REDUCING FOOD WASTE: HOW BEEF COLOR INFLUENCES CONSUMER BUYING DECISIONS

Annika J. Thies, Brianne A. Altmann, Amanda M. Countryman, Colton Smith, Maggie Holloway, Mahesh N. Nair

annika.thies@thuenen.de

Johann Heinrich von Thuenen Institute, Institute of Market Analysis, Bundesallee 63, 38116 Braunschweig, Germany

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Summary

Discoloration of beef products leads retailers to either offer discounts or discard beef, as consumers tend to reject discoloration. This practice contributes to food waste and wastage of economic and natural resources. This study analyzes U.S. consumer preferences for beef based on meat color. A mixed methods design including a discrete choice experiment and focus group discussions is applied to understand consumer willingness to pay (WTP), the effects of price discounts as well as color preference of beef shoppers. Results show that consumers perceive, prefer, and see color nearly linearly across days. Consumer WTP is negative for all days of retail display and decreases with an increase in discoloration. Focus group participants associate a bright cherry color with beef quality and eating satisfaction. Most participants reject discoloration and link a brownish beef color to concerns about food safety and product quality. Still, informative marketing measures in addition to price discounts may help to shift some consumers' purchasing behavior and reduce meat waste at the retail level.

keywords

Meat color, consumer preferences, mixed-methods approach

1   Introduction

Reducing food waste is crucial for creating sustainable food systems (SEARCHINGER et al. 2018). About one-third of global food production is lost or wasted annually, causing economic losses of US$1 trillion per year along the supply chain in addition to environmental costs of about US$700 billion and social costs of US$900 billion globally (FAO 2014). Meat is an important component of food items that are wasted as it is highly perishable and primarily associated with the environmental impact of food waste (LIPINSKI 2020; FAO 2014).

Meat consumers often associate visual appearance at the time of purchase at retail with product quality (HENCHION et al. 2014; LUSK et al. 2018). Recently, ALTMANN et al. (2022) reported that meat color strongly influences consumer purchase decisions. Consumers in Western industrialized countries often prefer a bright cherry red beef color (ALTMANN et al. 2023; MEYERDING et al. 2018) and consider brownish or other colors hues of beef discoloration. Discoloration of beef can lead to rejection (FEUZ et al. 2020) and is associated with a low willingness to pay (WTP) for these products (GREBITUS et al. 2013). Therefore, beef turning brownish red to brown is typically discounted or even discarded by retailers (RAMANATHAN et al. 2022), although it could be microbiologically safe for consumption in most cases (RAMANATHAN et al. 2021). RAMANATHAN et al. (2022) also reported that 194,700 tons of edible beef are discarded annually in United States (U.S.) food retail stores due this practice.

The objective of this study was to analyze consumer attitudes, preference and their willingness to pay (WTP) for beef based on meat color. A mixed methods design, including a discrete choice experiment as well as focus group discussions, was developed. Consumer preferences,

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[1] Johann Heinrich von Thuenen Institute, Institute of Market Analysis, Bundesallee 63, 38116 Braunschweig, Germany , annika.thies@thuenen.de

WTP, and the effects of price discounts were examined with a hypothetical discrete choice experiment conducted using digital photos of steaks with different color (associated with day of retail display), price, and discount labels in retail packaging. In addition, qualitative focus group discussions were conducted in order to assess consumers' beef color perceptions and their future purchasing ambitions in more detail. A profound understanding of consumer preferences for color will assist retailers in successfully marketing discolored beef to reduce food waste at the retail level.

2 Materials and Methods

A mixed methods design, including a hypothetical discrete choice experiment as well as focus group discussions, was developed.

2.1 Survey design

A consumer survey on beef purchasing behavior was conducted using Qualtrics software (XM, Seattle, WA, USA) on iPads (10th generation) between June and August 2023. Survey participants (n = 389) were recruited at supermarkets or other food purchase facilities in different neighborhoods throughout Fort Collins and Laporte, Colorado. The study was approved by the Colorado State University Institutional Review Board (IRB#4446). Descriptive statistics of the resulting sample (n = 315) are summarized in Table A1.

