IMPACT OF RETAIL TRAY COLOR ON RETAIL CASE LIFE AND CONSUMER ACCEPTABILITY

By

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CHAPTER I

INTRODUCTION

Numerous studies have been conducted to determine factors that impact consumer purchasing decisions at the retail case. Studies have also been conducted to determine the impact of packing type on retail case life and consumer acceptability. Based on the National Meat Case Study 2004 (Reicks et al., 2008), traditional polyvinyl chloride overwrap (TO) is the most prevalent packaging type for beef, being used on 77.6% of fresh beef packages. Modified atmosphere packaging (MAP) and vacuum packaging (VP) represent only 9.6 and 3.4% of fresh beef packaging, respectively (Reicks et al., 2008). While the goal is simple and common among packaging systems and types of packaging, one thing that remains unanswered is if tray color has an impact on retail case life and consumer acceptability. Reicks et al. (2008) documented that the three most common tray colors in retail on a national level are white (39.6%), yellow (22.4%), and black (11.5%). A preliminary study conducted at OSU determined that there was a significant d by tray color interaction on color stability of strip loin steaks packaged on white vs. black trays. By determining the consumer acceptability of packaging methods retailers may be able to utilize tray color and type of packaging of retail cuts to significantly increase shelf-life, therefore, economically benefiting all sectors of the beef industry. Consumers do prefer certain tray colors as time progresses for certain cuts of beef which are proven by the significant results shown in this study

CHAPTER II

REVIEW OF LITERATURE

In the case of beef, two important visual clues that determine perceived quality are color and packaging (Issanchou, 1996). Consumer studies have shown that physical appearance of a retail cut in the display case is the most important factor determining retail selection of meat products (Danner, 1959; Dunsing, 1959a, b). Packaging is a very important concept of consumer perspective in any industry. The beef industry is no different, where package type and color could possibly influence the consumer, just as much as the physical appearance of the meat itself.

Color

Color of fresh meat is among the most important characteristics to determine whether the product is purchased or not by an average consumer. Liu et al. (1995) along with Mancini and Hunt (2005) stated that color is a primary factor influencing meat purchasing decisions because consumers use discoloration as an indicator of beef quality, especially freshness and wholesomeness. Color is the visual characteristic of meat that gives the critical first impression and can be measured both subjectively and instrumentally. Romans et al. (1965) said meat pigment is composed largely of the chromoproteins, myoglobin and hemoglobin. Factors other than the amount of pigment present in beef muscle may influence its color, foremost among these factors are variations in pH, oxygen availability, and oxygen partial pressure (Romans, 1965). Guidelines for human evaluation of meat color have been published by AMSA (1991).

Smith et al. (2000) revealed nearly 15% of retail beef is discounted in price due to surface discoloration which relate to annual losses of $1 billion. Carpenter et al. (2001) noted a strong association between color preference and purchasing intent with consumers discriminating against beef that is not red (i.e., beef that is purple or brown). The descriptions of beef color included in USDA (1965) quality grading standards are subjective and, as such, are subject to wide variations in interpretation. Allen (1968) described "ideal" beef color as "cherry red." However, Billmeyer and Saltzman (1966) concluded that since people differ in their individual response to visual colors, they will also differ in their interpretations of subjectively defined terms for color. Therefore, visual observations of fresh meat are the true standard for assessing consumer perception.

While subjective color is important, objective color aspects of meat are just as important. Scheuplein (1964) stated in the near-ultraviolet and visible regions of the spectrum, light absorption is associated with the excitation of loosely bound electrons in molecules containing chromophors or lone pair, nonbonding electrons. This process occurs selectively in certain molecules and is responsible for the "color" seen (Scheuplein; 1964). Gray et al. (1996) asserts consumers will discriminate against meat cuts which lose a fresh appearance. Mancini and Hunt (2005) indicated discoloration is a result of oxidation of the protein myoglobin, producing metmyoglobin. Myoglobin formation depends on multiple factors such as oxygen partial pressure, temperature, pH, meat's reducing activity, and microbial growth (Mancini and Hunt, 2005). Discolored meat products are often ground and marketed as a reduced value item (Gray et al., 1996). Gray et al. (1996) stated lipid oxidation has been widely recognized as one of the primary contributing deterioration reactions responsible for loss of meat quality. This degradative process results in rancidity in raw meat or what has been dubbed as the warmed-over flavor in cooked meat products (Liu et al., 1995). Liu et al. (1995) expressed that radicals produced during the process of lipid oxidation may either act directly to promote pigment oxidation or may

indirectly damage pigment reducing systems; resulting in the known positive correlation between lipid oxidation and pigment oxidation. Lipid oxidation begins when a hydrogen atom is removed from an unsaturated fatty acid, which results in the formation of free radicals (Buege and Aust, 1978). Buege and Aust (1978) stated that, ultimately, the breakdown of polyunsaturated fatty acids produces malondialdehyde. Rancidity in meat begins to develop shortly after death and slowly increases in intensity until consumers find the product unacceptable (Gray et al., 1996).

