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Consumer preferences for beef color and packaging did not affect eating satisfaction

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Abstract

We investigated whether consumer preferences for beef colors (red, purple, and brown) or for beef packaging systems (modified atmosphere, MAP; vacuum skin pack, VSP; or overwrap with polyvinyl chloride, PVC) influenced taste scores of beef steaks and patties. To test beef color effects, boneless beef top loin steaks (choice) and ground beef patties (20% fat) were packaged in different atmospheres to promote development of red, purple, and brown color. To test effects of package type, steaks and patties were pre-treated with carbon monoxide in MAP to promote development of red color, and some meat was repackaged using VSP or PVC overwrap. The differently colored and packaged meats were separately displayed for members of four consumer panels who evaluated appearance and indicated their likelihood to purchase similar meat. Next, the panelists tasted meat samples from what they had been told were the packaging treatments just observed. However, the meat samples actually served were from a single untreated steak or patty. Thus, any difference in taste scores should reflect expectations established during the visual evaluation. The same ballot and sample coding were used for both the visual and taste evaluations. Color and packaging influenced ($P < 0.001$) appearance scores and likelihood to purchase. Appearance scores were rated red > purple > brown and PVC > VSP > MAP. Appearance scores and likelihood to purchase were correlated ($r = 0.9$). However, color or packaging did not affect ($P > 0.5$) taste scores. Thus, consumer preferences for beef color and packaging influenced likelihood to purchase, but did not bias eating satisfaction.

Keywords: Consumer preferences; Beef color; Packaging; Eating satisfaction

1. Introduction

Undoubtedly, appearance determines how consumers perceive quality and significantly influences purchasing decisions. In the case of beef, two important visual clues that determine perceived quality are color and packaging (Issanchou, 1996). Many experiments have supported an assimilation model where hedonic ratings are influenced in the direction of expected quality (Cardello & Sawyer, 1992), but it is not known to what extent color and packaging of beef influence subsequent eating satisfaction. Thus, we investigated whether consumer preference for beef colors (red, purple, and brown) and for fresh beef packaging systems (modified atmosphere, MAP; vacuum skin pack, VSP; or conventional overwrap with polyvinyl chloride, PVC) influenced taste scores of beef steaks and patties.

2. Materials and methods

2.1. Experiment design

To test effects of beef color, three single steaks from a single short loin and groups of four patties of freshly ground beef were packaged in different modified atmospheres to promote development of red, purple, and brown colors. To test effects of packaging, steaks and patties were pre-treated with carbon monoxide in MAP to promote formation of carbon monoxide myoglobin and development of the red color, and two packages of each were repackaged using VSP or PVC overwrap. The packaged, raw samples were displayed for members of a consumer panel (photographs of the steaks and patties displayed for consumers can be viewed at http://

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www.usu.edu/~famlife/nfs/foodscience/faculty/Carpenter2.htm). Panel members described the color of the beef, indicated their liking of the appearance, and indicated their likelihood to purchase similar meat. Next, the panel members tasted meat samples from what they had been told was the three packaging treatments (color or package type) just observed. However, the meat samples tasted by each panelist were actually from a single fresh (i.e. not treated) steak or patty so that any difference in taste scores would reflect expectations established during the visual evaluation. To promote assimilation of any visual bias for color or packaging, a single ballot and the same sample codes were used for the both visual and taste evaluations.

For experiment 1, boneless beef top loin steaks (choice) and ground beef patties (20% fat) were packaged in different modified atmospheres of either 0.5% carbon monoxide, 39.5% nitrogen, and 60% carbon dioxide (0.5% CO) to promote carbon monoxide myoglobin formation and red color; 100% nitrogen (N_2) to promote myoglobin formation and dark purple-red color; or 1% oxygen, 39% nitrogen, and 60% carbon dioxide (1% O_2) to promote metmyglobin formation and brown color. Packages were stored for 7 days at 4°C before evaluation by a consumer panel. For experiment 2, steaks and patties were packaged in the 0.5% CO atmosphere and stored at 4°C for 4 d to allow formation of carbon monoxide myoglobin. Two packages of each were repackaged on either styrofoam trays with PVC overwrap or VSP. The pretreatment with 0.5% CO ensured that meat in all three package types were a similar red color.