The survey included three sections: 1) color perception, 2) self-declared beef purchasing behavior and attitudes, and 3) a hypothetical discrete choice experiment. Additionally, the standardized questionnaire collected sociodemographic information as well as data on respondents' self-declared beef purchasing and consumption behavior based on short statement batteries. The comprehensibility of the questionnaire was checked by means of a pre-test with 94 colleagues and students participating in courses at the Department of Animal Sciences, Colorado State University. Screen acuity regarding color perception was tested using a condensed form (i.e., with one test image) of the ishihara test at the beginning of the survey.

A discrete choice experiment (DCE) was conducted to determine consumer preferences for discolored beef steaks in retail packaging. Three product attributes: 1) beef color, 2) price, and 3) discount sticker and their respective levels were included in the choice experiment using digital photos of packaged beef steaks. A d-optimal 12 choice design was created using Ngene (Choicemetrics, Version 1.1) with two product alternatives each and one opt-out option ("I choose neither of these alternatives") to refrain from forced choices. An example choice set is presented in **Figure 1**. The order of the choice sets, as well as the position of the two product alternatives, varied randomly for each respondent, while the position of the opt-out option was presented last in every choice situation. Respondents were placed into a theoretical shopping situation using a standard cheap talk script and asked to consider their actual budget when making purchasing or non-purchasing decisions. They were informed that they would be presented with a choice of 12 beef steaks, all of which were within their expiry date.

3

Figure 1: **Example of a choice set shown to participants.**

I would not purchase
any of those steaks

Source: Own presentation.

2.2 Model specification and data analysis

Based on the ishihara test results, a total of five participants (1.59%) were excluded from the sample prior to analyzing the choice data. Thirteen participants (4.13%) opted not to purchase any beef steak across all 12 choice scenarios, expressing a preference for alternative beef cuts. These individuals were also excluded from subsequent analysis. In total 297 participants' responses were analyzed.

Discrete choice modeling is based on utility theory, which assumes that the overall benefit (utility) of a product to its user (consumer) is deterministic and a sum of that product's attributes. Consequently, in a discrete choice experiment, participants choose the product returning their highest utility at the lowest cost. In this way, utility maximization of product attributes can be assumed to explain consumer behavior (MCFADDEN 1986). The Mixed Logit Model (MLM) accounts for repeated choices and allows preferences to vary randomly and independently amongst consumers (REVELT UND TRAIN 1998). The model assumes that a portion of the utility is deterministic, based on known attributes, and the remainder is random. The deterministic portion is assumed to be linear so that individual i's marginal utilities of observable attributes associated with alternative j can be summed:

$$(1)\ U_{ijt} = ASC + \alpha Price_{ijt} + \beta_i X_{ijt} + z_i \delta_j + \varepsilon_{ijt}$$

where ASC is the alternative specific constant (opt-out option); α is fixed marginal utility of price, $Price_{ijt}$ given the price of alternative j for individual i in scenario t. β_i are random utility coefficients X_{ijt}, a k-dimensional vector of observed non-monetary product attributes (i.e. color, sales tag) and their respective levels for alternative j, individual i and choice scenario t. δ_j are fixed alternative-specific coefficients for case-specific variables (z_i). ε_{ijt} is an i.i.d. error term that follows a type I extreme value distribution.

Consumers preferences for steak color, price as well as discount were modelled using mixed logit models (MLM). Zero days of retail display and no discount sticker were used as reference levels to determine the marginal utility and WTP. The Hemmersley integration sequence was specified using 3,500 points. The third-choice option, "no-buy," was selected as the base alternative. The mixed logit model accounted for the presence of a sale sticker as a binomal (1= discount sticker; 0 = no discount sticker) and is specified below:

$$(2) \quad U_i = ASC + \beta_i listedprice + \beta_i 4days + \beta_i 7days + \beta_i 9days + \beta_i Discountsticker + \varepsilon_{ijt}$$

Listed price was fixed and all other variables were considered random.