Packaging

Packaging is the second most important characteristic when purchasing any product, but especially true when purchasing fresh meat. Packaging has so much value in the marketing of fresh meat that often times, consumers may be persuaded to buy the same steak as the one placed next to it, but having a different colored tray. The three most common tray colors in the fresh meat retail case on a national level are white (39.6%), yellow (22.4%), and black (11.5%); (Reicks et al., 2004). Reicks and others (2004) stated that the trend for white tray frequency was followed by ground beef (56.9%) and whole muscle products (44.4%), however, the use of yellow trays was greatest ($P < 0.001$) for chicken (60.1%), followed by whole muscle beef products (8.6%); and black trays were most used for lamb (34.1%) and veal (42.0%). Foam trays were used in 72.6% of all packages in the retail meat case (Reicks et al., 2004). Rigid plastic trays accounted for 8.9% of all packages and were used most ($P < 0.001$) for lamb (15.4%) and ground beef products (20.8%); (Reicks et al, 2004). Cryovac (2003) stated that the foam trays accounted for approximately 80% of all packages and rigid plastic trays were approximately 4% of all packages in the fresh meat retail case. An increased amount of case-ready products going into the retail case proved that there is now an increase in MAP packaging and a decrease in foam trays.

Package type can influence red color perception on fresh meat products (Mancini and Hunt, 2005). Meat packaged with film contact (TO overwrap or vacuum) was perceived as more

red than meat packaged with headspace (Carpenter et al., 2001). Reicks and others (2004) found that traditional TO overwrap was used on 47% of packages in the fresh beef meat case nationwide and the most frequent packaging type for beef, pork, lamb, and veal. The TO overwrap was used for whole muscle beef products more ($P < 0.001$) than any other species (Reicks et al., 2004). Reicks and others (2004) also reported the use of MAP was greatest in ground beef (33.2%) and turkey (45.1%) products. Another very important aspect to packing that is often overlooked is lighting. Barbut (2001) reported that incandescent light increased beef and pork color desirability likely because its spectrum included more red wavelengths.

Conclusion

The United States beef industry of the 80's has recognized that no single definition can describe all consumers, but rather there are segments of consumers, each with unique attitudes and lifestyles (Yankelovich et al., 1985). Although not much research has been conducted on consumer purchasing decisions of fresh meat, a large amount of savings in monetary value could be possible by looking into which products in the fresh meat case our consumers purchase and why. Also looking at how the tray color can have influence on the actual meat its self has not been studied. Savell and others (1989) stated, "A successful marketing approach delivers products that satisfy specific demands for specific segments. In the past the beef industry has not been concerned enough with marketing to spend time, effort and money necessary to determine the size and scope of consumer needs. However, with apparent demand for beef decreasing in recent years, the beef industry is now focusing its attention on what consumers want and how it can be produced and marketed." All in all, the beef industry would not survive without marketing of product. As mentioned above the most important part of marketing besides the fresh meat itself, is the packaging. Packaging has and will continue to the sway the minds of normal consumers whom we consider uneducated in the area of purchase. Therefore, next time when purchasing a product, look at the package and see how it appeals to you, see how it is unappealing

to you, and decide on whether or not you too could be swayed to purchase without ever seeing the product inside. Packaging of fresh meat products may affect your purchasing decisions more than you think, especially overseen marketing advantages such as, tray color.

CHAPTER III

IMPACT OF RETAIL TRAY COLOR ON RETAIL CASE LIFE AND CONSUMER ACCEPTABILITY

ABSTRACT

The present study was conducted to determine if tray color (yellow, black, or white) influences retail case life and consumer acceptability of strip loin steaks, top sirloin steaks, tenderloin steaks, and eye of round steaks when packaged in traditional overwrap (TO) or modified atmosphere packaging (MAP). United States Department of Agriculture (USDA) Select strip loins, eye of rounds, top sirloins, and tenderloins (n = 30/cut) were fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Steaks assigned to MAP were packaged with a common mixture of 25% CO_2 and 75% O, and held in dark storage for 7 d at 4°C. Steaks assigned to TO were overwrapped and placed immediately in retail display. Every Monday, Wednesday, and Friday during display, a consumer panel (n = 10 consumers/d) was conducted. Consumers scored steaks from each cut by package type (one white tray vs. one black tray vs. one yellow tray (if applicable) of the same cut) by indicating which steak they would purchase by circling the number associated with that steak. Results of this study indicate that when each cut (strip loins, eye of rounds, top sirloins, and tenderloins) was scored by a subjective color panel, cut was only affected significantly by time, rather than treatment or the interaction between time and treatment ($P < 0.05$). Consumer data revealed yellow trays were

preferred on most cuts as time progressed ($P < 0.05$). Black was the most significantly favored color of tray for the tenderloin steaks each day ($P < 0.05$). Researchers believe that, given the intriguing results, more tray color data should be collected and analyzed to help satisfy and determine the preferences of the basic consumer eye.

