Meat and Muscle Biology™

Do published cooking temperatures correspond with consumer and chef perceptions of steak degrees of doneness?[1]

Lauren L. Prill[2], Lindsey N. Drey[2], Emily A. Rice[2], Brittany A. Olson[2], John M. Gonzalez[3], Jessie L. Vipham[2], Michael D. Chao[2], Phillip D. Bass[4], Michael J. Colle[4], and Travis G. O'Quinn[2]*

[2]Department of Animal Sciences and Industry, Kansas State University, Manhattan, KS 66506, USA
[3]Department of Animal & Dairy Science, University of Georgia, Athens, GA 30602, USA
[4]Department of Animal and Veterinary Science, University of Idaho, Moscow, ID 83844, USA
*Corresponding author. Email: travisoquinn@ksu.edu (T. G. O'Quinn)

Abstract: The objective of this study was to assess consumer and chef perceptions and knowledge of beef degrees of doneness (DOD) as well as to measure the changes in cooked color over time related to DOD. Steaks from strip loins (*M. longissimus lumborum*) from each of 5 quality treatments were used for this study. Steaks were cooked to an endpoint temperature of either very-rare (54°C), rare (60°C), medium-rare (63°C), medium (71°C), well-done (77°C), or very well-done (82°C). L*, a*, and b* were evaluated at 0, 1, 2, 3, 6, 9, and 12 min post-cutting and digital pictures were taken immediately on an internal surface of the steak. Digital surveys for the evaluation of the images of the cooked steaks were created for consumers and chefs. There were time × DOD interactions ($P < 0.05$) for L*, a*, and b* values. For very-rare, rare, medium-rare, and medium, a* values increased ($P < 0.05$) over time. For L*, well-done and very well-done steaks became darker ($P < 0.05$) and very-rare, rare, and medium-rare steaks became lighter ($P < 0.05$) over time. Surveys indicated consumers determine DOD when cooking beef in their home primarily by using color, whereas chefs primarily use touch to determine DOD. There were no quality grade effects ($P > 0.05$) for DOD responses for steak pictures evaluated by consumers or chefs. Consumers identified the DOD of cooked steaks as the DOD that corresponds to published end-point temperatures 27 to 35% of the time. Chefs typically identified the DOD as 1 DOD higher than which the steaks were cooked for steaks cooked to medium or less and 1 DOD lower for steaks cooked to well-done and higher. This indicates differences exist in the perceptions of DOD between culinary professionals and consumers, and may contribute to decreased consumer satisfaction when ordering steaks in a restaurant.

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Introduction

Degree of doneness (DOD) plays an important role in beef palatability (Lorenzen et al., 2005; Lucherk et al., 2016; Drey et al., 2019). It has been well documented that increases in DOD result in decreased tenderness and juiciness, as well as decreased consumer eating satisfaction (Parrish et al., 1973; McKillip et al., 2017; Drey et al., 2019). At most foodservice establishments, steaks are ordered by consumers to a requested DOD. Consumers vary widely in their DOD preferences, with most preferring steaks cooked between medium-rare and medium-well (Branson et al., 1986; Cox et al., 1997; Reicks et al., 2011). As steaks are cooked to increasing DOD, there is a greater amount of myoglobin denaturation that results in a color change from a typical raw-red color to a traditional cooked-brown color (Mancini and Hunt, 2005). It is the extent of this color change

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Table 1. Temperatures corresponding to different beef degrees of doneness published by selected sources

Degree of doneness	Beef It's What's for Dinner[1]	Certified Angus Beef[2]	Char-Broil[3]	What's Cooking America[4]	Food Network Kitchen[5]
	Peak temperature	Pull-off of the heat	Unspecified	Unspecified	Pull-off of the heat
Very-rare	55°C (130°F)	–	26 to 38°C (80 to 100°F)	26 to 38°C (80 to 100°F)	–
Rare	60°C (140°F)	52°C (125°F)	49 to 51°C (120 to 125°F)	49 to 51°C (120 to 125°F)	51°C [125°F (+3 min rest)]
Medium-rare	63°C (145°F)	57°C (135°F)	55 to 57°C (130 to 135°F)	55 to 57°C (130 to 135°F)	55 to 57°C (130 to 135°F)
Medium	71°C (160°F)	63°C (145°F)	60 to 63°C (140 to 145°F)	60 to 63°C (140 to 145°F)	57 to 60°C (135 to 140°F)
Medium-well	–	66°C (150°F)	65 to 69°C (150 to 155°F)	65 to 69°C (150 to 155°F)	60 to 66°C (140 to 150°F)
Well-done	77°C (170°F)	71°C (160°F)	71 > °C (160 > °F)	> 71°C (> 160°F)	69+°C (155+°F)
Very well-done	82°C (180°F)	–	–	–	–

[1]Beef Checkoff, 2019

[2]Certified Angus Beef, 2019

[3]Char-Broil, 2018

[4]Stradley, 2019

[5]Food Network Kitchen, 2015

that most consumers utilize to assess the final DOD of beef products. If steaks do not meet consumers' expectations for DOD, their eating experience can be negatively impacted (Cox et al., 1997; Schmidt et al., 2002).

When describing and discussing beef DOD, the beef industry faces a large challenge. According to the American Meat Science Association (AMSA), beef DOD is related to the final internal temperature to which a steak is prepared, rather than color or time (AMSA, 2016). However, there is a great deal of variation as to what temperatures correspond to the traditional DOD terms that include "rare", "medium-rare", "medium", "medium-well", and "well-done" (Table 1). Depending on the source, consumers could be provided with a temperature range that varies by more than 10°C. Additionally, steaks will continue to rise in temperature an additional 5°C or more once removed from the heat (AMSA, 2016). This post-cooking temperature rise creates an additional level of confusion for consumers with published temperatures, as some recommendations take this temperature rise into account, whereas others do not, or do not even specify. The National Cattlemen's Beef Association (NCBA), in collaboration with the AMSA and the USDA Agricultural Research Service, has published a Beef Steak Color Guide with corresponding temperatures that is the result of more than 35 yr of effort by industry professionals and is generally accepted by the scientific community as the "gold standard" for beef DOD (NCBA, 2016).

Ultimately, these suggested temperatures are an attempt to estimate the color change that will correspond with the traditional DOD terminology. Because of this, previous authors have concluded that the use of pictorial references may be the best way to communicate about DOD with consumers in restaurants (Schmidt et al., 2002). Moreover, it is common in restaurants for wait-staff to verbally describe the visual appearance that can be expected at various DOD when customers place their order. These recommendations and practices are in response to the large amount of consumer-to-consumer variation in DOD interpretation and the corresponding impact cooked color has on consumer perceptions (Suman et al., 2016). Moreover, chefs at foodservice also play a pivotal role in consumer understanding of DOD, as the in-restaurant experience consumers receive influences their impressions of beef DOD. It is unclear whether these professional chefs have similar expectations related to DOD as consumers with no formal training.

To date, no studies have extensively evaluated consumer or chef impressions or practices related to beef DOD. Additionally, it is unclear if the published temperatures suggested for each DOD actually correspond to consumer interpretations of beef DOD. Therefore, the objectives of this study were to assess if the DOD visually determined by consumers and chefs are consistent with current published industry standards and to evaluate consumer and chefs' understanding of and practices related to beef DOD.

Materials and Methods

The Kansas State University Institutional Review Board approved all procedures for use of human subjects in internet survey distribution (IRB: #9101, January 2018).