Willingness to pay in preference space for the beef color was calculated according to Hensher et al. (2015):

$$(3) \quad WTP = -\frac{\beta_{attribute}}{\beta_{price}}$$

with 1000 Krinsky repetitions to calculate confidence intervals.

2.3 Qualitative focus group discussions

Qualitative research enables the acquisition of profound insights into the societal perspectives of individuals or groups, facilitating the exploration of overarching relationships within the context of real-life behavioral actions (FLICK et al. 2007). In order to understand consumer attitudes and their perception with regard to beef color and discoloration, qualitative focus groups were therefore conducted in addition to the consumer survey. Through active engagement with one another, participants in the focus groups articulated their perspectives and offer spontaneous reactions to a designated topic, in this case, beef color (FLICK et al. 2007).

In January 2024, four qualitative focus group sessions were carried out, each comprising seven to ten beef consumers. This research was approved by the Colorado State University Institutional Review Board (IRB#5092). The purpose was to thoroughly examine consumers' perceptions of beef color and gain a comprehensive understanding of their perspectives. The focus group guideline included open questions regarding meat buying behavior, beef color preferences, beef quality perceptions, discoloration in beef, meat shelf life, as well as food and meat waste prevention. Focus group participants were also given a scientific definition of meat discoloration. Each focus group session was recorded in audio format and later transcribed for further analysis and documentation. A qualitative content analysis according to MAYRING (2000) was applied to evaluate the text material. Thematic categories were established, deducting the corresponding codes from the text material. The codes were combined into four main categories and 11 sub-categories, whereby the codebook was developed jointly by two researchers using MAXQDA.

3 Results

3.1 Consumer preferences

Statistically significant ($P < 0.05$) results of a mixed logit model (MLM) are presented in **Table 1**. Preference heterogeneity within the total sample was demonstrated by statistically significant ($P < 0.05$) standard deviations of the random attributes (4, 7, and 9 days of retail display color levels and discount stickers). A negative and significant coefficient for listed price aligns with utility theory that the increasing price negatively affects participants' welfare and, therefore,

preferences. The positive and significant ($P < 0.001$) constant coefficients for choices 1 through 2 (per choice set) indicate that survey participants chose to engage and would "purchase" one out of the two beef steaks instead of choosing the base alternative "I would not purchase any of those steaks." The negative and significant coefficients for 4, 7, and 9 days of retail display demonstrate that beef consumers perceive discrete differences in beef color and prefer color nearly linearly across days. As coefficients were negative, color level 0 was the most preferred, followed by levels 4 and 7. The steak that discolored over 9 days of retail display was the least preferred.

Table 1: **Mixed Logit Model estimates of coefficient means and standard deviations (SD) for the total sample (n = 297)**

Variable	Total participants (n=297)		
	Coefficient	Standard error (SE)	p-value
Listed price	-0.13	0.01	***
4 days of retail display	-0.67	0.09	***
7 days of retail display	-1.31	0.11	***
9 days of retail display	-2.65	0.16	***
Discount sticker	0.88	0.10	***
SD			
4 days of retail display	0.73	0.11	***
7 days of retail display	0.99	0.11	***
9 days of retail display	1.80	0.17	***
Discount sticker	1.33	0.09	***
Constant alt1	4.51	0.25	***
Constant alt2	4.38	0.25	***
Log likelihood	-1277.48		

Significances levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$
Source: Own estimations based on choice data

On average, consumer WTP in preference space (**Table 2**) was negative for all days of retail display and decreased nearly proportionately with an increase in discoloration. For a steak that was in retail display (and discolored) for 4 days, respondents in this study were willing to pay $5.09 per lb. less compared to a steak with 0 days of retail display. The WTP was the lowest for 9 days of retail display, and the respondents will only spend $20 per lb. less compared to 0 days of retail display. As the average price for the steaks presented was $15.99 per lb., the results imply that the respondents would have to be financially compensated for choosing a steak left for 9 days in retail display. Full results can be found at THIES et al. (2024).

