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Determination of Consumer Purchase Thresholds for Discoloration of Beef Strip Steaks in Retail Display

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Abstract

The objectives of this study were to determine the consumer purchase threshold for discoloration of beef steaks in simulated retail display and to determine the best objective measurement to predict consumer purchase intent. Beef strip steaks were evaluated by trained sensory panelists and consumer panelists, and objective color data were collected. Trained panelists determined percent discoloration, redness score, and fat color score, while consumer sensory panelists were asked to rate the sample appearance, and then asked if they would purchase the sample, with a follow-up question of if they would purchase the sample at a discounted rate, or if they said they would not purchase at full price. Objective L^* (lightness), a^* (redness), and b^* (yellowness), and spectral data were collected using a HunterLab MiniScan Spectrophotometer (Illuminant A, 10° observer, 1-in aperture). Objective color data were then used to calculate hue angle, chroma, and percent deoxymyoglobin, metmyoglobin, and oxymyoglobin according to the Guidelines for Meat Color Measurement. The a^* values were a good objective predictor of purchase intent ($R^2 = 0.64$ full-priced and $R^2 = 0.56$ for discounted; $P < 0.05$). Trained sensory panel percent discoloration scores were also a good predictor of consumer purchase intent ($R^2 = 0.61$ full-priced and $R^2 = 0.47$ discounted; $P < 0.05$).

Introduction

Meat color is one of the most important purchasing motivators for beef consumers (Olson et al., 2019; Farmer et al., 2022; Harr et al., 2022). Annually, 2.2 billion pounds of beef are discarded due to discoloration at retail (Ramanathan, 2022). Discoloration alone accounts for about a $3.73 billion economic loss yearly in addition to other wasted resources such as water and energy. Previous studies have been conducted to try to establish a consumer purchase threshold for discoloration of steaks. However, previous work has been conducted with an online survey, which does not ensure uniform evaluation by consumers (Holman et al., 2016; Holman et al., 2017). Other work had been completed over 50 years ago and did not account for the full range of discoloration (Hood and Riordan, 1973).

A study conducted at Kansas State University worked to determine consumer purchase thresholds for discoloration of ground beef in retail display and established highly predictive models. (Lybarger et al., 2023). While Lybarger's study followed a very similar design to the current study, it has been established that steaks discolor differ-

ently than ground beef. Ground beef discolors in an "all at once" manner (Lybarger et al., 2023), whereas steaks develop brown spots that expand. While Lybarger's models were very predictive for ground beef, consumer purchase thresholds for discoloration of steaks have not been explored widely in this manner.

Experimental Procedures

Samples were acquired from Cargill Meat Solutions (Wichita, KS) and transported to Kansas State University under refrigeration conditions (36-40°F). Samples were delivered in mother bags of six packages. Mother bags were kept in the absence of light under refrigeration until the designated display day. Five of the six packages per mother bag were allocated randomly to one of five retail case sections. One steak per package was covered with a piece of black tape so only one steak was visible. If one of the steaks had the *gluteus medius* present, that steak was covered, otherwise the steak for display was randomly selected. The last package in the mother bag was allocated to pH and proximate analysis. Three mother bags were opened every other day to allow for variation in sample discoloration. Packages were placed in their respective case sections on the morning of their designated display day. Samples were placed in three coffin style cases (model DMF8; Tyler Refrigeration, Niles, MI) at 36°F to 40°F under continuous fluorescent lighting (32 W Del-Warm White 3,000 K; Philips Lighting Company, Somerset, NJ).

Trained panelists (n= 12-20) were required to attend at least three training sessions to become familiar with the scales being used. Trained panelists evaluated all samples daily on 100-point line scales for percent discoloration (0% - 100%), redness score with 0 being extremely dark red and 100 being bright cherry-red, and fat color score with 0 being brownish-white and 100 being bright white. Objective L^* (lightness), a^* (redness), and b^* (yellowness), and spectral data were collected using a HunterLab MiniScan Spectrophotometer (Illuminant A, 10° observer, 1-in aperture). Three readings were collected, averaged, and used to calculate chroma, hue angle, and percent metmyoglobin, deoxymyoglobin, and oxymyoglobin according to the Guidelines for Meat Color Measurement (King et al., 2023). Consumer panelists (n = 200) evaluated 24 samples varying from 0% to 100% discoloration. Consumers were asked to designate an overall appearance score on a 100-point continuous line scale with 0 being extremely undesirable and 100 being extremely desirable. They also were asked if they would purchase the sample at retail. If they selected yes, they would move on to the next sample; however, if they selected no, they would be shown an additional question asking if they would purchase the sample if it was discounted.