Experimental treatments

Further details of sub-primal fabrication, enhancement, and steak allocation are described in detail by Drey et al. (2019). In brief, 24 beef strip loins (Institutional Meat Purchasing Specifications #180; [North American Meat Institute, 2014]; *M. longissimus lumborum*) representing 4 quality grades (Prime [slightly abundant^{00} to abundant^{100} marbling], Top Choice [modest^{00} to moderate^{100} marbling], Low Choice (small^{00} to small^{100} marbling), and Select [slight^{00} to slight^{100} marbling]) were collected from 12 animals from each grade at a Midwest beef processor and transported to the Kansas State University Meat Laboratory. An additional 24 Select loins from 12 animals were collected and designated for enhancement using a water, salt, and sodium phosphate solution at a 7.8 ± 0.80% pump level. This enhanced treatment was included in the current study due to the 16% of beef sold at retail undergoing a similar enhancement strategy to improve palatability (Kelly, 2006). It is also well established that the use of alkaline phosphates in such enhancement solutions produce a darker color in raw beef (Lucherk et al., 2017; McKillip et al., 2017), yet further examination is needed to evaluate how these enhancement solutions impact cooked beef color. Following a 21 d aging period, steaks were fabricated from the loins, with a single steak from each animal randomly assigned to a DOD of either very-rare (54°C [130°F]), rare (60°C [140°F]), medium-rare (63°C [145°F]), medium (71°C [160°F]), well-done (77°C [170°F]), or very well-done (82°C [180°F]), with the temperatures for each DOD corresponding to the temperatures provided by the NCBA Beef Steak Color Guide (NCBA, 2016). These steaks were utilized for cooked color readings and for digital photographs, with only 1 steak from each animal cooked to each DOD used in the current study. Following fabrication, all steaks were vacuum-packaged and frozen at –40°C until further analysis.

Cooking

Steaks were thawed at 2 to 4°C for 24 h prior to cooking. Steaks were cooked on a clam-shell electric grill (Cuisiart Griddler Deluxe, Model GR-150, East Windsor, NJ) set to a surface temperature of 177°C. A probe thermometer (Super-Fast Thermopen, ThermoWorks, American Fork, UT) was inserted into the geometric center of each steak. The thermometer remained in place during the cooking process and steaks were removed following cooking so that the peak endpoint temperature would correspond to the assigned DOD either of very-rare (54°C [130°F]; SEM = 0.19), rare (60°C [140°F]; SEM = 0.15), medium-rare (63°C [145°F]; SEM = 0.13), medium (71°C [160°F]; SEM = 0.18), well-done (77°C [170°F]; SEM = 0.16), or very well-done (82°C [180°F]; SEM = 0.12).

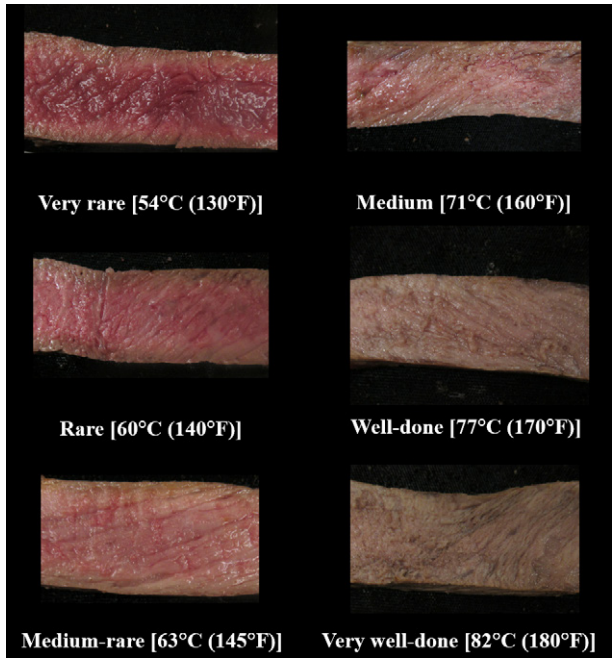

Figure 1. Representative degree of doneness images evaluated by consumers and chefs.

Color readings and digital photographs

Following cooking, steaks (N = 360) were rested for 3 min before cutting for evaluation. Each cooked steak was cut in half, perpendicular to the long axis of the steak, and digital photographs were taken immediately using a digital camera (Canon PowerShot SX620 HS; Canon U.S.A., Huntington, NY) on a slice from the internal face of the lateral side. The camera was programmed to take each photograph in portrait mode, at a 15.2 cm distance from the face of the steak, on a solid black background under florescent lights (Fig. 1). Instrumental color was measured on the internal face of the medial side of the cooked steak and was evaluated immediately for L*, a*, and b* values using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 1.27-cm aperture, 10° observer; Hunter Associates Laboratory, Reston, VA) at 3 locations on the steak slice and averaged, following the guidelines described by the AMSA (AMSA, 2012). The spectrophotometer was calibrated each day by measuring against black and white calibration tiles, and was checked for calibration using a red color tile every 30 min. L*, a*, and

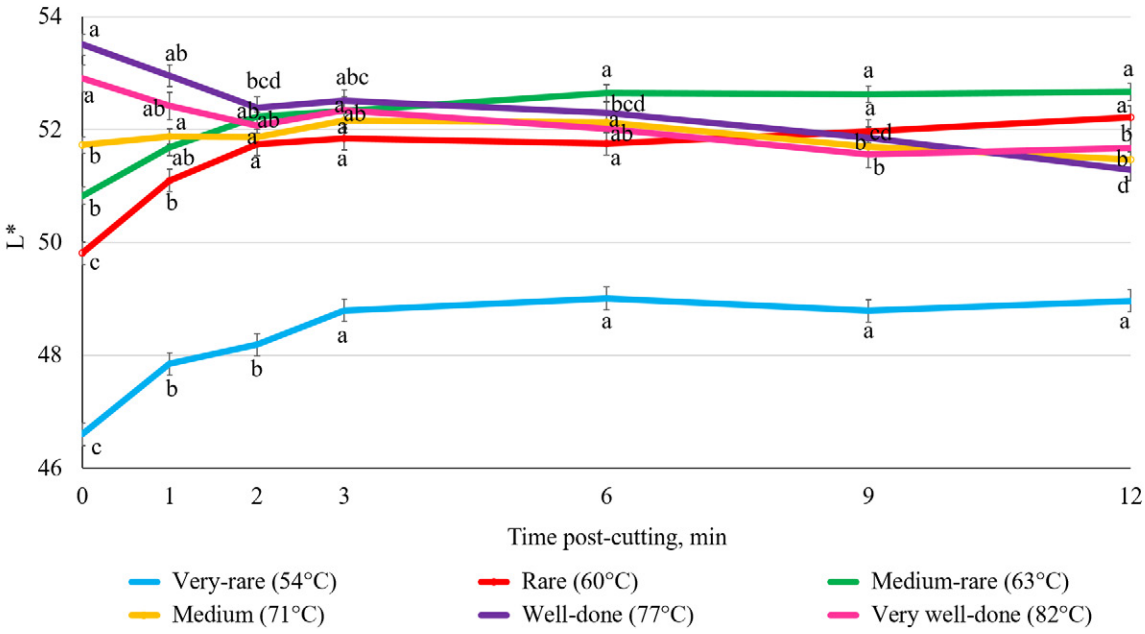

Figure 2. Interaction ($P < 0.01$) between time and degree of doneness on L* color readings of beef strip loin steaks (*M. longissimus lumborum*); L*: 0 = black, 100 = white. [a–d]Means within a degree of doneness without a common superscript differ ($P < 0.05$).

b* were evaluated at 0, 1, 2, 3, 6, 9, and 12 min post-cutting for each steak.

Visual survey distribution

A digital survey for consumers (N = 1134) was made for electronic evaluation (Qualtrics Software, Provo, UT). A majority of consumers (approximately 90%) in the current study were participants in other sensory surveys conducted at Kansas State University. These consumers were provided an electronic tablet (Model 5709 HP Steam 7; HewlettPackard, Palo Alto, CA) to fill out the survey. The remaining consumers (approximately 10%) who participated were recruited via email from a previous consumer database. Surveys contained a basic demographic questionnaire, followed by questions pertaining to consumer knowledge of, and determination of DOD. Specifically, consumers were asked what DOD they prefer and how and when they determine DOD when served steaks at a restaurant. Additionally, consumers were asked about how they determine DOD when cooking beef themselves at home. Consumers who stated they used cooked temperatures for DOD determination were asked to provide the temperatures that correspond with each DOD, including the option of "I do not know" to verify that they do actually use a temperature for DOD determination. Finally, the Qualtrics Software selected 10 randomized digital photographs from the bank of pictures (N = 360) of varying DOD and quality grades for each consumer to identify the DOD of the steak pictured. The Qualtrics Software was programmed to balance the number of times each picture was evaluated across the entire study. In total, each picture was evaluated by more than 30 different consumers in the study.