Table 2: **Willingness to pay (WTP) for different days of retail display based on Mixed Logit Model estimates (n = 297)**

Variable	Total sample n=297		
	WTP	Lower bound	Upper bound
4 days of retail display	-5.08	-6.65	-3.52
7 days of color display	-9.89	-12.21	-7.58
9 days of retail display	-20.05	-24.74	-15.28

Source: Own estimations based on choice data

3.2 Associations with discoloration

Four main categories (i.e., "beef purchasing behavior, beef color perception, food and meat waste awareness, and future buying decisions based on beef color") as well as 11 sub-categories were identified based on the text material of the qualitative focus group sessions.

Focus group participants associated a bright cherry beef color with beef quality, food safety and eating satisfaction. Beef consumers expected a cherry red steak to be more fresh than the brownish counterpart. They were also assuming a red beef steak to be more tender and thought that color indicates juiciness. Furthermore, the anticipation of a premium-quality steak was in line with the interviewees' acquired product expectations, marked by a distinctive cherry-red steak color.

"If I'm paying the full price, I want it to be bright red."

Participants perceived a beef steak as a premium product for which they were willing to pay a higher price if the product meets their requirements and expectations. The majority of participants stated they rejected discoloration in beef steak and linked a brownish color to concerns about food safety, toughness, and dryness. Beef consumers were assuming that "there's something off at the very least" with brownish beef steaks. They supposed that a discolored beef steak would taste differently compared to a steak of a cherry red color. Participants further believed that a brownish discoloration indicated a shorter shelf life. They were convinced that beef color was an indicator for incorrect product handling during storage.

"Maybe it wasn't at the correct temperature. Maybe it was like frozen and then thawed."

In some cases, participants even linked beef color to animal handling and assumed that cattle had been treated incorrectly before or during slaughter. They concluded that a brownish discoloration of steaks was a representation of bruising.

Still, participants suggested a potential shift in their purchasing behavior, contingent upon receiving information on discoloration in beef and on the occurrence of meat waste at the retail level. Beef consumers mentioned that they were not aware that product quality and eating satisfaction were not affected by discoloration in beef steaks. After being provided with a definition of discoloration many participants stated that they would now consider to buy a brownish steak if they could be guaranteed by an independent body that the meat was still safe to eat. At the same time, the participants expected a price discount for any form of discoloration in beef.

"If you could confirm it's safe, I mean, I said I would buy it if it was a little brown, but if it's really brown, if you could confirm it's safe and the juiciness, tenderness is still not affected, then I would definitely buy it, especially if it was discounted, I mean, too."

4 Discussion and concluding remarks

When purchasing beef, consumers often view color as an indicator of freshness and wholesomeness (MANCINI AND HUNT 2005). Despite this, only limited studies have examined the consumer preferences and acceptance of different beef color levels (ALTMANN et al. 2023). GREENE et al. (1971) showed that U.S. consumers reject fresh beef with a brown metmyoglobin level of over 40%. Similarly, CARPENTER et al. (2001) reported a close link between beef color preferences and likelihood to buy, but not between color preferences and eating satisfaction.

This study offers crucial and contemporary insights into the purchasing behavior of beef consumers, specifically concerning their color, price, and discount preferences based on quantitative and objective color measurements. Results of the discrete choice experiment showed that beef consumers perceive discrete differences in beef color and prefer color nearly linearly across days of retail display. A steak that has had the chance to discolor over 9 days was least preferred by consumers. Accordingly, the WTP of beef shoppers decreased with increasing days of retail display, as what can be considered discoloration increased. In fact, according to our hypothetical experiment, consumers would require financial compensation to consider purchasing a steak with discoloration associated with 9 days of retail display.