The packaged meats were placed on ice and displayed for consumers recruited by placing posters in the Nutrition and Food Science and Physical Plant buildings of Utah State University. Panelists were primarily university students, faculty, and staff. They were 18–65 years old, 52% were male, 43% were female, and 5% did not identify their gender on the ballot. For each experiment, the packages of steaks or patties were evaluated on different days. Thus, a total of four panels were convened, each comprised of 82–99 consumers. Panelists were informed on their ballot that each sample was microbiologically safe, but had been stored or packaged differently. The order of package display and evaluation was rotated every twenty panelists to avoid position bias. For the visual evaluation, each panelist was asked to describe (1) the color of the meats as red, purple, or brown; (2) to indicate how well they liked the color or packaging, and (3) to indicate their likelihood to purchase a similar product. A hedonic scale was used for rating where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. Immediately following the visual appraisal, panelists entered divided booths with fluorescent white lighting, and were served three warm steak or patty pieces (1″×2″) from an untreated steak or patty cooked to an internal temperature of 74°C. To reiterate, the samples received by individual panelists were from a single untreated steak or patty, although they had been told that the samples were treated similarly to the meat just observed. Steak and patty pieces were rated for juiciness, taste, tenderness, and overall palatability using a hedonic scale of 1–9. For their participation, panelists received a coupon for an ice cream cone at the Dairy Bar located in the Nutrition and Food Science building. The color of the displayed meat was measured at five random locations through the packaging using a portable spectrophotometer (Miniscan, Hunter Labs, Reston, Va) with illuminant setting of Daylight-65 and standard observer angle of 10°. The instrument was standardized daily to the white and black standard plates provided by the manufacturer.

2.2. Packaging

Meats were packaged in modified atmospheres using a Multivac (Kansas City, MO) model M855 packaging machine with white forming film for the bottom (Item no. D2935-9Y963, Cryovac, Simpsonville, SC) and a clear film for the top (Item no. 3PASU-5001003, Cryovac). The gasses were obtained from Praxair Distribution (Salt Lake City, UT) and certified to be within ±0.5% of the indicated mixtures. Meats were packaged in VSP using clear nylon-polyethylene pouches (Item no. 030035-200214, Koch, Kansas City, MO) and a floor model vacuum packaging machine (Hollymatic, Countryside, IL). The steaks were placed directly in the pouches, but the patties were first placed on a white cardboard backing to minimize mishaping the patties by handling and vacuum. For conventional PVC overwrap, samples were placed on white styrofoam trays and over wrapped with an oxygen permeable PVC film (Anchor Packaging item no. SWM-518 selectwrap purchased from Koch).

2.3. Statistical analysis

For each experiment, the panel data for steaks and patties were pooled, and each experiment was analyzed as a complete factorial using MANCOVA (Statistica for Mac, StatSoft, Tulsa, OK). Means were compared using Fishers least significant difference procedure. In experiment 1, the independent factors were meat type (steak or patties) and the meat color in each atmosphere (red, purple, brown). In experiment 2, the independent factors were meat type (steak or patties) and package type (MAP, VSP, or PVC).

3. Results and discussion

In experiment 1, the steaks and patties displayed for consumers were similar with regard to fat content and

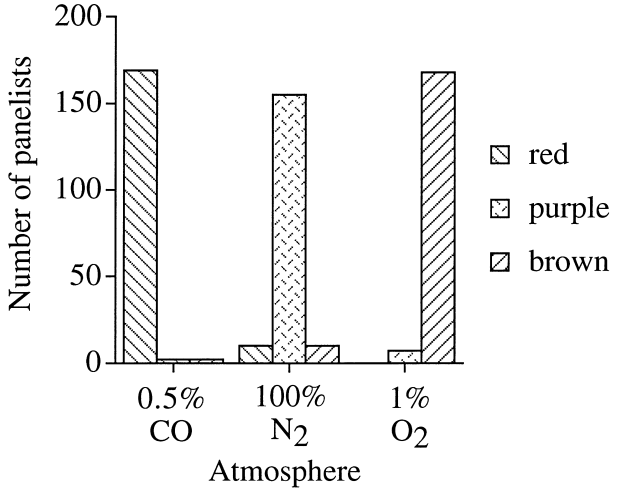

Fig. 1. Histogram of consumer panel color description for meat packaged in different atmospheres.

