

Establishing Spoilage Thresholds of Ground Beef in a Traditional Retail Case Scenario

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Abstract

The objective of this study was to determine spoilage in fresh ground beef and the perception of consumers regarding changes in sensory characteristics, as well as the desirability at different days of shelf-life. Ground beef loaves ($n = 84$) of 80% lean, 20% fat composition and 2.25 lb were utilized. Ground beef loaves in plastic overwrap foam trays were placed in a retail refrigerated case for 0–6 days. Consumers ($n = 96$) were asked to evaluate samples independently for visual color, odor, touch, and flavor to rate overall desirability, purchase intent, and identification of spoilage. Colorimeter data, thiobarbituric acid reactive substances (TBARS), lipid oxidation, and aerobic plate count (APC; log CFU/g) and *Enterobacteriaceae* (EB) count plate were collected after consumer evaluation. On day 3, consumers reported decreased ($P < 0.05$) purchase intent, desirability, and identified spoilage for visual color. The L^* (lightness), a^* (redness), and b^* (yellowness) decreased ($P < 0.05$) from day 0 to 4. Odor identification of spoilage by consumers increased ($P < 0.05$) across different shelf-life days, with the highest ($P < 0.05$) spoilage identification at day 6. Touch showed the largest decrease ($P < 0.05$) in purchase intent and increase ($P < 0.05$) in spoilage identification on days 5 and 6. Microbial analysis revealed a steady increase in log CFU/g for each consecutive display day for APC and EB ($P > 0.05$), with EB having the largest increase ($P < 0.05$) in log CFU/g from day 0–6. Flavor did not show differences in consumer perception for all days of shelf-life ($P > 0.05$). The TBARS did not show differences between treatment days ($P > 0.05$). Results of this study reveal that previously established values of spoilage used as a threshold in the industry for fresh meat products does not translate to negative consumer perceptions or consumer-identified points of spoilage. Consumers relied most on visual color to assess spoilage. Most of the other variables evaluated, including microbial counts, were not reliable indicators of ground beef spoilage.

Introduction

Understanding meat spoilage and the perception of consumers related to meat spoilage characteristics enables the meat industry to accurately assess shelf-life and establish a correct threshold of microbial growth. Meat spoilage can be defined as the negative alteration of a meat product because of a chemical, environmental, or bacterial process that compromises the quality or safety of the product (Nychas et al., 2007). The resulting economic loss from spoiled meat products is considerable for the meat industry (Odeyemi et al., 2020). A value of 10^7 log CFU/g has been used by the industry as a standard for spoilage for years (Ellis et al., 2002). However, consum-

er-focused studies validating this threshold are lacking. Therefore, the objective of this study was to determine an accurate shelf-life of fresh ground beef and perceptions of consumers to various sensory characteristics regarding spoilage.

Experimental Procedures

Ground beef samples ($n = 84$) of 80% lean, 20% fat composition were collected from a commercial meat processor in the Midwest region. Ground beef loaves that were 2.25 lb packaged in plastic overwrap foam trays were assigned as pairs, and randomly placed into a coffin-style cooler retail case scenario under fluorescent lights with constant 24-hour intensity. As the ground beef loaves were assigned as pairs, one package from each pair was designated for visual and spectral color, consumer panel, microbial plating, and lipid oxidation. The paired sample was utilized in the following consumer panels: odor, texture, and flavor. All samples were identified by a random 4-digit code. Consumers ($n = 96$) were placed in panels of eight, and seven samples were evaluated by each panel where all display days were represented. Consumers were asked to assess each sample independently for visual color, odor, touch, and flavor. For visual color, odor, and touch, consumers were asked to rate overall desirability, purchasing intent, and identification of spoilage. Consumers rated desirability on a sliding scale of 0–100 using an electronic ballot in Qualtrics (Version 2417833; Provo, UT) using an electronic tablet. For purchasing intent and identification of spoilage, consumers answered yes or no questions in the same electronic ballot.