A digital survey (Qualtrics Software, Provo, UT) for chefs was also created for the electronic evaluation of the pictures of the cooked steaks. Chefs (N = 83) were recruited via email from across the United States using an established database of chefs from all segments of the industry. Chef demographics were assessed, including age, ethnicity, geographical location, education, and classification of chef. Furthermore, chefs were asked questions regarding their experiences with consumer orders and DOD as well as questions regarding their preferred methods for determination of DOD. Similar to consumers, chefs who indicated they used temperature for DOD determination were prompted to provide the corresponding temperatures for each of the degrees of doneness. Additionally, chefs were asked to assess the DOD of 30 digital steak pictures representing multiple DOD and quality grades that the Qualtrics Software randomly selected from the bank of pictures. As with the consumer survey, the survey randomized the selection process of pictures to preserve balance, with each picture evaluated by 6 to 8 different chefs.

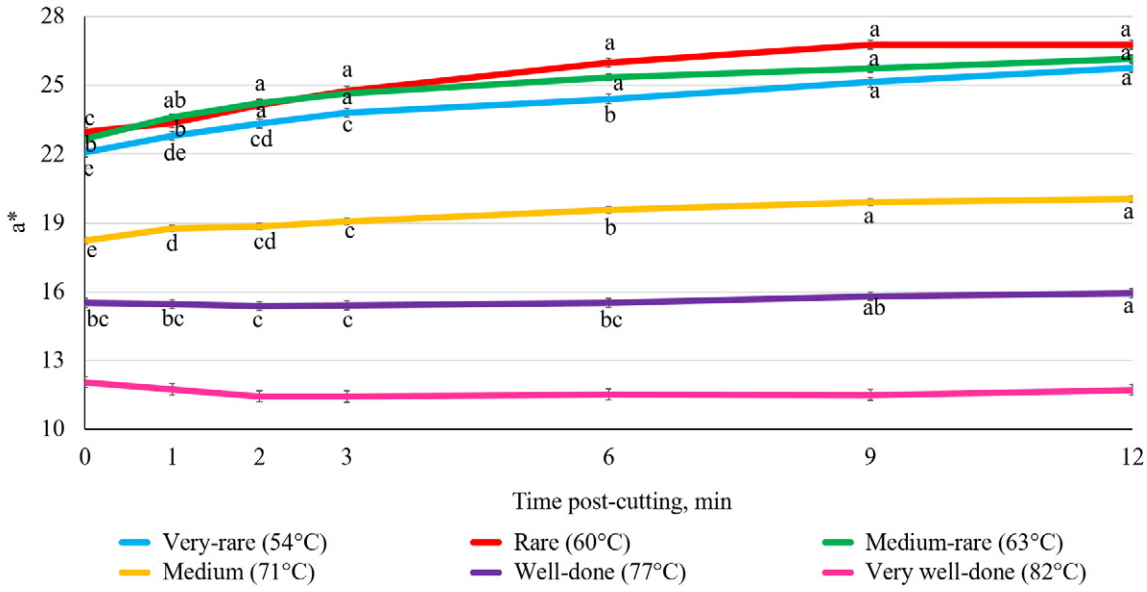

Figure 3. Interaction ($P < 0.01$) between time and degree of doneness on a* color readings of beef strip loin steaks (*M. longissimus lumborum*); a*: –60 = green, 60 = red. [a–e]Means within a degree of doneness without a common superscript differ ($P < 0.05$).

Statistical methods

Statistical analyses were conducted using the procedures of SAS (Version 9.4, SAS Inst. Inc., Inc., Cary, NC). The PROC GLIMMIX procedure in SAS was used to evaluate treatment effects and their interactions with an α of 0.05. Instrumental color data were analyzed as a split-plot, with the whole plot factor of quality treatment and sub-plot factor of DOD. For instrumental color data, time was used as a repeated measure with a first-order ante-dependence covariance structure. All consumer and chef survey data were analyzed as a completely randomized design. For all quantitative analyses, the Kenward–Roger approximation (Kenward and Roger, 2009) was utilized. For all significant interactions, the SLICE option of the LS MEANS statement was used to restrict comparisons to within a DOD. Demographic data were summarized using PROC FREQ.

Results and Discussion

L, a*, b**

There were no ($P > 0.05$) DOD × quality treatment × time interactions for L*, a*, or b* values. For L* values, there was a quality treatment × time interaction ($P < 0.05$). There were no differences ($P > 0.05$) among quality treatments for L* value at any time point, except at 12 min, in which Top Choice samples were lighter ($P < 0.05$) than Select Enhanced samples (52.3 vs. 50.4, SEM = 0.58; data not presented in tabular form). Additionally, there were time × DOD interactions ($P < 0.05$) for L*, a*, and b* values. For L*, in very-rare, rare, and medium-rare samples, the color lightened ($P < 0.05$; Fig. 2) as time increased from 0 to 12 min. Whereas, for well-done and very well-done, the color darkened ($P < 0.05$) over time. For very-rare, rare, medium-rare, and medium, a* values increased ($P < 0.05$; Fig. 3) over time. However, for well-done, time only had a minimal impact ($P < 0.05$) on a* values and no differences ($P > 0.05$) were found across time for very well-done samples. For b*, values increased ($P < 0.05$; Fig. 4) over time within each DOD; however, these changes were more prevalent at lower DOD, with increased ($P < 0.05$) b* values at each successive time point within very-rare samples, but similar ($P > 0.05$) across the final 3 time points for well-done and very well-done steaks. For a* values, quality treatment had an effect ($P < 0.05$; Table 2), with Select Enhanced samples having a lower ($P < 0.05$) a* value than all treatments other than Prime. Moreover, Select Enhanced samples had a lower ($P < 0.05$) b* value than all other quality treatments, with no differences ($P > 0.05$) found among the other quality grades. For visual sensory panelists, L* and a* have been shown to be strongly correlated to muscle color (Brewer et al., 2001; Hulsegge et al., 2001); however, b* is more correlated to brown pigments (O'Sullivan et al., 2003). Zhu and Brewer (1999) reported an a* value change of 0.589 was required before consumers perceived a significant difference in meat redness. This indicates

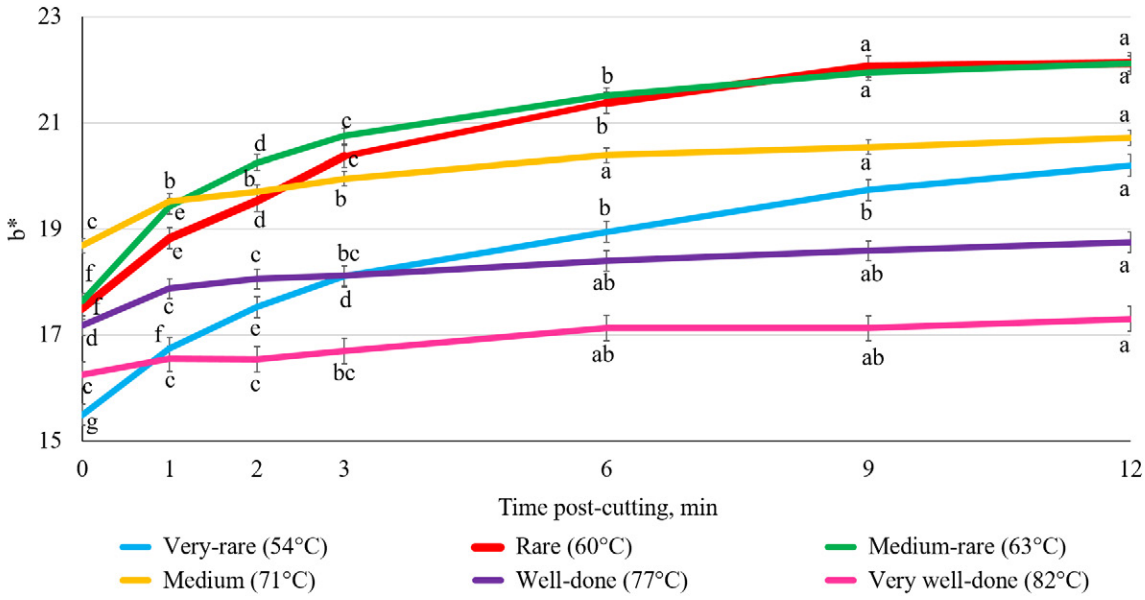

Figure 4. Interaction ($P < 0.01$) between time and degree of doneness on b* color readings of beef strip loin steaks (*M. longissimus lumborum*); b*: –60 = blue, 60 = yellow. [a–g]Means within a degree of doneness without a common superscript differ ($P < 0.05$).

that consumers in the current work would likely be able to detect changes in redness across time for many of the DOD treatments in the current work. Within the lower DOD, differences in redness would be detectable within the first 2 min following cutting.