INTRODUCTION

Numerous studies have been conducted to determine factors that impact consumer purchasing decisions at the retail case. Studies have also been conducted to determine the impact of packing type on retail case life and consumer acceptability. Based on the National Meat Case Study 2004 (Reicks et al., 2008), traditional polyvinyl chloride overwrap (TO) is the most prevalent packaging type for beef being used on 77.6% of fresh beef packages. Modified atmosphere packaging (MAP) and vacuum packaging (VP) represent only 9.6 and 3.4% of fresh beef packaging, respectively (Reicks et al., 2008). The main goals of meat preservation are maintaining fresh appearance and preventing bacterial spoilage (Gill, 1996). While the goal is simple and common among packaging systems and types of packaging, one thing that remains unanswered is if tray color has an impact on retail case life and consumer acceptability. Reicks et al. (2008) documented that the three most common tray colors in retail on a national level are white (39.6%), yellow (22.4%), and black (11.5%). A preliminary study conducted at OSU determined that there was a significant d by tray color interaction on color stability of strip loin steaks packaged on white vs. black trays. The objective of this study was to determine if tray color (black, white or yellow) influences retail case life and consumer acceptability of strip loin steaks, eye of round steaks, top sirloin steaks, and tenderloin steaks when packaged in traditional overwrap or modified atmosphere packaging.

MATERIALS AND METHODS

United States Department of Agriculture (USDA) Select strip loins IMPS # 180 (n = 30) ranging in age from 24 d – 26 d postmortem were purchased from Ralph's Packing Company,

Perkins, OK, and transported to OSU Food Agriculture Processing Center. Strip loins were faced on the anterior end and then were fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Steaks from each strip were alternated accordingly to ensure all tray color and package systems had steaks represented from all locations of cut and one steak from each cut assigned to all treatments. Package types were traditional overwrap (TO) and modified atmosphere (MAP). Trays were black (TO and MAP), white (TO and MAP), or yellow (TO only). Steaks assigned to MAP were packaged with a common mixture of 25% CO_2 and 75% O, and held in dark storage for 7 d at 4°C. Steaks assigned to TO were overwrapped and placed immediately in retail display. All steaks were placed in simulated retail case conditions under 150 foot candle watt traditional lighting conditions for color evaluation. Each steak was subjectively evaluated for color attributes at 12-h intervals during retail display.

USDA Select eye of round IMPS # 171C (n= 30) ranging in age from 19 d – 20 d postmortem were purchased from Ralph's Packing Company, Perkins, OK, and transported to OSU Food Agriculture Processing Center. Eye of rounds were faced on the ventral end and then were fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Same package treatments and retail evaluation was used for eye of round steaks, as for strip loin steaks.

USDA Select top sirloins IMPS # 184 (n = 30) ranging in age from 27 d – 38 d postmortem were purchased from Ralph's Packing Company, Perkins, OK, and transported to OSU Food Agriculture Processing Center. The cap muscle was removed and top sirloins were faced on the posterior end and then were fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Same package treatments and retail evaluation was conducted as for strip loin steaks

USDA Select tenderloins IMPS # 190A (n = 30) ranging in age from 5 d – 20 d postmortem were purchased from Ralph's Packing Company, Perkins, OK, and transported to OSU Food Agriculture Processing Center. Heads and tails were removed leaving center cut tenderloins which were then fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Same package treatments and retail evaluation was used as previously stated.

SUBJECTIVE COLOR EVALUATION

Color was subjectively evaluated by a six person trained panel of Oklahoma State University personnel; panelists were trained using Munsell color tiles and required to receive a passing score before participating on a color panel. Evaluators assigned scores to each steak for muscle color, overall appearance, and surface discoloration at each evaluation time. Muscle color was characterized on an 8-point scale (8 = extremely bright cherry red; 1 = extremely dark red) as outlined in the Guidelines for Meat Color Evaluation (AMSA, 1991). Scores for overall appearance (8 = extremely desirable; 1 = extremely undesirable) and surface discoloration (7 = 100% discoloration 1 = no discoloration) were also assigned according to AMSA (1991) guidelines. Steaks were evaluated until at least 80% of the TO and MAP steaks had been assigned a mean overall appearance score of 3 (moderately undesirable) or lower.

