

Beef Color Preferences Among Meat Shoppers: An International Comparison

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ABSTRACT

In the course of developing a more sustainable food system, food waste, including retail meat waste, needs to be reduced to a minimum. Since meat discoloration often leads retailers to discount and then discard meat products due to consumer rejection, this study aimed to examine German consumer attitudes and preferences regarding beef color. We conducted a discrete choice experiment using digital photos of beef steaks with varying colors, prices, and discount levels to analyze consumer preference behavior and willingness to pay in Germany in the course of a pre-test. We then compared these results with the beef color preferences we found for US beef consumers.

Keywords: consumer preference behavior, discoloration, willingness to pay, food waste, cross-cultural comparison

Introduction

The food system is directly linked to global environmental and climate challenges. Considering a constantly growing demand for food due to population growth and the corresponding overshoot of planetary limits (Searchinger et al., 2018; Springmann et al., 2018), wasted food quantities need to be reduced to a minimum in order to achieve a more sustainable food system (UN, 2015).

On a global level, about one-third of global food production is lost or wasted annually (FAO, 2014). Meat is an important component of food waste as it is highly perishable and is primarily associated with the environmental impact of wasted food along the value chain (FAO, 2014; Lipinski, 2020). Reducing the waste of nutritious beef products considering the entire beef value is crucial with regard to resource efficiency (Ramanathan et al., 2022), as cattle have a longer growth period and lower feed-use efficiency than other species (Greenwood, 2021; Mekonnen et al., 2019; Mottet & Tempio, 2017).

In order to inform potential pathways to reduce meat waste at the retail level, consumer preferences for meat products need to be understood. The visual appeal of food, particularly meat products, is a key factor influencing consumer purchasing decisions (Altmann et al., 2023). With regard to beef, consumers in Western industrialized countries tend to prefer products with a bright cherry-red color (Altmann et al., 2023) and seem to reject beef products with brown color hues. Discoloration of beef leads to a low willingness to pay (WTP) for these products (Feuz et al., 2020; Thies et al., 2024). In the course of a previous study of US consumers we found that beef shoppers would expect a significant price discount before considering the purchase of a discolored beef steak compared to a bright cherry-red or unicolored option (Thies et al., 2024). Non-purchase decisions for beef often result in these products being discarded at the retail level. According to Ramanathan et al. (2022), an estimated 197.4 million kg of beef is wasted annually in the United States due to consumers' reluctance to buy beef with brownish discoloration.

Consumer preferences and corresponding WTP for beef color have been recently studied in the U.S. (Thies et al., 2024). However, there is a lack of current research on the preferences of German consumers. Therefore, this study aims to examine consumer behavior regarding beef color in Germany and compare the findings with those from the U.S. We anticipate significant differences in preferences, as beef in Germany is typically purchased at fresh meat counters, while in the U.S., it is more commonly sold pre-packaged.

Methodology

Following a study of US consumers (Thies et al. 2024), a Qualtrics consumer survey was conducted in Germany including a section on color perception, a section on beef purchase attitudes, and a section with a discrete choice experiment (DCE). Based on a standardized questionnaire we collected sociodemographic information as well as data on meat consumption frequency and the frequency of fresh (not frozen) steak purchases of 60 participants in the course of a pre-test in January 2025. Hedonic attitudinal statements measured respondents' perceptions regarding beef quality and food waste prevention.

Similar to our study with US consumers (Thies et al. 2024), we conducted a DCE using digital photos of beef steaks of different color, price and discount level to analyze consumer preferences and their WTP based on beef color and discount. We used images of beef steaks in retail packaging

which were stored in a retail case (3°C) under constant fluorescent light exposure for 14 days. Details with regard to the image preparation can be found at Thies et al. (2024). Three product attributes: 1) beef color, 2) price, and 3) discount sticker and their respective levels (**Table 1**) were included in the choice experiment using digital photos of packaged beef steaks.

Table 1. Different attributes of beef (color, price, and discount) and associated levels considered in the Discrete Choice Experiment

Attribute	Level
<i>Beef steak color</i>	Color at day 0 of retail display
	Color at day 4 of retail display
	Color at day 7 of retail display
	Color day at 9 of retail display
<i>Price (per lb. beef steak)</i>	18.99 €
	20.99 €
	22.99 €
	24.99 €
<i>Discount sticker (total savings per steak)</i>	30% off price per kg
	No discount

Note: Participants were ask to make 12 choice decisions with different combinations of the individual attribute levels.

A D-optimal 12 choice design was created using Ngene (Choicemetrics, Version 1.1), including 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 position of the two product alternatives and the order of the choice sets varied randomly for each respondent. The position of the opt-out option was presented last in every choice set. Participants were introduced to a hypothetical shopping scenario through a standard cheap talk script. They were asked to take their real-life budget into account when making decisions about purchasing or not purchasing retail beef steaks. Moreover, participants were told that they had the option to choose from 12 beef steaks, all of which were within their use-by-date.