The length of time a consumer allows a steak to sit on their plate before determining DOD at a restaurant will alter their perception of if the steak was cooked properly. Additionally, the length of time it takes the consumer to eat the steak, will also impact DOD perception. Current results would indicate that for steaks cooked to less than medium, consumers would be able to see increased redness and a lighter color as the time the steak is allowed to sit on the plate post-cutting increases. The same would not be true for consumers who order steaks cooked to medium or higher, where there would be very little change in redness through time on the plate, with steaks cooked to greater than medium also becoming darker in color through time. Thus, it is important for consumers in a restaurant setting, especially those who order steaks at lower DOD, to use the initial color of the cooked steak when they first cut into the steak for DOD determination as the color will change the longer the cut steak is exposed to air on their plate. This difference in the observed color change over time in more well-done vs. more rare steaks is likely attributed to the increased amount of heat-induced myoglobin denaturation in the more well-done samples with a longer cooking time, thus resulting a greater amount of ferrihemochrome (brown-colored pigment) and a lower proportion of ferrohemochrome (pink-red colored pigment) resulting in the less-red and more brown color of the well-done and very well-done samples (Suman and Joseph, 2013).

Degree of doneness, interpreted as changes in color on completion of cooking, can be influenced by many factors including fat content (marbling), added ingredients, length of cooking, and internal temperature (Mancini and Hunt, 2005). Yet, results of the cur-

Table 2. The effect of quality treatment on a* and b* values of beef strip loin (*M. longissimus lumborum*) steaks cooked to 6 degrees of doneness

	Instrumental color reading	
Quality treatment	a*[1]	b*[2]
Select enhanced[3]	19.05[b]	17.61[b]
Select	20.47[a]	19.24[a]
Low Choice[4]	20.50[a]	19.39[a]
Top Choice[5]	20.06[a]	19.26[a]
Prime	19.82[ab]	19.30[a]
SEM	0.35	0.21
P-value	0.02	< 0.01

[a,b]Within a column, means without a common superscript differ ($P < 0.05$).

[1]a*: –60 = green, 60 = red.

[2]b*: –60 = blue, 60 = yellow.

[3]Enhanced to 108% of raw weight with water, salt, and alkaline phosphate solution.

[4]Low Choice: marbling scores of small00 to small[100].

[5]Top Choice: marbling scores of modest00 to moderate[100].

rent work would indicate that marbling content does not influence DOD. For non-enhanced samples, marbling level had no impact on a* and b* values and only a very minor impact on L* value. These results are consistent with previous works which have evaluated cooked color of ground beef of varying fat contents and reported only minimal differences in cooked color related to fat level (Troutt et al., 1992; Berry, 1998). Our results would suggest that steaks will produce the same DOD despite differences in quality grade, and thus indicates quality grade has no impact on beef DOD development. Additionally, freezing has been shown to have an impact on cooked beef color (King and Whyte, 2006), with beef that has undergone freezing and thawing having less of a red or pink color than beef that remained in the fresh state prior to cooking. However, most of the previous work evaluating the impact of freezing on cooked beef color has focused on ground beef (Van Laack et al., 1996; Lyon et al., 2000; Berry et al., 2001) rather than intact steaks, as were used in the current work.

In a study conducted by McKillip et al. (2017), the authors analyzed raw steak L*, a*, and b* of both enhanced and non-enhanced samples from 3 quality grades. In that study, the authors reported lower a* values for enhanced Select strip loin steaks when compared to the non-enhanced samples. These results are similar to the results of the current study which found non-enhanced cooked Select strip loin steaks to be more red in color than the enhanced treatment. Conversely, McKillip et al. (2017) reported enhanced samples were darker in color than the non-enhanced samples, whereas there was no difference in L* value in the current work due to enhancement, thus indicating that this darkening effect due to alkaline phosphate enhancement may be lost when the steak is cooked.

Consumer and chef participant demographics

The consumer survey was completed by 1,134 consumers. Consumers were a majority female (51.5%), Caucasian/White (79.4%), 20 to 29 yr old (39.0%), and single (52.2%; Table 3). Forty-seven percent of consumers reported consuming beef 1 to 3 times a week and 51% reported flavor as the most important palatability trait when eating beef. These results are consistent with other recent reports (Corbin et al., 2015; Lucherk et al., 2016; Vierck et al., 2018) that have shown consumers indicate beef flavor as the most important palatability trait considered when consuming beef.

For the chef survey, chefs were dispersed across the United States, with the most being located on the west coast (34.9%), followed by the east coast (25.3%), and the Midwest (20.5%; Table 4). Chef respondents were 87% male, with 67% between the age of 30 and 49, and 90% Caucasian/White. Sixty percent reported their education as formal culinary school and 25% as informal, on the job training. Chefs classified the establishments they worked in as independent restaurants (18.1%), casual dining (13.3%), distributors (13.3%), and fine dining (12.1%). Additionally, 69% reported most commonly working with a Premium Choice beef product.

Table 3. Demographic characteristics of consumers (N = 1134) who participated in degree of doneness survey

Characteristic	Response	Percentage of consumers
Sex	Male	48.5
	Female	51.5
Household size	1 person	15.0
	2 people	24.9
	3 people	17.0
	4 people	22.7
	5 people	11.4
	6 or more people	8.9
Marital status	Single	52.2
	Married	47.8
Age group	Under 20	10.2
	20 to 29	39.0
	30 to 39	16.2
	40 to 49	14.4
	50 to 59	11.0
	Over 60	9.2
Ethnic origin	African-American	4.6
	Caucasian/white	79.4
	Hispanic	5.8
	Asian	4.3
	Native American	0.9
	Mixed race	3.6
	Other	1.4
Annual household income, $	Less than 25,000	19.5
	25,000 to 34,999	8.3
	35,000 to 49,999	9.5
	50,000 to 74,999	16.0
	75,000 to 100,000	14.7
	More than 100,000	32.0
Highest level of education completed	High school graduate	10.2
	Some college/technical school	32.5
	College graduate	33.1
	Post graduate	23.1
Weekly beef consumption	1 to 3 times	47.4
	4 to 6 times	31.6
	7 or more times	21.0
Most important palatability trait when eating beef	Flavor	51.0
	Juiciness	16.5
	Tenderness	32.5

Table 4. Demographic characteristics of chefs (N = 83) who participated in degree of doneness survey

Characteristic	Response	Percentage of consumers
Sex	Male	86.8
	Female	13.3
Age group	20 to 29	7.2
	30 to 39	32.5
	40 to 49	34.9
	50 to 59	19.3
	Over 60	6.0
Ethnic origin	Caucasian/white	90.4
	Hispanic	2.4
	Asian	1.2
	Mixed race	3.6
	Other	2.4
Geographical location	North	7.2
	South	12.1
	East coast	25.3
	West coast	34.9
	Midwest	20.5
Training	Informal	25.3
	Formal culinary school	60.2
	Apprenticeship	7.2
	Other	7.2
Type of chef	Casual dining	13.3
	Fine dining	12.1
	Independent restaurant	18.1
	Corporate	10.8
	Distributor	13.3
	Research and development	6.0
	Culinary instructor	4.8
Quality grade most commonly worked with	Low Choice	6.0
	Premium Choice	68.7
	Prime	20.5
Percentage of steaks returned due to DOD	0 to 5	63.9
	6 to 10	26.5
	11 to 20	6.0
	20+	3.6
Is degree of doneness retail cut dependent	Yes	24.1
	No	30.1
	Maybe	45.8