CONSUMER PREFERENCES

Every Monday, Wednesday, and Friday during display, a consumer panel (n = 10 consumers/d) was conducted. Consumers were asked basic demographic information and general beef purchase questions when initially selected (Table 3.1). This study had a close split among gender at 43% male and 57% female. Ethnicity was dominated by 97% Caucasian and 3% other. Age ranged from under twenty to over sixty, including 27% from age twenty-one to twenty-nine, 17% in their thirties, 27% in their forties, and 23% in their fifties. Household income level was a

very wide range consisting of 27% making less than nineteen thousand dollars, 6% making between nineteen thousand and twenty-nine thousand, 13% making between thirty thousand and forty-nine thousand, 20% making between fifty thousand and sixty-nine thousand, 17% making between seventy thousand and eighty-nine thousand, and lastly 17% making over ninety thousand. Education had a large majority centered with 40% having a bachelor's degree. Beef consumption per week was also asked which showed that 33% of consumers consumed beef at least five times a week, and 27% holding close with more than five times a week for consumption. When asked if they were they primary purchaser of beef in the home, 83% stated yes, and the 17% stated no. Following with that question if the consumer answered yes they were asked to notify how many times a week they purchase beef from a retail operation. Here we had our strongest percentage of 28 that purchases beef over five times a week at retail. Lastly, consumers were asked to circle which characteristic (price, color, convenience, taste, past experience, or other) influenced their meat purchasing decision the most, here we found 57% of consumers circled price, followed by past experience, taste, and other. Consumers scored steaks from each cut by package type (one white tray vs. one black tray vs. one yellow tray (if applicable) of the same cut) by indicating which steak they would purchase by circling the number associated with that steak.

STATISTICAL ANALYSIS

The experiment was an analysis of each subprimal and package type. The experiment was replicated eight times, each subprimal cut by each packaging type. Data were analyzed using the GLIMMIX procedure of SAS Version 9.2 (Cary, NC). The fixed effects of tray color, hour of display and the interaction were included in the model for all cuts. Interaction was not significant so removed from model. Hour of display was defined as a repeated measure. Subprimal cut was used as the random block. Denominator degrees of freedom for statistical analyses were determined using the Kenward-Roger method. Treatment means were averaged across panelists

before analysis. When the computed F-test was significant, comparisons among means were conducted using pairwise t-tests. The predetermined significance level was set at $\alpha = 0.05$. Consumer frequency percentages were calculated for d 1, 3, and 5 by package type, then analyzed using Chi square test for each subprimal cut to determine significant differences ($P < 0.05$).

RESULTS AND DISCUSSION

Subjective Color Evaluation

Subjective color evaluation from the trained color panel of packaged strip loin steaks can be found in Table 3.2. An evident difference in color throughout almost the entire retail display period was detected ($P < 0.05$). The muscle color in TO packages was significantly different from 24 h to 60 h and again from 72 h to 96 h ($P < 0.05$). Surface discoloration was significantly different every 12 h after 24 h ($P < 0.05$). Overall appearance significantly decreased every 12 h ($P < 0.05$), until 84 h which was similar to 96 h had no significant difference. Least squares means (Table 3.2) indicated that panelists thought TO packaged strip loin steaks, as a whole, were deemed slightly undesirable at 48 h in retail display. Modified atmosphere packaging showed muscle color had a significant difference from 12 h to 72 h ($P < 0.05$). Surface discoloration was significantly different every 12 h to 72 h ($P < 0.05$). Panelists rated overall appearance difference every 12 h to 72 h ($P < 0.05$). Least squares means (Table 3.2) indicated that panelist thought MAP packaged strip loin steaks, as a whole, were deemed slightly undesirable at 24 h in retail display. Table 3.3 shows no significant differences were found between each treatment by package type ($P > 0.05$).

Subjective color evaluation from the trained color panel of packaged eye of round steaks can be found in Table 3.4. An evident difference in color throughout almost the entire retail display period was detected ($P < 0.05$). The muscle color in TO packages was significantly different from 12 h to 72 h and again from 84 h to 108 h ($P < 0.05$). Surface discoloration was

significantly different every 12 h after 24 h ($P < 0.05$). Overall appearance significantly decreased every 12 h to 108 h ($P < 0.05$). Least squares means (Table 3.4) indicated that panelists thought TO packaged eye of round steaks, as a whole, were deemed slightly undesirable at 48 h in retail display ($P < 0.05$). Modified atmosphere packaging showed muscle color had a significant difference from 12 h to 72 h ($P < 0.05$). Surface discoloration was significantly different every 12 h to 72 h ($P < 0.05$). Panelists rated overall appearance significantly different every 12 h to 72 h ($P < 0.05$). Least squares means (Table 3.4) indicate that panelists thought MAP packaged eye or round steaks, as a whole, were deemed slightly undesirable at 24 h in retail display. Table 3.5 shows no significant differences were found between each treatment by package type ($P > 0.05$).