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

A Mixed Logit Model (MLM), which accounts for repeated choices and allows preferences to vary randomly and independently amongst consumers (Revelt & Train, 1998) was used to analyze the choice data using STATA. We used zero days of retail display and no discount sticker as reference levels in order to determine the marginal utility and WTP. The Hemmersley integration sequence was specified using 3,500 points, while the “no-buy”-choice option was specified as the base alternative. Further model specifications can be found at (Thies et al., 2024).

Results

Sampling

In the course of the online pre-test, 88 participants were approached in total through the direct network of the Thünen-Institute and the University of Veterinary Medicine Hanover. Among these, 60 participants indicated they were regular beef buyers and consumers and completed the questionnaire. Descriptive statistics of the resulting pre-test sample ($n = 60$) are summarized in **Table 2**. The sample consisted of 53% female, 46% male, and 2% non-binary participants aged between 18 and over 75 years. Participants in the pre-test mostly had a high school leaving certificate level and lived in a 2-person household with a net monthly household income of 3,000 € up to 6,999 €.

Table 2. Descriptive statistics of demographic variables (n = 60)

Variable	Level	Total sample (%)
<i>Age in years</i>	18-24	3.6
	25-34	9.1
	35-44	38.2
	45-54	40.0
	55-64	5.5
	65-74	1.8
	≥75	1.8
<i>Gender</i>	Female	52.7
	Male	46.4
	Non-Binary	1.8
<i>Education (highest degree or level of school you have completed)</i>	Secondary school certificate	5.5
	Intermediate or general secondary school certificate	9.1
	High school diploma	7.3
	Bachelor or Master degree	50.1
	Doctorate degree	21.8
<i>Income (net monthly household income)</i>	< 2,999 €	18.2
	3,000 € – 4,999 €	29.1
	5,000 € - 6,999 €	34.6
	7,000 € - 8,999 €	9.1
	≥ 9,000 €	0.0
<i>Household size</i>	1 person	29.1
	2 people	34.6
	3 people	12.7
	4 people	18.2
	5 people	1.8
	More than 5 people	1.8

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

Beef color preferences among German consumers

The statistically significant ($P < 0.05$) mixed logit estimates are presented in Table 3. Statistically significant ($P < 0.001$) standard deviations of the random attributes (4, 7, and 9 days of retail display and corresponding discount stickers) indicated preference heterogeneity among participants. The listed price affected participant choice negatively. Negative and significant coefficients for 7 and 9 days of retail display demonstrated that pre-test participants perceived beef color differences and preferred a shorter retail display time (7 days) over 9 days of retail display. Contrary to our findings for US consumers (Thies et al., 2024), the negative coefficient for 4 days of retail display was not significant. Finally, the positive and significant ($P < 0.001$) constant coefficients for choices 1 and 2 indicated that survey participants opted to "purchase" a beef steak rather than selecting the third option, "I would not purchase any of these steaks" ("Ich würde keins dieser Steaks kaufen").

Table 3. Mixed Logit Model estimates of coefficient means and standard deviations (SD).

Variable	Total participants (n=60)		
	Coefficient	Standard error (SE)	p-value
Listed price	-0.10	0.03	***
4 days of retail display	-0.33	0.28	n.s.
7 days of retail display	-1.77	0.33	***
9 days of retail display	-3.81	0.60	***
Discount sticker	0.79	0.27	***
SD			
4 days of retail display	1.64	0.29	***
7 days of retail display	1.80	0.33	***
9 days of retail display	2.90	0.56	***
Discount sticker	1.78	0.27	***
Constant alt1	3.76	0.76	***
Constant alt2	3.40	0.74	***
Log likelihood	-580.74		

Significances levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 4 shows consumer WTP in preference space based on the MNL results presented in **Table 3**. Accordingly, the WTP of German beef consumers in our sample was negative for all days of retail display compared to zero days of retail display. Beef consumers in our sample spend 3.39 € per kg less compared to a steak with a light cherry beef color at zero days of retail display. Moreover, WTP decreased with longer display times and was lowest (-38.75 €) for 9 days of in-store display. Considering the average price for a beef steak presented in the course of the choice experiment (21.99 €/kg), participants in our pre-test would have to be financially compensated to purchase a beef steak that has discolored in a retail case over 9 days.

Table 4. Willingness to pay (WTP) for different days of retail display based on the Mixed Logit Model

Variable	Total sample n=60		
	WTP	Lower bound	Upper bound
4 days of retail display	-3.39	-9.35	-2.56
7 days of color display	-18.09	-30.50	-5.67
9 days of retail display	-38.75	-66.43	-11.06

Note: Zero days of retail display were used as reference levels to determine WTP.

International comparison

Figure 2 shows WTP values in preference space based on our study results in the US (Thies et al., 2024) and for Germany based on our pre-test results for 4, 7 and 9 days of retail display in comparison to zero days of retail display.

Comparing WTP values between German and US consumers reveals a clear trend: US consumers are willing to pay less for a steak with four days of discoloration compared to their German counterparts. However, for longer discoloration periods of 7 and 9 days, US consumers are still willing to pay only \$10 and \$20 less than for a fresh steak (zero days of retail display). In contrast, German consumers in the pre-test indicated a stronger price reduction, willing to pay only half as much for steaks with the same discoloration duration.