Consumer knowledge of degree of doneness

Forty-one percent of consumers reported medium-rare as their preferred DOD, followed by 23% preferring medium (Table 5). In previous literature, 61 to 70% of consumers reported they prefer beef steaks cooked to at least medium (Branson et al., 1986; Schmidt et al., 2002; Reicks et al., 2011). More recently, 39 to 42% of consumers reported they prefer beef steaks cooked to medium-rare (McKillip et al., 2017; Vierck et al., 2018). Based on data from Longhorn Steakhouse from May 2016 to 2017, consumers ordered steaks cooked to rare (2.5%), medium-rare (22.5%), medium (37.5%), medium-well (25.8%), and well-done (11.7%; Hickey and Dottle, 2017). Cox et al. (1997) reported consumers that ordered their steak well-done reported their preference was primarily emotive, citing choosing this DOD due to food safety concerns and disliking of blood. In the same study, consumers who ordered their steak to a lower DOD, reported their focus was on the improved palatability traits at the lower DOD (Cox et al., 1997). This would indicate consumers with differing DOD preferences typically have differences in their personal experiences and justifications to support their DOD preference. Collectively, results of these studies would indicate that the relative proportion of consumers who prefer steaks of differing DOD had remained relatively constant throughout time, with Branson et al. (1986) reporting 32% of consumers preferred steaks cooked to medium-well or higher and 46% of consumers preferred steaks cooked to medium-rare or less. These are close to the proportion of consumers in the current study as well as the Longhorn Steakhouse study (Hickey and Dottle, 2017) who identified the same DOD.

Additionally, in our study, in a restaurant setting, 59.9% of consumers reported they determine DOD after the first cut into the steak (Table 5). Another 18.7% reported determining the DOD on the first bite. Suman et al. (2016) previously stated consumers generally assess doneness of cooked beef using interior color visual appearance, which supports the findings in our study. Furthermore, 20.3% of consumers reported they determine DOD after waiting a couple minutes. For these consumers, the previously discussed changes in color through time will impact their DOD assessment. If these consumers order steaks cooked to medium-rare or less, their assessment of DOD will likely be lower (more rare) than the steak was prepared due to the change in redness. Whereas if these consumers order steaks at medium-well or higher, their assessment of DOD will likely be unaffected.

Consumers were also asked how they determine DOD when cooking beef at home (Table 5). Fifty-four percent reported they use color, feel or firmness (15.7%), and cooking time (10.4%). Additionally, 2.5% reported they do not determine DOD and 1.6% used a different method than the options provided. Responses that fell in the "other" category included "luck", "juice", and "fat texture". Finally, only 16% of consumers reported using temperature or a food thermometer for determining the correct DOD when cooking beef. Consumers that answered as using a food thermometer were then prompted to state the temperature they utilize, and were asked to state

Table 5. Percentage of consumer (N = 1134) and chef (N = 83) participants who indicated various practices related to beef degree of doneness

Question	Response	Percentage of consumers	Percentage of chefs
What is your preferred degree of doneness?	Very rare	1.0	
	Rare	7.8	
	Medium-rare	41.1	
	Medium	23.1	
	Medium-well	17.6	
	Well-done	6.7	
	Very well-done	2.7	
When do you determine degree of doneness when consuming beef in a restaurant?	Immediately at first cut	59.9	
	At first bite	18.7	
	After waiting a couple of minutes and then cutting into the steak	15.7	
	Wait a couple of minutes after steak is cut into and then determine	4.6	
	Other	1.1	
How do you determine degree of doneness when cooking beef at home?	Color	53.9	
	Feel, firmness	15.7	
	Pull-off the heat temperature	11.1	
	Carry-over cooking temperature	4.8	
	Time	10.4	
	Other	1.6	
	Do not determine	2.5	
How do you determine degree of doneness when cooking beef in a restaurant?	Color		1.2
	Feel, firmness		66.3
	Pull-off the heat temperature		14.5
	Carry-over cooking temperature		13.3
	Other		4.8

whether the temperatures reported were either pull-off the heat temperature or temperature following the post-cooking temperature rise (peak temperature). Of consumers that utilized a thermometer, 70% reported the temperature they use as their indication of DOD is the temperature they pull-off the heat, whereas 30% reported the temperature they use for DOD determination is the temperature following the post-cooking temperature rise. However, more than 58% of consumers that stated they use a carry-over temperature then reported they did not know the temperatures that correspond with each DOD (Table 6). For the consumers that reported using carry-over cooking temperatures, 31.8% reported using 58 to 60°C (136 to 140°F) to correspond to rare and 33.3% reported 72 to 74°C (161 to 165°F) for well-done. Only 31.8, 21.7, 22.7, 19.1, and 14.3% of consumers were able to identify the temperature that matches the NCBA published numbers for rare, medium-rare, medium, medium-well, and well-done, respectively. This equates to no more than 1.5% of the total consumers in the study being able to correctly identify the cooking temperatures for all of the DOD. These percentages are concerningly very low for consumer knowledge of cooked beef DOD temperatures. The percentage of consumers that reported temperatures 2 or more DOD away from the published DOD was overwhelming as well. For example, 36.4% of consumers reported using a peak temperature of less than 54°C (130°F) for rare. Also, 24% percent of consumers reported less than 71°C (160°F) and 24% reported over 80°C (176°F) for the carry-over temperature that corresponds to well-done.

Within consumers that stated they use pull-off the heat temperatures, more than 47.6% reported "I do not know" when asked to state the specific temperatures for each DOD (Table 6). Thus, these consumers indicated on the survey that they used a food thermometer to determine DOD, yet when pressed, indicated that they did not know any, or at least some, of the corresponding temperatures off-hand. That indicates that these consumers either reference published materials when using the food thermometer or do not actually use a food thermometer when determining DOD as they indicated. When evaluating the temperatures provided by consumers, there was more variation within the pull-off cooking temperatures provided than with consumers who reported using carry-over temperatures. This might be expected as the exact temperature in which a steak should be pulled from the heat to reach the desired final end-point temperature is highly

Table 6. Percentage of consumers who reported using temperature to determine degree of doneness who identified various temperatures with each degree of doneness

	Pull-off of the heat[1] (n = 126)					Carry-over cooking[2] (n = 57)				
Temperature	Rare	Medium-rare	Medium	Medium-well	Well-done	Rare	Medium-rare	Medium	Medium-well	Well-done
I do not know	47.6	50.0	51.6	50.0	47.6	61.4	58.9	60.7	62.5	60.7
<48.9°C (<120°F)	27.6	4.8	–	–	–	13.6	4.4	–	–	–
49.0 to 51.7°C (121 to 125°F)	12.1	4.8	–	–	–	9.1	–	–	–	–
51.8 to 54.4°C (126 to 130°F)	19.0	11.1	3.3	–	–	13.6	8.7	4.6	–	–
54.5 to 57.2°C (131 to 135°F)	3.5	14.3	1.6	4.8	–	9.1	13.0	4.6	–	–
57.3 to 60.0°C (136 to 140°F)	12.1	19.1	18.0	–	1.5	31.8	13.0	9.1	14.3	–
60.1 to 62.8°C (141 to 145°F)	13.8	15.9	19.7	4.8	1.5	9.1	21.7	4.6	4.8	9.5
62.9 to 65.6°C (146 to 150°F)	3.5	9.5	13.1	15.9	1.5	9.1	21.7	31.8	–	9.5
65.7 to 68.3°C (151 to 155°F)	1.7	6.4	9.8	22.2	1.5	4.6	8.7	13.6	9.5	–
68.4 to 71.1°C (156 to 160°F)	1.7	7.9	16.4	19.1	22.7	–	4.4	22.7	33.3	4.8
71.2 to 73.9°C (161 to 165°F)	3.5	1.6	11.5	15.9	28.8	–	4.4	–	19.1	33.3
74.0 to 76.7°C (166 to 170°F)	–	–	3.3	9.5	18.2	–	–	–	14.3	14.3
76.8 to 79.4°C (171 to 175°F)	1.7	1.6	–	3.2	9.1	–	–	4.6	–	4.8
79.5 to 82.2°C (176 to 180°F)	–	–	1.6	3.2	7.6	–	–	4.6	–	19.1
>82.3 (>181°F)	–	3.2	1.6	1.6	7.6	–	–	–	4.8	4.8

[1]Consumers indicated the reported temperature corresponds with the temperature that they remove the steak from the heat source.