Results and Discussion

Logistic regression equations calculated for the prediction of purchase intent by the consumer sensory panel of beef strip steaks are presented in Table 1. All models were predictive of consumer purchase intent ($P < 0.05$). Using the logistic regression models, thresholds (50%, 75%, 90%, and 95%) for consumer purchase intent were identified for full-price and at discount. The a^* values were a good objective predictor of purchase intent ($R^2 = 0.64$ full-priced and $R^2 = 0.56$ for discounted; $P < 0.05$). At full price, a^* values of 25.3, 29.9, 34.4, and 37.6 corresponded to a 50%, 75%, 90%, and 95% likelihood for consumers to purchase the sample (Figure 1); whereas if the product was discounted, a^* values of 20.3, 25.8, 31.3, and 35.0 corresponded to those same thresholds. Trained sensory panel percent discoloration scores were also a good predictor of consumer purchase intent ($R^2 = 0.61$ full-priced and $R^2 = 0.47$ discounted; $P < 0.05$).

At full price, trained discoloration scores of 12% corresponded to a 50% likelihood of consumers purchasing the samples (Figure 2); whereas, if the product was discounted, trained discoloration scores of 35.8% and 8.3% corresponded to 50% and 75% thresholds.

Implications

The a^* value and trained panel redness score are good indicators of consumer purchase intent showing that consumers highly value redness when choosing steaks.

Acknowledgments

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Table 1. Logistic regression equations for predicting consumer sensory panel purchase intent of beef strip steaks

Measurement	Intercept	Slope	Adjusted R^2	P – value	C – statistic[1]	% Correct[2]
Product sold at full price						
L^*	-12.97	0.29	0.30	< 0.01	0.75	73.2
a^*	-6.07	0.24	0.64	< 0.01	0.87	83.5
b^*	-8.69	0.41	0.60	< 0.01	0.85	82.6
Metmyoglobin[3]	3.70	-0.13	0.51	< 0.01	0.85	79.4
Oxymyoglobin[3]	-5.63	0.09	0.56	< 0.01	0.86	81.9
Chroma[3]	-7.11	0.21	0.64	< 0.01	0.87	83.6
Hue angle[3]	8.27	-0.22	0.33	< 0.01	0.79	75.1
Trained sensory panel redness score[4]	-4.08	0.06	0.64	< 0.01	0.88	82.9
Trained sensory panel discoloration score[5]	0.84	-0.07	0.56	< 0.01	0.88	82.3
Trained sensory fat score[6]	-4.10	0.06	0.61	<0.01	0.86	82.4
Consumer appearance score[7]	-4.62	0.08	0.78	< 0.01	0.91	86.2
Product sold at discounted price						
L^*	-10.49	0.25	0.27	< 0.01	0.72	66.4
a^*	-4.06	0.20	0.56	< 0.01	0.82	75.0
b^*	-6.60	0.36	0.53	< 0.01	0.81	74.8
Metmyoglobin[3]	3.36	-0.09	0.41	< 0.01	0.80	70.8
Oxymyoglobin[3]	-3.45	0.07	0.49	< 0.01	0.81	74.6
Chroma[3]	-5.27	0.19	0.58	< 0.01	0.82	76.0
Hue angle[3]	6.39	-0.15	0.27	< 0.01	0.74	69.7
Trained sensory panel redness score[4]	-2.34	0.05	0.59	< 0.01	0.84	76.2
Trained sensory panel discoloration score[5]	1.43	-0.04	0.47	< 0.01	0.83	73.0
Trained sensory fat score[6]	-2.15	0.05	0.48	<0.01	0.80	72.1
Consumer appearance score[7]	-3.03	0.08	0.72	< 0.01	0.87	78.4

[1]Measure of goodness of fit for binary outcomes in a logistic regression model, ranging from 0 – 1.
[2]Percentage of correctly classified events and nonevents by the model.
[3]Calculated utilizing the equations presented in the American Meat Science Association Guidelines for Meat Color Measurement (King et al., 2023).
[4]Sensory scores: 0 = extremely dark red, 100 = bright cherry red.
[5]Sensory scores: 0 = no visible discoloration, 100 = complete discoloration.
[6]Sensory scores: 0 = brownish-white, 100 = bright white.
[7]Sensory scores: 0 = extremely undesirable, 100 = extremely desirable.