trim level, but varied in color depending upon the gas atmosphere used when packaging. Most panelists described the color of beef packaged in 0.5% CO as red, that packaged in 100% N_2 as purple, and that packaged in 1% O_2 as brown (Fig. 1). These were the expected colors for these treatments (Cornforth, 1994), and were used as the color factor levels for the analysis of variance. However, there was some "misclassification" for beef packaged in each atmosphere. For example, beef packaged in 100% N_2 was most frequently described as purple, but was described as either red or brown by about 10% of the panelists. The instrumental color values ($L^*a^*b^*$) for beef packaged in the different modified atmospheres is given in Table 1. Beef packaged in 0.5% CO had the greatest a^* values indicating that it was the most red. In comparison to beef packaged in CO, beef packaged in 100% N_2 had lower a^* values, but similar b^* values resulting in its description as purple by most panelists. Beef packaged in 1% O_2 had greater b^* values than beef packaged in N_2, indicating a greater contribution of yellow and a visual description as brown by most panelists.

There were no differences in the appearance scores between steaks or patties, although steaks received somewhat higher taste scores (Table 2). This suggests that panelists visually evaluated each on its own merits, but preferred the taste of steak. The visual scores for appearance and likelihood to purchase were correlated ($r = 0.9$), and scores decreased in the order of red > purple > brown. These observations confirmed that for beef there is a close link between color preference and the decision to purchase, and that consumers prefer to purchase bright red beef rather than purple or brown beef. Consumers use color as an indicator of beef freshness, and will make a no-purchase decision when brown metmyoglobin reaches 30 to 40% of total pigments on the surface of fresh beef (Greene, Hsin, & Zipser, 1971). Bright red beef outsells discolored beef (20% surface metmyoglobin) by a ratio of 2:1 (Hood & Riordan, 1973). American consumers have also demonstrated a definite bias against purchase of vacuum packaged beef which displays the purple color of deoxymyoglobin (Meischen, Huffman, & Davis, 1987).

Table 1
Mean values (± S.E.M.) for Hunter color lightness (L^*), redness (a^*), and yellowness (b^*) of beef loin steaks and ground beef patties[a]

Meat type and packaging	L^*	a^*	b^*
Steaks[b]			
0.5% CO	31.3±2.0[a,b]	15.0±2.2[a]	7.8±2.4[a,b]
100% N_2	29.5±1.5[a]	4.7±0.6[b]	6.3±1.0[a]
1% 02	34.6±3.2[b]	3.8±0.3[c]	8.5±1.0[b]
Patties[b]			
0.5% C0	46.6±3.4[a]	14.7±0.8[a]	10.0±1.0[a,b]
100% N_2	42.0±3.0[b]	5.1±0.4[b]	8.7±2.3[a]
1% 0_2	47.0±2.1[a]	4.8±0.4[b]	11.4±1.1[b]
Steaks[c]			
MAP	30.0±0.2[a]	14.6±0.9[a]	8.4±1.1[a]
VSP	31.5±1.0[a,b]	13.7±0.2[b]	8.5±0.5[a]
PVC	31.1±1.3[b]	13.1±1.1[b]	14.1±1.0[b]
Patties[c]			
MAP	46.3±3.6[a]	12.7±1.7[a]	10.6±1.9[a]
VSP	45.8±7.5[a]	11.2±3.1[a]	11.4±0.5[a]
PVC	42.9±3.2[a]	13.7±1.4[a]	16.2±0.6[b]

[a] Within a meat type and packaging, mean values not sharing a letter are different at $P < 0.05$ (Student's t-test).

[b] Steaks and patties were packaged in atmospheres containing the indicated gasses and stored for 7–9 days at 2°C.

[c] Steaks and patties were pretreated with 0.5% CO in modified atmosphere packages (MAP) to produce red color, and some meat repackaged for display in vacuum skin packages (VSP) or using polyvinyl chloride overwrap (PVC).