[2]Consumers indicated the reported temperature corresponds with the temperature following the post cooking temperature rise after removing the steak from the heat source.

variable and is affected by numerous factors including cooking temperature, cooking method, and steak temperature, among others. Of the consumers that reported a temperature, 27.6% reported using a temperature less than 49°C (120°F) to correspond with rare. For medium-rare, 19.1% of consumers stated using 58 to 60°C (136 to 140°F). Additionally, 19.7% identified 61 to 63°C (141 to 145°F) for medium, 22% reported 66 to 68°C (151 to 155°F) for medium-well, and for well-done pull-off temperature, 51.5% reported using 69 to 74°C (156 to 165°F). Even using a wide (0 to 10°C) window to account for post-cooking temperature rise, no more than 73% of consumers who reported using pull-off the heat temperature would have identified a temperature that would have correctly equated to the correct DOD. This in turn relates to an equally alarmingly low 8% of all consumers in the current study who provided an answer that might be correct, dependent on their individual carry-over cooking conditions. Combining this data with the consumers who used carry-over cooking, in total, less than 10% of consumers were able to correctly identify cooking temperatures that would correspond with each DOD.

The USDA-Food Safety and Inspection Service (FSIS) recommends using a food thermometer to ensure safety and to determine desired doneness (FSIS, 2013). When focus groups were previously asked how they determine DOD, most consumers stated they use the "eye-ball" method and learned it by practice and trial and error through experience (Koeppl, 1998). Some consumers even stated that when in doubt, overcooking is better than undercooking (Koeppl, 1998). Ultimately, this preference for overcooking for some consumers may come from the fact that the emotion of fear is most commonly associated with consuming fish and meat products (Desmet and Schifferstein, 2008), most likely due to consumers' concerns related to foodborne illness. This is further exemplified by a study by McCurdy et al. (2005), who also utilized focus groups to gain knowledge on consumers' feelings and use of thermometers. In that study, consumers responded to prompted questions, stating they typically do not use thermometers because of lack of time, laziness, and forgetfulness (McCurdy et al., 2005). Additionally, when asked what would motivate them to use a food thermometer, the most commonly mentioned response was illness; however, consumers also stated, improved meat quality and the avoidance of overcooking would also motivate them to use a thermometer (McCurdy et al., 2005).

Even though using a thermometer is advantageous, consumers have a variety of options when it comes to the source that they utilize for the temperature they will cook to (Table 1). The NCBA Beef Steak Color Guide reports 6 DODs: very-rare 54°C (130°F), rare 60°C (140°F), medium-rare 63°C (145°F), medium 71°C (160°F), well-done 77°C (170°F), and very well-done 82°C (180°F; NCBA, 2016). However, it is unclear if these temperatures are related to pull off the heat or carry-over cooking peak temperature, though it is inferred through AMSA cooking recommendations that

Table 7. Percentage of chefs who reported using temperature to determine degree of doneness who identified various temperatures with each degree of doneness

	Pull-off of the heat[1] (n = 11)					Carry-over cooking[2] (n = 11)				
Temperature	Rare	Medium-rare	Medium	Medium-well	Well-done	Rare	Medium-rare	Medium	Medium-well	Well-done
<48.9°C (<120°F)	36.4	9.1	–	–	–	63.6	–	–	–	–
49.0 to 51.7°C (121 to 125°F)	27.3	27.3	–	–	–	27.3	36.4	–	–	–
51.8 to 54.4°C (126 to 130°F)	18.2	9.1	36.4	–	–	9.1	36.4	–	–	–
54.5 to 57.2°C (131 to 135°F)	9.1	36.4	9.1	18.2	–	–	27.3	45.5	–	–
57.3 to 60.0°C (136 to 140°F)	9.1	9.1	27.3	27.3	9.1	–	–	45.5	–	–
60.1 to 62.8°C (141 to 145°F)	–	–	18.2	–	18.2	–	–	9.1	63.6	–
62.9 to 65.6°C (146 to 150°F)	–	9.1	9.1	9.1	18.2	–	–	–	36.4	27.3
65.7 to 68.3°C (151 to 155°F)	–	–	–	36.4	–	–	–	–	–	18.2
68.4 to 71.1°C (156 to 160°F)	–	–	–	9.1	36.4	–	–	–	–	54.6
71.2 to 73.9°C (161 to 165°F)	–	–	–	–	9.1	–	–	–	–	–
74.0 to 76.7°C (166 to 170°F)	–	–	–	–	9.1	–	–	–	–	–

[1]Chefs indicated the reported temperature corresponds with the temperature that they remove the steak from the heat source.

[2]Chefs indicated the reported temperature corresponds with the temperature following the post cooking temperature rise after removing the steak from the heat source.

these temperatures correspond to carry-over temperatures. Certified Angus Beef reports rare corresponds to 52°C (125°F) and well-done corresponding with 71°C (160°F; Certified Angus Beef, 2019). Furthermore, the website provides instructions to pull steaks off the heat when the thermometer is 2.8°C (5°F) below the preferred DOD, which indicates these temperatures correspond with end-point temperatures rather than pull-off the heat temperatures (Certified Angus Beef, 2019). Similarly, What's Cooking America reports 49 to 52°C (120 to 125°F) as rare and 71°C (160°F) or greater as well-done (Stradley, 2019). Additionally, their internal temperature cooking chart described the color and feel of each DOD. Very-rare is described as deep red color and barely warm, with a squishy feel and medium-well as mostly gray-brown throughout and firm to the touch (Stradley, 2019). The previously discussed DOD charts are just a limited example of the sources available to consumers for DOD determination. Most of these recommendations report beef steak cooking temperatures lower than what is published by the NCBA Beef Steak Color Guide and are commonly utilized in research. This lack of consistency as well as lack of inclusion of whether these temperatures correspond to peak cooked temperatures or pull-off the heat temperatures is, in part, responsible for the variation in the consumer reported temperatures observed in the current study.

Chef knowledge of degree of doneness

The majority (66%) of chefs reported using feel or firmness for DOD indication, whereas 28% stated they use a thermometer, color (1.2%), and other (4.8%; Table 5). Chefs that reported "other" commonly listed "appearance", "time", or "a combination of multiple methods". Lehmuller and Hunt (2000) previously reported 95% of chefs determined doneness of steaks by touch. Chefs can become proficient at using the method of touch for DOD determination, as they cook hundreds of steaks within a given time period on the same equipment daily. This allows the chefs to gain valuable experience and expertise as to how their own equipment performs when cooking steaks that average consumers do not have. Within our study, the chefs that reported they use thermometers stated the specific temperature they used were "pull-off the heat" temperature (14.5%) and "carry-over" cooking temperature (13.3%; Table 7). Of the chefs that reported using "carry-over" temperature, 63.6% use a temperature of less than 49°C (120°F) for rare, whereas 36.4% of chefs that reported "pull-off" temperatures stated rare as less than 49°C (120°F). For well-done, 54.6% of "carry-over" temperature chefs reported using between 69 and 71°C (156 and 160°F). Additionally, only 1% of chefs reported determining DOD using color, which is to be expected as most chefs will not cut into steaks to check internal color while preparing steaks for customers. Much like the conclusion drawn from our study, Lehmuller and Hunt (2000) concluded that internal temperatures reported to be used by chefs tended to be lower than those published by AMSA, USDA, or the Food and Drug Administration.

Schmidt et al. (2002) conducted a study in which one-half of a consumer group were "educated" by wait-staff as to what DOD meant, versus a group that received no education or help from wait-staff. Wait-

staff provided verbal descriptions and visual illustrations of the different DOD prior to the consumer ordering. Results showed consumers that received DOD education provided greater ratings for flavor-like and overall-like; however, no differences were seen for tenderness or juiciness ratings (Schmidt et al., 2002). In attempt to improve customer satisfaction through the use of thermometers, Schmidt et al. (2002) also compared the method of touch for DOD determination versus thermometers when steaks were prepared by experienced chefs. Ultimately, within both panel sessions, chefs that used thermometers more closely achieved the desired DOD with mean differences of 0.6 and 1.3°C versus the consumer's desired temperature (Schmidt et al., 2002). Chefs that utilized the touch method for determining DOD were 10.2°C too low when the consumers were educated on DOD and 27.6°C too low when the consumers ordered without guidance from the wait staff (Schmidt et al., 2002). These results indicate that despite the experience chefs gain using touch to determine DOD, cooked temperature is still the best method to accurately deliver steaks to meet consumer DOD expectations.