For flavor assessment, ground beef was collected and made into 0.25-lb patties, vacuum sealed, and stored at -4°F until used for panels. Samples were thawed 24 hours prior to use, cooked to 165°F peak internal temperature, and served to panelists with palate cleansers. For flavor assessment, panelists answered yes or no regarding the desirability of the flavor, the likelihood of purchase, if the panelist considered the sample spoiled, and if the panelist liked the sample overall based upon flavor. All surveys contained a demographic questionnaire and questions regarding handling practices, storage practices, use-by-date understanding, and spoilage perception that was completed prior to evaluation of samples.

For instrumental color measurement, L^* (lightness), a^* (redness), and b^* (yellowness) were measured on each ground beef loaf using a Hunter Lab Miniscan EZ spectrophotometer (Hunter Associates Laboratory, Reston, VA). Three scans were collected from various locations on the top of the ground beef loaf and averaged to yield a single value for each loaf. The extent of lipid oxidation during simulated retail display was assessed using the thiobarbituric acid reactive substances (TBARS) assay. A ground beef aliquot was frozen in liquid nitrogen, pulverized, and stored at -112°F in a Whirl Pak bag until analysis. The TBARS procedure was performed, and samples were read in a spectrophotometer at a wavelength of 532 nm (BioTek Eon; BioTek Instruments Inc., Winooski, VT) to determine malondialdehyde (MDA) concentration, and MDA concentration was recorded as mg of MDA/kg of muscle tissue.

Microbial analysis was conducted after the visual color consumer panel was concluded. Ground beef loaves were collected from the retail case and the plastic overwrap was removed. Using aseptic technique, serial dilutions were performed, and appropriate dilutions were plated onto aerobic count plate (APC) petrifilm and *Enterobacteriaceae* (EB) count plate petrifilm for each sample, incubated, and counted.

Results and Discussion

For instrumental color measurements, L^* decreased ($P < 0.05$) from day 0–2. There was no decline ($P > 0.05$) in L^* from days 3–6, and day 6 ground beef was darker than day 1 ground beef (Table 1; $P < 0.05$). There was a decline in a^* and b^* values ($P < 0.05$) from day 0–3 (Table 1). Consumer assessment of visual color showed that purchase intent and overall desirability rating decreased most on day 3 ($P < 0.05$) and was lowest on day 6 ($P < 0.05$). Additionally, consumers did not consider the samples spoiled until day 3, with the largest increase occurring between days 3–4 (Figure 1; $P < 0.05$). When considering the instrumental color data with consumer perceptions in this study, it was determined that spoilage-affected color occurred between days 2–3. Consumers revealed the largest negative alteration of odor occurred between day 0 and 1 ($P < 0.05$). There were no differences ($P > 0.05$) in purchase intent, overall desirability, and spoilage perception between days 1–5. Day 6 demonstrated the lowest purchase intent and overall desirability with the highest number of samples considered spoiled ($P < 0.05$). The lack of a steady decrease in sensory assessment reveals that odor is not as large of a priority to consumers as visual color assessment. Additionally, consumers reported that samples were acceptable by touch until days 5 and 6 ($P < 0.05$).

When comparing day 0 to 6, the APC of ground beef increased 0.29 log CFU/g (Table 2; $P < 0.05$). The EB counts remained constant ($P > 0.05$) from day 0 to day 3, and there was no change in EB from day 3 to day 6 ($P > 0.05$). The increase of EB over display days was higher than for APC, increasing 0.60 log CFU/g from day 0 to day 6 ($P < 0.05$).

Panelists noted no differences ($P > 0.05$) in desirability of the flavor, the desirability of purchase, if the panelist considered the sample spoiled, and if the panelist liked the sample overall based upon flavor. In addition, there was no difference ($P > 0.05$) in TBARS between treatment days.

Implications

Understanding the role of spoilage and the interaction of spoilage with consumers' perception can allow market industry and retail establishments to accurately assess shelf-life. This can lead to decreasing waste from meat products that do not have sensory alterations. In this study, ground beef color appeared to be the most important product characteristic indicative of spoilage to consumers. Overall, based on this research, the industry threshold of 10^7 log CFU/g is not an accurate value to assess spoilage and the alteration of sensory characteristics that is detectable by consumers.