Despite the effects that color had on appearance and likelihood to purchase, color did not affect taste scores (Table 2). The three samples tasted by individual panelists were from a single untreated steak or patty and were uniform in quality. However, the panelists were purposely misinformed that the three samples represented the three treatments that they had just observed. Thus, any differences in taste scores were due to bias carried over from the visual evaluation. Differences between scores were determined using an unprotected Fishers LSD test, which is very liberal, to allow detection of even slight bias. The results indicated that consumer preference for beef color was sufficient to influence their likelihood to purchase, but was not enough to bias taste scores. It is likely that once a decision to purchase beef is made in the market — whether the beef is the red of fresh bloomed beef, the brown of discounted beef, or the purple of vacuum packaged beef — consumer eating satisfaction at home will

Table 2
Effect of meat type (steaks or patties) and color (red, purple, or brown) on visual and taste scores

Effect	Significance (P value)		Mean scores from consumer panels[a]					
			Visual scores		Taste scores[b]			
	Visual scores	Taste scores	Appearance[b]	Purchase[c]	Flavor	Juiciness	Tenderness	Overall
Meat	0.84	< 0.001						
Steak			5.4[a]	5.4[a]	6.6[a]	6.7[a]	6.5[a]	6.7[a]
Patty			5.3[a]	5.3[a]	6.2[b]	6.5[a]	6.6[a]	6.5[b]
Color[d]	< 0.001	0.50						
Red (0.5% CO)			7.1[a]	7.2[a]	6.4[a]	6.7[a]	6.8[a]	6.8[a,b]
Purple (100% N_2)			5.7[b]	5.7[b]	6.4[a]	6.6[a]	6.5[a]	6.6[b,c]
Brown (1% 0_2)			3.2[c]	3.1[c]	6.2[a]	6.6[a]	6.5[a]	6.4[c]
Meat×color	0.69	0.98						

[a] Within a main effect or interaction, mean values not sharing a letter are different at at $P < 0.05$ (Fishers LSD test)
[b] Hedonic rating: 1, dislike extremely; 5,neither like nor dislike; 9, like extremely.
[c] Likelihood to purchase 1, extremely unlikely; 5, neither likely nor unlikely; 9, extremely likely.
[d] The color most frequently described by consumers for meat packaged in the indicated atmosphere.

depend only on the beef quality attributes of tenderness, juiciness and flavor.

In experiment 2, the steaks and patties were pretreated with 0.5% CO (Sorheim, Aune, & Nesbakken, 1997; Sorheim, Nissen, & Nesbakken, 1999) so that all samples were bright red color when placed in the different package types. The instrumental color measurements of meat in the different packages were similar, except that b^* values were greater for the beef overwrapped with PVC (Table 1). The greater b^* values may have resulted from measuring the color through the different films, or possibly due to metmyoglobin formation as oxygen diffused through the PVC overwrap. Most panelist described the meats in each of the packages as red (Fig. 2). Beef packaged with PVC overwrap or beef packaged in VSP were described as purple or brown by less than 14% of the panelists, while beef packaged in modified atmosphere containing 0.5% CO was described as either purple or brown by 40% of the panelists ($P < 0.001$ by Chi-square). Given the similar $L^*a^*b^*$ values of the meat, and our individual appraisal of the colors, it was surprising the number of panelists that described the beef as other than red. This suggests that without a visual reference, verbal description of color will vary according to individual cognition (MacDougal, 1994). For the beef packaged in modified atmospheres, it is also possible that the red was not as visually distinct because the meat was not in contact with the surface of the package as when packaged in vacuum or with PVC overwrap.