These results should be interpreted with caution, as the estimated WTP value for Germany is based on a significantly smaller sample size, and the two surveys used different units (€ per kg vs. \$ per lb).

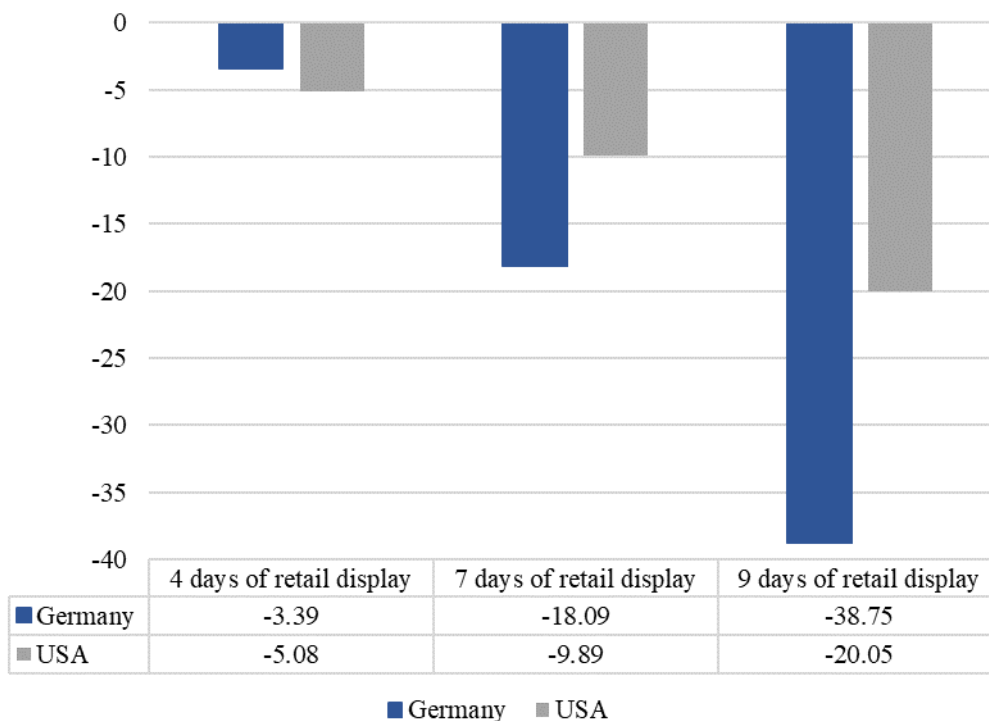


Figure 2. Willingness to pay (WTP) in preference space or steak color in Germany and the USA

Note: Results for Germany are based on a pre-test.

Discussion and concluding remarks

This study provides contemporary insights into the purchasing behavior of beef consumers, focusing on their preferences for color, price, and discounts. It employs quantitative and objective

color measurements to examine these factors within a cross-cultural comparison of German and US consumer preferences.

Our findings indicate that German and US beef consumers perceive distinct differences in beef color. Additionally, their willingness to pay (WTP) for the presented beef steaks was lower for all retail display durations and color levels compared to a cherry-red steak with zero display time. WTP in both studies further declined as the presence of brown hues on the product increased.

However, results of this study also point to different beef shopping patterns of German and US beef consumers. German beef consumers appear to be more tolerant of steaks with a 4-day display time but less accepting of steaks displayed for longer periods (7 and 9 days). Accordingly, German grocery stores might have a larger window of time to sell beef products at higher prices, before they are perceived as "discolored" by customers. However, once a beef product is perceived as having an off-color, it may be even more challenging to market in Germany compared to US retail stores. Even significant price discounts may not be enough to persuade German consumers to purchase a steak that has been packaged for seven days or longer. This would make food waste prevention measures at retail level even more difficult to implement than in the US (Thies et al., 2024).

The findings of this study are limited, as it remains uncertain whether the pre-test results for Germany will be consistent with those from a larger, more representative sample. Moreover, it also remained unclear where cross-cultural differences in beef color perception stem from and how they translate into country specific or more general meat waste reducing measures. Differences in typical packaging at the point of sale, consumer risk aversion regarding food safety, and price sensitivity—both for food in general and beef in particular—may be influential factors that require further in-depth study. In this context, complementing quantitative survey methods with qualitative focus groups with regular beef shoppers and consumers is an effective approach to gaining deeper insights into these differences.

To ensure the timely sale of beef and meat products at the retail level, a deeper understanding of consumer shopping and preference behavior is essential. In this context, a detailed cross-cultural comparison of consumer preferences as described above will support more targeted marketing strategies for beef products in Germany and the US, ultimately contributing to a long-term reduction in retail meat waste. This, in turn, supports the achievement of the United Nations Sustainable Development Goals (SDGs), particularly SDG Target 12.3, which aims to halve per capita food waste at the retail and consumer levels by 2030 (UN, 2015).

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