Furthermore, in the current study chefs were asked if DOD was cut dependent and the specifics on why they believed so. Chefs responded yes (24.1%), no (30.1%), and maybe (45.8%; Table 4). Chefs indicated that DOD was cut specific due to "differing steak thicknesses", "variable marbling content", and "sometimes consumers do not have a choice, such as braises and stews". Jens Dahlmann, the executive chef at Longhorn Steakhouse, interviewed in the article published by Five Thirty Eight, states that the DOD the consumer orders is retail cut dependent (Hickey and Dottle, 2017). Longhorn Steakhouse reported prime rib had the greatest occurrence of being ordered rare or medium-rare, whereas a T-bone steak had the highest share of medium-well and well-done orders (Hickey and Dottle, 2017), which differs from the responses of chefs in the current work.

Evaluation of steak pictures cooked to 6 degrees of doneness

A study conducted by Chan et al. (2013) validated the use of internal pictures as a more accurate representation of a consumer's preferred DOD versus terms such as rare and medium. The authors utilized *M. longissimus lumborum* steaks, cooked to rare (60°C [140°F]), medium (70°C [158°F]), medium-well (75°C [167°F]), well-done (80°C [176°F]), and very well-done (85°C [185°F]). To study consumers' perceptions of doneness, 2 panel sessions were conducted, one for both the external and internal surface of the cooked steak, and a second for the corresponding photographs of each sample. Perception scores for both external and internal surfaces between the steak samples and the corresponding photos, were not significantly different. Ultimately, the authors concluded that for assessing consumer preference for meat doneness, photographs can be used as a valid approach.

In the current study, there were no quality grade effects ($P > 0.05$) for any DOD of the pictures evaluated by consumers. Consumers identified pictures of the steaks cooked to very-rare (54°C [130°F]) as cooked to rare the greatest ($P < 0.05$) percentage of the time followed by very-rare and medium-rare, which were similar ($P > 0.05$; Fig. 5). Over 35% of consumers rated the pictures of steaks cooked to very-rare (54°C [130°F]) as medium-rare or a greater DOD. Considering chefs reported they cook to lower temperatures than the NCBA color guide temperatures, it follows suite that consumers would associate the 54°C (130°F) color with rare instead of very-rare. For the pictures of rare (60°C [140°F]) steaks, the greatest ($P < 0.05$) percentage of consumers identified the steaks as cooked to rare, followed by medium-rare, very-rare, and medium, which were all different ($P < 0.05$). In total, 35% of respondents correctly identified the steaks as rare, with 47.7% within 1 DOD. Within the pictures of the medium-rare (63°C [145°F]) steaks, most ($P < 0.05$) consumers correctly identified the pictures as medium-rare. Although, 34.6% of consumers perceived the medium-rare (63°C [145°F]) steak pictures as medium-rare, 45.3% were within 1 DOD, and there were still 20.2% of consumers that perceived the steaks to be at least 2 DODs from medium-rare. For steaks cooked to medium (71°C [160°F]), a similar ($P > 0.05$) percentage of samples were identified as both medium and medium-well. Though there were no differences ($P > 0.05$) in the proportion of well-done (77°C [170°F]) steaks identified as both medium-well and well-done, a greater number of consumers identified the samples as medium-well. Additionally, 29% of consumers identified the well-done (77°C [170°F]) samples as cooked to medium or less. Lastly, for steaks cooked to very well-done (82°C [180°F]), more ($P < 0.05$) consumers identified the steaks as well-done than all other DOD. Ultimately, the published NCBA temperatures matched the average consumer perceptions of DOD. However, for no single DOD were more than 35% of consumers able to correctly identify the pictured DOD. Moreover, for each DOD, 16 to 36% of consumers identified the pictured DOD as 2 or more DOD off of the correct DOD.

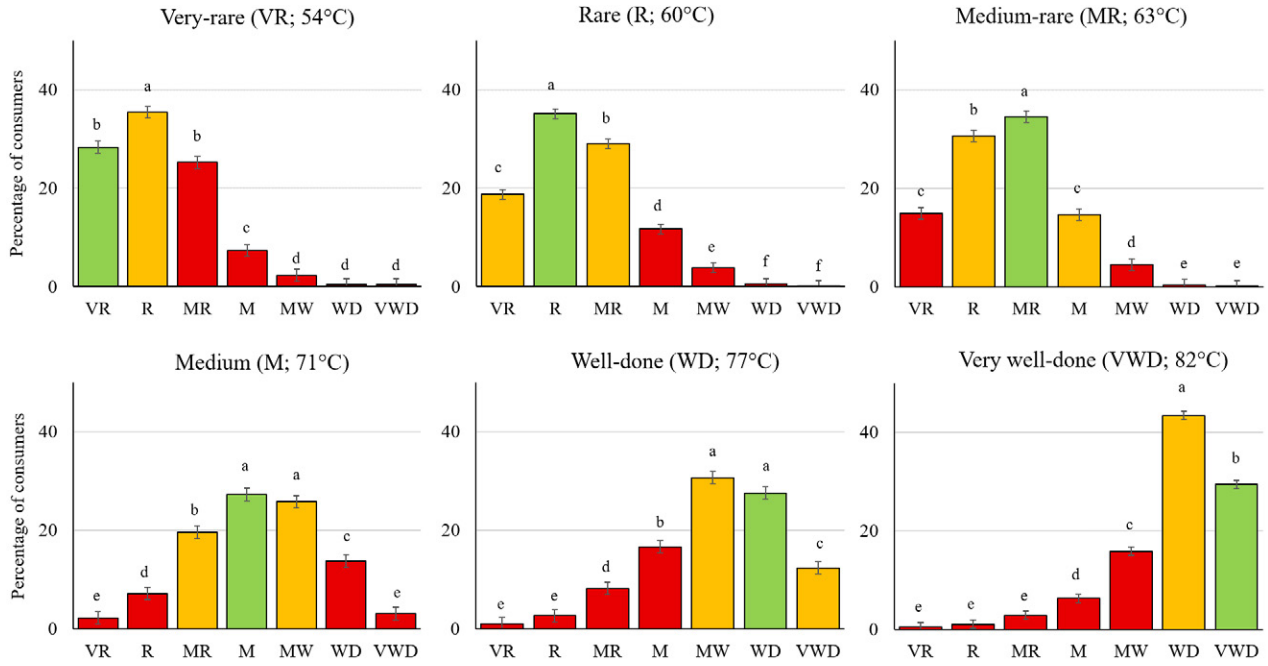

Figure 5. Percentage of consumers ($N = 1134$) that identified beef strip loin steaks (*M. longissimus lumborum*) cooked to various end-point temperatures as various degrees of doneness. [a–f]Means within a degree of doneness without a common superscript differ ($P < 0.05$).

For these consumers they could be served a steak in a restaurant, prepared as ordered, and would still likely be unsatisfied with the DOD, as they would perceive the DOD to be significantly wrong. This highlights a significant problem for the beef industry. With such a wide variation in consumer perceptions of DOD, it becomes extremely difficult for foodservice to meet consumer expectations for DOD and deliver the product prepared as desired by consumers.