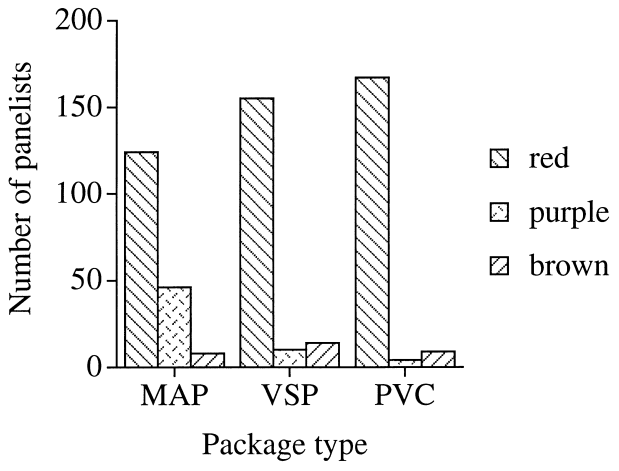

Fig. 2. Histogram of consumer panel color description for carbon monoxide-pretreated meat in modified atmosphere package (MAP), vacuum skin package (VSP), or overwrapped with polyvinyl chloride (PVC).

As observed in Experiment 1, there were no differences in the appearance scores for steaks or patties, but again steaks received somewhat higher taste scores (Table 3). The visual scores for appearance and likelihood to purchase were correlated ($r = 0.9$), although package type had somewhat different effects in steaks and patties. The visual scores for packaged steaks followed the decreasing order PVC > VSP > MAP, while the scores for patties followed the decreasing order of PVC > VSP = MAP. The difference was likely because the patties, but not steaks, were somewhat misshapen by vacuum packaging. Although package type influenced appearance scores and likelihood to purchase, package type did not affect taste scores. Thus, consumer preference for package type did not influence their taste evaluations, and it is not likely that consumer preference for packaging in the market will influence eating satisfaction at home.

Table 3
Effects of meat type (steaks or patties) and package type (modified atmosphere package, MAP; vacuum skin package, VSP; overwrapped with polyvinyl chloride, PVC) on appearance and taste scores

Effect	Significance (p value)		Mean scores from consumer panels[a]					
			Visual scores		Taste scores[b]			
	Visual scores	Taste scores	Appearance[b]	Purchase[c]	Flavor	Juiciness	Tenderness	Overall
Meat	0.42	< 0.001						
Steak			6.4[a]	6.6[a]	6.9[a]	7.0[a]	7.1[a]	7.1[a]
Patty			6.4[a]	6.4[a]	6.4[b]	6.5[b]	6.8[b]	6.7[b]
Package type	< 0.001	0.77						
MAP			5.1[a]	5.4[a]	6.7[a]	6.7[a]	6.9[a]	6.8[a]
VSP			5.9[b]	6.1[n]	6.6[a]	6.8[a]	7.0[a]	6.9[a]
PVC			7.7[c]	7.9[o]	6.6[a]	6.8[a]	7.0[a]	7.0[a]
Meat×package	< 0.001	0.90						
Steak-MAP			5.0[a]	5.2[a]	6.9[a]	7.0[a]	7.1[a]	7.0[a]
Steak-VSP			6.5[b]	6.8[b]	6.9[a]	7.0[a]	7.1[ab]	7.1[a,b]
Steak-PVC			7.5[c]	7.7[c]	6.9[a,b]	7.1[a]	7.2[a,b]	7.1
Patty-MAP			5.3[a]	5.6[a]	6.5[b,c]	6.4[b]	6.7[b]	6.6[c]
Patty-VSP			5.3[a]	5.4[a]	6.3[c]	6.5[b]	7.0[a,b]	6.7[b,c]
Patty-PVC			7.9[c]	8.0[c]	6.4[c]	6.4[b]	6.8[a,b]	6.8[a,b,c]

[a] Within a main effect or interaction, mean values not sharing a letter are different at $P < 0.05$ (Fishers LSD test).
[b] Hedonic rating: 1, dislike extremely; 5, neither like nor dislike; 9, like extremely.
[c] Likelihood to purchase: 1, extremely unlikely; 5, neither likely nor unlikely; 9, extremely likely

4. Conclusions

The consumers surveyed in this study had preferences for beef color and type of packaging that would likely sway their decision to purchase. However, preferences for beef color and packaging did not bias taste scores. As the meat industry moves toward central processing that employs MAP and VSP packaging, they may need to overcome consumer preference for fresh beef that is bright red in color and packaged with the traditional PVC overwrap. Nevertheless, it is encouraging that the initial perceptions of quality will likely not bias eating satisfaction once a decision to purchase is made and the meat is taken home, thereby hastening the acceptance of the newer packaging technologies.

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