Similar to the current study, Grebitus et al. (2013) used a choice experiment focusing on various ground beef attributes modifiable through packaging. The participants in their study favored a light red color and cherry red color compared to a brownish red color and were willing to pay the highest price for cherry red ground beef. HOLMAN et al. (2017) provided a more intricate examination of beef color preferences by conducting a web-based survey using digital photographs of beef steaks (longissimus lumborum) with predetermined colorimetric values. Their survey aimed to explore international beef color acceptability on a six-level interval scale. The authors found that consumers considered beef color to be acceptable, with $a*$ value[2] being equal to or above 14.5. The findings of our current study indicated that beef steaks in retail display for up to 7 days could still be marketable with a price discount; the color measurements for 7 days of retail display had an $a*$ value of 17. In our study, consumers required compensation to consider purchasing steaks that were displayed for 9 days, yet still with an $a*$ value of 14.

Moreover, results of the choice experiment revealed that discount stickers did not reduce the utility gained through a product purchase (i.e., coefficients were not negative). Therefore, a discounted beef price might not be necessarily associated with a negative quality, or at the very least the perception of saving money offsets concerns around negative quality. Certainly, participants in the focus groups for this study expressed an expectation for a discounted price when it came to brown-discolored beef steaks. Additionally, they expressed a willingness to consider purchasing slightly discolored steaks as a cost-saving measure.

Targeted marketing measures, including informative measures could be used in addition to price discounts to address beef buyers, ensuring timely sales of beef products in retail to reduce food waste. Findings from the focus group sessions indicated a favorable response among participants to additional information regarding food safety and beef discoloration. Many, but not all, expressed their intention to consider purchasing such beef products during their next grocery shopping trip. Individual participants also responded positively to the discussion about the potential reduction of meat waste through the purchase of brown-discolored beef.

The findings of this research could be translated into appropriate marketing measures including consumer education on beef quality and safety in order to potentially reshaping long-term consumer perceptions of beef quality and preferences and thereby combating meat waste and its associated resource wastage.

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[2] Beef color was measured and evaluated for lightness ($L*$), redness ($a*$), and yellowness ($b*$).

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Appendix

Table A1. Descriptive statistics for demographic variables in the total sample (n = 315)

Variable	Level	Total sample (%)	Census 2022 (%)
Age in years	18-24	17.5	16.0
	25-34	25.7	16.5
	35-44	13.7	16.0
	45-54	11.4	14.9
	55-64	13.7	15.7
	65-74	11.8	12.5
	≥75	6.4	8.3
Gender[1]	Female	53.0	50.4
	Male	45.7	49.6
	Non-Binary	0.6	
Hispanic origin	Hispanic	11.4	19.1
	Not Hispanic	88.6	80.9
Ethnic heritage[2]	White	88.8	75.5
	American Indian or Alaskan Native	2.2	1.3
	Black or African American	2.3	13.6
	Asian	2.5	6.3
	Native Hawaiian or other Pacific Islander	0.3	0.3
	Middle Eastern	0.6	
Education (highest degree or level of school you have completed[2]	Less than high school	0.6	
	High school/GED	6.4	37.3
	Some college degree	15.6	16.4
	2-year degree	4.1	10.1
	4-year degree	38.4	22.6
	Graduate degree	34.9	13.3
Income (net monthly household income)[1,3]	< $ 29,999	14.0	
	$ 30,000 – $ 59,999	17.1	
	$ 60,000 - $ 89,999	16.2	
	$ 90,000 - $ 119,999	14.0	
	$ 120,000 - $ 149,999	10.8	
	≥ $ 150,000	21.3	
Household size[1]	1 person	13.0	28.9
	2 people	45.1	34.7
	3 people	20.0	15.1
	4 people	14.3	12.3
	5 people	5.7	5.6
	More than 5 people	1.6	3.4

[1] Total percentages do not sum up to 100% due to participants having the option of choosing not to answer this question.

[2] Total percentages exceed 100% due to participants having the option to check all ethnic heritages that apply.