Subjective color evaluation from the trained color panel of packaged top sirloin steaks can be found in Table 3.6. An evident difference in color throughout almost the entire retail display period was detected ($P < 0.05$). The muscle color in TO packages was significantly different from 12 h to 84 h ($P < 0.05$). Surface discoloration was significantly different every 12 h after 24 h ($P < 0.05$). Overall appearance significantly decreased every 12 h to 84 h ($P < 0.05$). Least squares means (Table 3.6) indicate that panelist thought TO packaged top sirloin steaks, as a whole, were deemed slightly undesirable at 36 h in retail display ($P < 0.05$). Modified atmosphere packaging showed muscle color had a significant difference from 12 h to 36 h ($P < 0.05$). Surface discoloration was significantly different every 12 h to 36 h ($P < 0.05$). Panelists rated overall appearance significantly different every 12 h to 36 h ($P < 0.05$). Least squares means (Table 3.6) indicate that panelists thought MAP packaged top sirloin steaks, as a whole, were deemed slightly undesirable at 12 h in retail display. Table 3.7 shows no significant differences were found between each treatment by package type ($P > 0.05$).

Subjective color evaluation from the trained color panel of packaged tenderloin steaks can be found in Table 3.8. An evident difference in color throughout almost the entire retail display period was detected ($P < 0.05$). The muscle color in TO packages was significantly

different from 12 h to 72 h ($P < 0.05$). Surface discoloration was significantly different from 12 h to 72 h ($P < 0.05$). Overall appearance significantly decreased every 12 h to 72 h ($P < 0.05$). Least squares means (Table 3.8) indicated that panelist thought TO packaged tenderloin steaks, as a whole, were deemed slightly undesirable at 24 h in retail display ($P < 0.05$). Modified atmosphere packaging showed muscle color had a significant difference from 12 h to 36 h ($P < 0.05$). Surface discoloration was significantly different every 12 h to 36 h ($P < 0.05$). Panelists rated overall appearance significantly different every 12 h to 36 h ($P < 0.05$). Least squares means (Table 3.8) indicate that panelist thought MAP packaged tenderloin steaks, as a whole, were deemed slightly undesirable at 12 h in retail display. Table 3.9 shows no significant differences were found between each treatment by package type ($P > 0.05$).

Belcher (2006) stated, "Packaging companies must carefully monitor retail and consumer trends to best utilize, direct, or prioritize their research dollars in developing packaging and packaging systems to meet these demands." Steaks packaged in both TO and MAP stayed consistent in terms of color for the duration of retail display. Consistent color is important in the bottom line of companies considering, Zerby et al. (1999) reported that at more than 10% discoloration, in retail, meat should be discounted. However, the shelf life of meat in conventionally overwrapped trays is generally too short to allow retail packs to be centrally prepared and distributed (Gill and Jones, 1994).

Consumer Evaluation

Reicks et al. (2008) stated traditional TO overwrap was used on 47.0% of packages in the fresh meat case nationwide and the most frequent packaging type for beef, ground beef, pork, lamb, and veal. The TO overwrap was used for whole muscle beef products more ($P < 0.001$) than any other species. The 3 most common tray colors in the fresh meat retail case on a national level were white (39.6%), yellow (22.4%), and black (11.5%), whereas 18.0% of all products did

not utilize a tray (Reicks et al., 2008). Styrofoam (foam) trays were the most widely used; 72.6% of all packages in the retail meat case utilized foam trays. Nationally, the use of MAP contributed to 13.2% of all packages in the fresh meat case (Reicks et al., 2008).

Table 3.10 provides percent of consumers willing to purchase each tray color, presented by packaging systems of beef strip loin steaks on d 1, 3, and 5. Traditional overwrapped packaged strip loin steaks at d 1 shows no significant differences by tray color ($P > 0.05$). Day 3 significant differences were found among each tray color ($P < 0.05$), in order of yellow (54.8%), white (38.5%), and black (6.7%). Day 5 significant differences were found between yellow (62.7%) among the other two tray colors with 37.3% ($P < 0.05$), yellow being favored. *Modified atmosphere packaged* strip loin steaks detected significant differences d 1 and 3 in favor of black over white colored trays ($P < 0.05$). On d 1black trays were favored 61.7% over white trays at 38.3%. On d 3 black was favored 56.3% over white at 43.7%.