References

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Table 1. Least square means for instrumental measurements¹ for lightness (L*), redness (a*), and yellowness (b*) after retail display

Instrumental measurement	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	SEM ²	P-value
L*	57.60 ^a	55.54 ^b	53.56 ^c	53.02 ^{cd}	52.97 ^{cd}	52.88 ^{cd}	52.61 ^d	0.36	< 0.01
a*	32.81 ^a	28.28 ^b	22.83 ^c	18.01 ^d	12.29 ^e	11.29 ^e	9.38 ^f	0.57	< 0.01
b*	24.44 ^a	22.30 ^b	19.26 ^c	17.28 ^d	15.84 ^e	15.56 ^e	15.57 ^e	0.26	< 0.01

^{abcdef}Least square means within rows without common superscript differ ($P < 0.05$).

¹Standard error of the least square mean.

Table 2. Least square means (log CFU/g) for aerobic plate count (APC) and *Enterobacteriaceae* (EB) counts on aerobically packaged ground beef displayed refrigerated for 6 days

Plate type	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	SEM ¹	P-value
APC	7.73 ^d	7.81 ^{cd}	7.86 ^{bcd}	7.88 ^{abc}	7.89 ^{abc}	7.97 ^{ab}	8.02 ^a	0.07	< 0.01
EB	4.76 ^c	4.77 ^c	4.95 ^{bc}	5.09 ^{abc}	5.12 ^{ab}	5.35 ^a	5.36 ^a	0.18	< 0.01

^{abcdef}Least square means within rows without common superscript differ ($P < 0.05$).

¹Standard error of the least square mean.

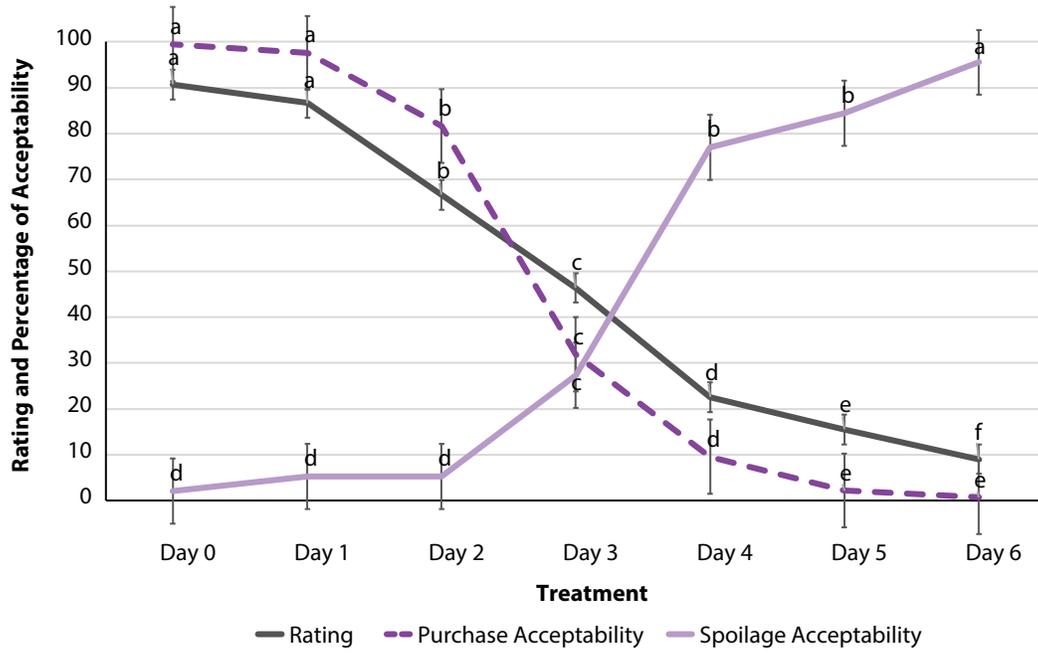


Figure 1. Least square means for consumers (n = 96) panel rating and percentage rated acceptable for purchase and spoilage based upon visual color. Least square means without common superscript differ ($P < 0.05$).