P < 0.01$ ) between time and degree of doneness on a\*<sup>1</sup> color readings of beef steaks.

<sup>1</sup>-60 = green, 60 = red.

<sup>abcde</sup>Means within a degree of doneness without a common superscript differ ( $P < 0.05$ ).



**Figure 3.** Least squares means for the interaction ( $P < 0.01$ ) between time and degree of doneness on b\*<sup>1</sup> color readings of beef steaks.

<sup>1</sup>-60 = blue, 60 = yellow.

<sup>abcdefg</sup>Means within a degree of doneness without a common superscript differ ( $P < 0.05$ ).