Table 3.11 shows percent of consumers willing to purchase each tray color, presented by packaging systems of beef eye of round steaks on d 1, 3, and 5. Traditional overwrapped packaged eye of round steaks at d 1 shows significant differences between yellow and other tray colors ($P < 0.05$), favoring black (39.7%) or white (35.7%) versus yellow (24.6%). Day 3 significant differences were found among each tray color ($P < 0.05$), in preference order of white (42.0%), black (32.7%), and yellow (25.3%). Day 5 significant differences were found between white and other tray colors ($P < 0.05$), white being favored. *Modified atmosphere packaged* eye of round steaks detected significant differences d 1 and 3 in favor of black over white colored trays ($P < 0.05$). On d 1black trays were favored 59% over white trays at 41%. On d 3 black was favored 55.9% over white at 44.1%.

Table 3.12 represents percent of consumers willing to purchase each tray color, presented by packaging systems of beef top sirloin steaks on d 1and 3. Traditional overwrapped packaged

top sirloin steaks at d 1 shows no significant differences between tray colors ($P > 0.05$). Day 3 significant differences were found between white and other tray colors ($P < 0.05$), in favor of black (34.3%) or yellow (39.4%) over white (26.3%). *Modified atmosphere packaged* top sirloin steaks detected significant differences d 1 in favor of white (56%) over black (44%) colored trays ($P < 0.05$).

Table 3.13 shows percent of consumers willing to purchase each tray color, presented by packaging systems of beef tenderloin steaks on d 1and 3. Traditional overwrapped packaged tenderloin steaks at d 1 show no significant differences between tray colors, in preference order of yellow (34.3%), white (34%), and black (31.7%), ($P > 0.05$). Day 3 significant differences were found between each tray color ($P < 0.05$), in preference order of black (60%), white (27.4%), and yellow (12.6%). *Modified atmosphere packaged* tenderloin steaks detected significant differences on d 1 in favor of black (57%) over white (43%) colored trays ($P < 0.05$).

CONCLUSION

Results of this study indicate when each cut (strip loins, eye of rounds, top sirloins, and tenderloins) were scored by a subjective color panel each cut was only affected significantly by time, rather than treatment or the interaction between time and treatment. Each color attribute based on package type decreased as time progressed. Consumer preference varied by cut and was found to be unusual. Yellow is an uncommon tray color for fresh beef products, but was favored on d 3 and 5 for strip loin steaks, as well as, d 3 of top sirloin steaks packaged in TO. Black was the preferred color of consumers for each d for strip loin, eye of round, and tenderloin steaks packaged in MAP. In the tenderloin data, black was consistently preferred for both TO and MAP tray colors where as other cuts were not.

When comparing the trained color panel to the everyday consumers, you will notice that there is definitely some type of affect based on tray color, as shown by the trained panelists

finding no significant differences among tray, but rather only by time, and the consumers did show significant differences on tray color purchasing for different cuts on different days. Therefore this consumer data does prove that tray color must be influencing consumer purchasing decisions to some extent. Researchers believe that, given the intriguing results, more tray color data should be collected and analyzed to help satisfy and determine the preferences of the basic consumer eye. Extending this research into a retail setting would greatly increase your demographic data, which could then give a more realistic approach as to what really affects consumer's beef purchasing decisions. Determining consumer acceptability of packaging methods, retailers may be able to utilize tray color and type of packaging of retail cuts to significantly increase shelf-life therefore economically benefiting all sectors of the beef industry.

Table 3.1. Demographic characteristics of consumer panel. (n = 30)

Trait	No, of Consumers	Percent
Gender		
Male	13	43
Female	17	57
Ethnicity		
Caucasian	29	97
Hispanic	0	0
African American	0	0
American Indian	0	0
Other	1	3
Age, yr.		
<20	1	3
21-29	8	27
30-39	5	17
40-49	8	27
50-59	7	23
>60	1	3
Household Income Level		
<19,000	8	27
19,000-29,999	2	6
30,000-49,999	4	13
50,000-69,999	6	20
70,000-89,999	5	17
>90,000	5	17
Education		
High School or Equivalent	2	7
Some College	8	26
Bachelor's Degree	12	40
Master's Degree	2	7
Doctoral or Professional Degree	6	20
Beef Consumption[a]		
0	0	0
1	0	0
2	0	0
3	6	20
4	6	20
5	10	33
>5	8	27
Primary Purchaser of Beef In Home		
Yes	25	83
No	5	17
If Yes, Purchases at Retail[b]		
0	2	8
1	0	0
2	4	16

3	6	24
4	3	12
5	3	12
>5	7	28
Influences Your Meat Purchasing The Most		
Price	17	57
Color	0	0
Convenience	0	0
Taste	5	17
Past Experience	7	23
Other	1	3

[a] Number of times consumers consume beef a week.
[b] Number of times consumers purchase beef at retail in a week.