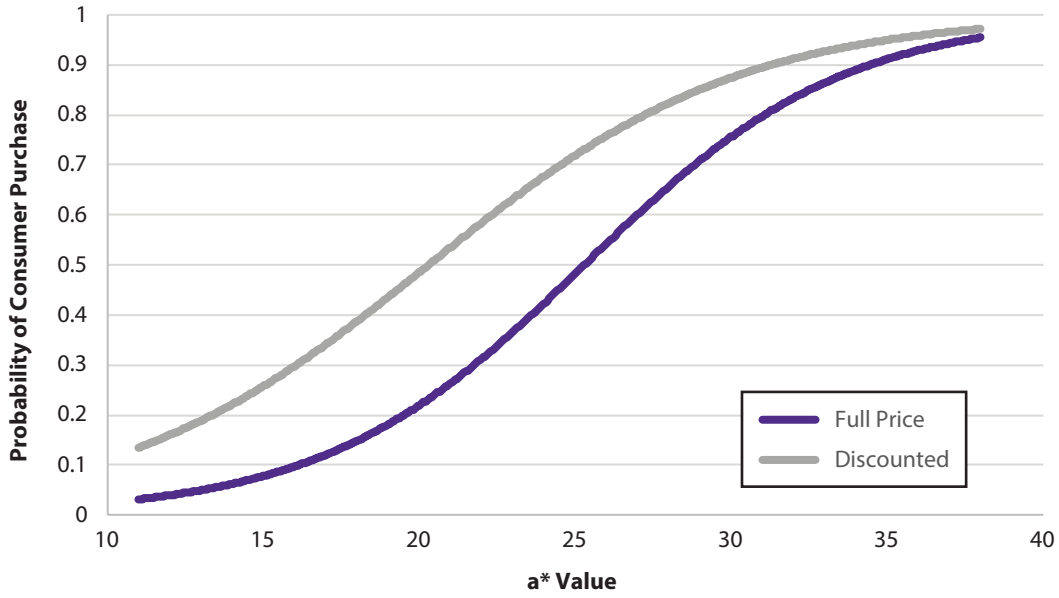

Figure 1. Probability of a consumer purchasing a steak based on a* value

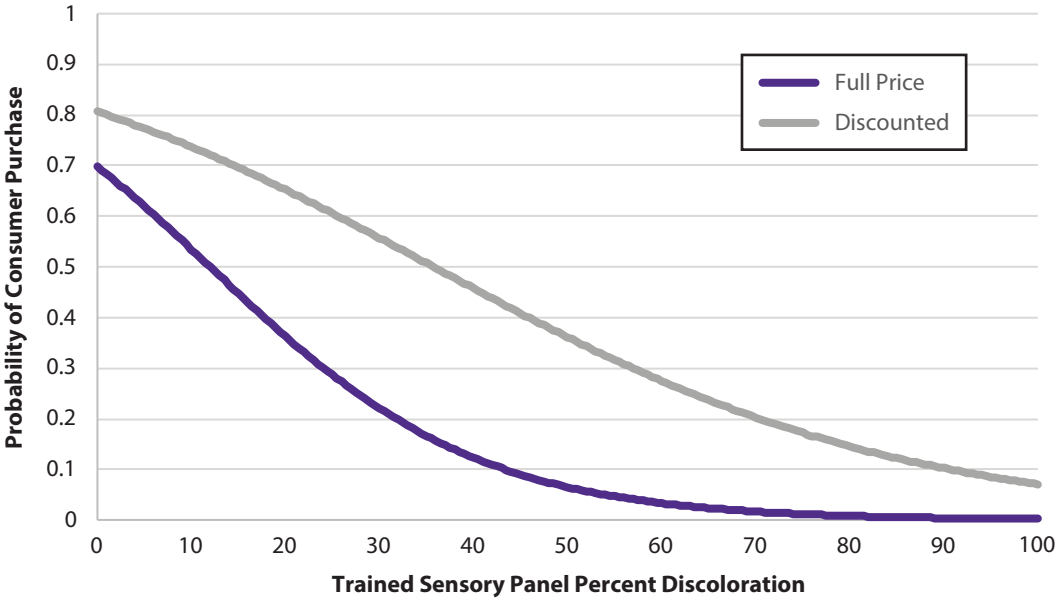

Figure 2. Probability of a consumer purchasing a steak based on trained sensory panel discoloration score and pricing: sensory discoloration scores: 0 = 0% discoloration, 100 = 100% discoloration.