Similarly, there were no quality grade effects ($P > 0.05$) for any DOD of the pictures evaluated by chefs. While evaluating pictures of steaks cooked to very-rare (54°C [130°F]), the greatest ($P < 0.05$; Fig. 6) percentage of chefs identified steaks as rare and medium-rare, which were not different ($P > 0.05$). Only 14% of chefs identified steaks cooked to very-rare (54°C [130°F]) as very-rare; however, 47.5% of chefs rated very-rare steaks as medium-rare or higher. Ultimately, within the pictures, there were no steaks cooked to a low enough temperature for chefs to consistently identify them as very-rare. Furthermore, for pictures of steaks cooked to rare (60°C [140°F]), the greatest ($P < 0.05$) percentage of chefs identified the images as medium-rare. Only 24% of chefs identified them as rare, which was similar ($P > 0.05$) to medium. Uniquely, the greatest ($P < 0.05$) percentage of chefs were able to correctly identify pictures of steaks cooked to medium-rare (63°C [145°F]) as medium-rare. Forty-seven percent of chefs identified the medium-rare (63°C (145°F]) steaks as rare or medium and only 9% of chefs were 2 or more DODs away from medium-rare. Most ($P < 0.05$) of the chefs identified steaks cooked to medium (71°C [160°F]) as medium-well, with only 26% identifying the steaks as medium. Essentially, for the majority of chefs, pictures of steaks cooked to a medium DOD did not exist, with most of the medium images identified as medium-well and the greatest proportion of medium-rare steaks correctly classified as such. The chefs' perceptions of medium and below tended to side with steaks cooked to higher temperatures, inferring that steaks ordered between very-rare and medium-rare chefs inherently tend to undercook. This practice assumes that for the consumer who prefers a lower DOD, undercooking is less detrimental than overcooking (Cox et al., 1997).

For steaks cooked to well-done (77°C [170°F]), the most ($P < 0.05$) chefs identified the steaks as medium-well, followed by well-done, which was a greater ($P < 0.05$) percentage than all of the other DOD. Finally, for steaks cooked to very well-done (82°C [180°F]), the greatest percentage of samples were classified as well-done, with only 12% of chefs identifying the steaks as medium-well or less. These results infer that chefs cook steaks that are ordered medium-well or well-done to be closer to overdone rather than underdone, likely because of a belief that for the consumers that prefer these DODs, it is plausible that overdone is more acceptable versus underdone. It is also noteworthy that for the chef data a much higher proportion (52 to 91%)

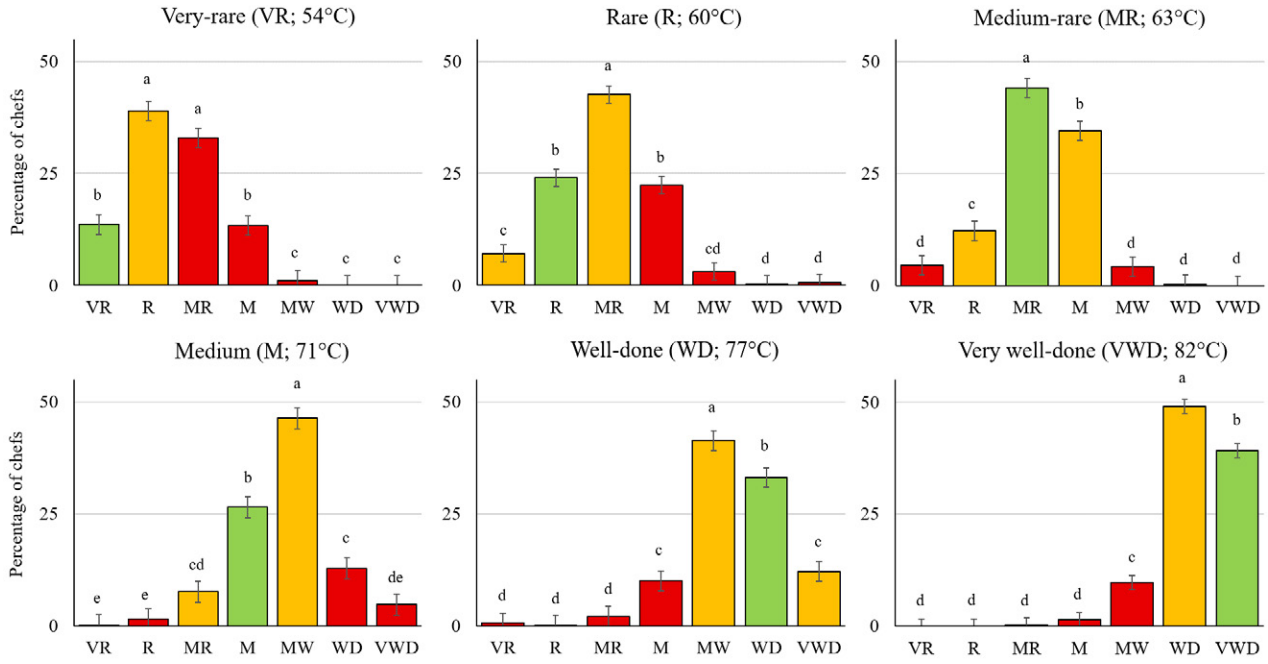

Figure 6. Percentage of chefs ($N = 83$) that identified beef strip loin steaks (*M. longissimus lumborum*) cooked to various end-point temperatures as various degrees of doneness. [a–c]Means within a degree of doneness without a common superscript differ ($P < 0.05$).

of steaks were identified within 1 DOD from the DOD to which the steak was prepared compared to the consumer data. This indicates that though the average chef responses did not correspond with the DOD to which the steaks were prepared, there was much less variation in chefs' perceptions of DOD than with the consumers.

Previously, Lehmuller and Hunt (2000) conducted a study to determine chefs' appraisal of cooked color compared to endpoint temperature. The authors reported that 49°C (120°F) was most commonly associated with rare, although this is tremendously lower than current published sources identifying rare as 60°C (140°F); however, details pertaining to if these were pull-off or carry-over temperatures were not provided by Lehmuller and Hunt (2000). In contrast to our study, over 85% of the chefs correctly identified doneness of steak pieces cooked very-rare, medium-rare, medium-well, and well-done. But it is worth noting that this study had a limited number of chefs who participated (22) as well as had the chefs evaluate cooked steaks in person, rather than evaluate pictures, as was done in the current study. Additionally, Lehmuller and Hunt (2000) allowed for a 5 to 6°F variance, and found chefs still were generally unable to correctly determine actual endpoint temperatures based on visual color.

It is also of note that in the current study, a clam-shell style grill was utilized for cooking the steaks. This cooking method provides heat from both the top and bottom throughout the cooking process. Consumers and chefs utilize a variety of cooking methods at home or in-restaurant including pan-grilling, outdoor grilling, broiling, and oven-roasting, among others. It is unclear how these different cooking methods may impact visual DOD and how the current results may differ with different cooking methods.

It is inevitable that the divide between consumers and chef's interpretation of DOD is a frustrating factor for consumers and chefs alike. In an article published by Quora, respondents listed a point scale on how upset chefs get when certain situations arise. Topping the list was "steak was cooked perfectly, but they [consumer] thought medium meant medium-rare" (Sutton, 2017). Overall, chefs' frustration with consumers could be decreased by reducing the gap in disconnect of DOD perception. In a separate article in the New York Post, a former chef states kitchens error on the rare side, knowing the steak can always be rescued with a minute or two more heat, "If a customer says their steak is overcooked, it can only be thrown out" (Cuozzo, 2018). In the same article, a different chef states "At this rate, we soon might have to ask for it medium-well to guarantee it won't be raw." (Cuozzo, 2018). Collectively, these reports along with the current work indicate that chefs do prepare steaks to lower end-point temperatures for steaks ordered as medium or less and provide context for the observed results in the current study. Overall, it is critical that chefs and consumers interpret the beef DOD similarly so that chefs at foodservice can deliver

steaks to customers that will meet their DOD expectations. Current and future DOD cooking recommendations published for consumers should include, or be revised to include, whether the stated temperatures correspond to either pull-off the heat or final peak temperatures to help consumers be able to better prepare beef to meet their visual DOD expectations.

Conclusion

These results provide insight into cooked beef color changes related to time and how this might impact DOD perceptions by consumers. Consumers do not have a good understanding of beef cooking temperatures and DOD, with no more than 35% able to correctly identify the DOD, visually, of steaks cooked to specified end-point temperatures. There remains a large amount of variation in consumer DOD perceptions, with a large percentage of consumers who identify beef DOD as 2 or more degrees different than what steaks are prepared to. Additionally, chefs do not assess the visual DOD of steaks in agreement with consumer DOD perceptions. This can create challenges for foodservice establishments to successfully meet customer DOD expectations. The beef and foodservice industries should find innovative approaches to better communicate about DOD and to help close this gap between consumer and chef DOD perceptions.

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