Table 3.2. Least squares means[4] of subjective color evaluation of beef strip loin steaks across 96 h

	Time, h								
Color Characteristics	12	24	36	48	60	72	84	96	SEM
Traditional Overwrap Packaging									
Muscle Color[1]	6.39[a]	6.27[a]	5.84[b]	5.22[c]	4.66[d]	4.54[d]	3.64[e]	3.37[f]	0.11
Surface Discoloration[2]	1.05[g]	1.21[g]	1.86[f]	2.78[e]	3.76[d]	4.47[c]	5.25[b]	5.54[a]	0.13
Overall Acceptability[3]	6.79[a]	6.45[b]	5.20[c]	3.78[d]	2.59[e]	1.78[f]	1.40[g]	1.22[g]	0.12
Modified Atmosphere Packaging									
Muscle Color[1]	6.15[a]	5.06[b]	4.43[c]	4.21[d]	3.87[e]	3.49[f]			0.09
Surface Discoloration[2]	1.46[f]	1.95[e]	2.52[d]	3.24[c]	4.21[b]	4.86[a]			0.09
Overall Acceptability[3]	6.11[a]	4.54[b]	3.51[c]	2.69[d]	1.86[e]	1.47[f]			0.12

[abcdefg]Least squares means in the same row without common superscripts differ ($P < 0.05$).

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).
[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).
[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).
[4]Least squares means calculated based on 6 observations or scores per sample.

Table 3.3. Least squares means[6] of beef strip loin steaks across three TO[4] and two MAP[5] packaging treatments

	Package Treatment					
	TO			MAP		
Color Characteristics	Black	White	Yellow	Black	White	SEM
Muscle Color[1]	4.70	4.77	4.60	4.44	4.56	0.175
Surface Discoloration[2]	3.53	3.31	3.30	3.56	3.59	0.155
Overall Acceptability[3]	3.23	3.37	3.30	3.05	3.16	0.181

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).

[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).

[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).

[4]Polyvinyl chloride overwrapped package.

[5]Modified atmosphere package (75% O_2 and 25% CO_2).

[6]Least squares means calculated based on 6 observations or scores per sample.

Table 3.4. Least squares means[4] of subjective color evaluation of beef eye of round steaks across 108 h

	Time, h									
Color Characteristics	12	24	36	48	60	72	84	96	108	SEM
Traditional Overwrap Packaging										
Muscle Color[1]	6.66[a]	6.27[b]	5.68[c]	5.40[d]	4.96[e]	4.89[ef]	4.87[f]	4.55[g]	4.21[h]	0.04
Surface Discoloration[2]	1.03[h]	1.19[h]	1.58[g]	1.91[f]	2.48[e]	2.79[d]	3.28[c]	3.90[b]	4.42[a]	0.09
Overall Acceptability[3]	7.30[a]	6.79[b]	5.48[c]	4.97[d]	3.81[e]	3.37[f]	2.96[g]	2.14[h]	1.79[i]	0.08
Modified Atmosphere Packaging										
Muscle Color[1]	6.23[a]	5.52[b]	5.11[c]	5.03[cd]	4.98[de]	4.88[e]				0.05
Surface Discoloration[2]	1.80[f]	2.18[e]	2.54[d]	2.95[c]	3.58[b]	3.98[a]				0.16
Overall Acceptability[3]	5.41[a]	4.42[b]	3.78[c]	3.31[d]	2.69[e]	2.56[e]				0.15

[abcdefghi]Least squares means in the same row without common superscripts differ ($P < 0.05$).

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).
[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).
[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).
[4]Least squares means calculated based on 6 observations or scores per sample.

Table 3.5. Least squares means[6] of beef eye of round steaks across three TO[4] and two MAP[5] packaging treatments

	Package Treatment					
	TO			MAP		
Color Characteristics	Black	White	Yellow	Black	White	SEM
Muscle Color[1]	5.08	5.10	5.14	5.18	5.21	0.064
Surface Discoloration[2]	2.87	3.07	3.00	2.83	2.68	0.189
Overall Acceptability[3]	3.69	3.51	3.55	3.76	3.86	0.207

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).

[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).

[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).

[4]Polyvinyl chloride overwrapped package.

[5]Modified atmosphere package (75% O_2 and 25% CO_2).

[6]Least squares means calculated based on 6 observations or scores per sample.

Table 3.6. Least squares means[4] of subjective color evaluation of beef top sirloin steaks across 84 h

	Time, h							
Color Characteristics	12	24	36	48	60	72	84	SEM
Traditional Overwrap Packaging								
Muscle Color[1]	5.57[a]	5.42[b]	5.06[c]	4.96[d]	4.73[e]	4.60[f]	4.52[g]	0.05
Surface Discoloration[2]	1.01[f]	1.09[f]	1.28[e]	1.50[d]	1.96[c]	2.31[b]	3.01[a]	0.07
Overall Acceptability[3]	6.16[a]	5.55[b]	4.90[c]	4.69[d]	3.98[e]	3.51[f]	2.70[g]	0.08
Modified Atmosphere Packaging								
Muscle Color[1]	4.29[a]	3.97[b]	3.37[c]					0.08
Surface Discoloration[2]	3.98[c]	4.65[b]	5.74[a]					0.17
Overall Acceptability[3]	2.76[a]	2.04[b]	1.48[c]					0.14

[abcdefg]Least squares means in the same row without common superscripts differ ($P < 0.05$).

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).
[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).
[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).
[4]Least squares means calculated based on 6 observations or scores per sample.

Table 3.7. Least squares means[6] of beef top sirloin steaks across three TO[4] and two MAP[5] packaging treatments

	Package Treatment					
	TO			MAP		
Color Characteristics	Black	White	Yellow	Black	White	SEM
Muscle Color[1]	4.27	4.42	4.41	4.48	4.46	0.161
Surface Discoloration[2]	3.51	3.21	3.23	2.89	3.02	0.362
Overall Acceptability[3]	2.87	3.14	3.06	3.36	3.33	0.339

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).

[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).

[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).

[4]Polyvinyl chloride overwrapped package.

[5]Modified atmosphere package (75% O_2 and 25% CO_2).

[6]Least squares means calculated based on 6 observations or scores per sample.

Table 3.8. Least squares means[4] of subjective color evaluation of beef tenderloin steaks across 72 h

	Time, h						
Color Characteristics	12	24	36	48	60	72	SEM
Traditional Overwrap Packaging							
Muscle Color[1]	4.90[a]	4.47[b]	4.03[c]	3.67[d]	3.49[e]	3.16[f]	0.05
Surface Discoloration[2]	1.10[f]	1.78[e]	2.55[d]	3.22[c]	4.26[b]	4.76[a]	0.10
Overall Acceptability[3]	5.85[a]	4.45[b]	3.28[c]	2.57[d]	1.74[e]	1.46[f]	0.08
Modified Atmosphere Packaging							
Muscle Color[1]	3.53[a]	2.56[b]	2.22[c]				0.10
Surface Discoloration[2]	4.86[a]	5.90[b]	6.15[a]				0.20
Overall Acceptability[3]	2.12[a]	1.48[b]	1.45[b]				0.16

[abcdef] Least squares means in the same row without common superscripts differ ($P < 0.05$).

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).
[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).
[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).
[4]Least squares means calculated based on 6 observations or scores per sample.

Table 3.9. Least squares means[6] of beef tenderloin steaks across three TO[4] and two MAP[5] packaging treatments

	Package Treatment					
	TO			MAP		
Color Characteristics	Black	White	Yellow	Black	White	SEM
Muscle Color[1]	3.23	3.22	3.35	3.33	3.36	0.185
Surface Discoloration[2]	4.63	4.50	4.16	4.40	4.44	0.398
Overall Acceptability[3]	1.92	2.09	2.31	2.20	2.17	0.299

[1]Muscle color was measured on an 8-point scale (1 = extremely dark red, and 8 = extremely bright cherry red).

[2]Surface discoloration was measured on a 7-point scale (1 = no discoloration-0%, and 7 = total discoloration-100%).

[3]Overall acceptability was measured on an 8-point scale (1 = extremely undesirable, and 8 = extremely desirable).

[4]Polyvinyl chloride overwrapped package.

[5]Modified atmosphere package (75% O_2 and 25% CO_2).

[6]Least squares means calculated based on 6 observations or scores per sample.

Table 3.10. Percent[1] of consumers willing to purchase each tray color, presented by packaging systems of beef strip loin steaks on d 1, 3, and 5.

	D 1	D 3	D 5
Traditional Overwrap Packaging			
Black Trays	33.9	6.7[a]	17.0[a]
White Trays	33.9	38.5[b]	20.3[a]
Yellow Trays	32.2	54.8[c]	62.7[b]
Modified Atmosphere Packaging			
Black Trays	61.7[b]	56.3[b]	
White Trays	38.3[a]	43.7[a]	

[abc]Least squares means in the same column within a packaging system without common superscripts differ ($P < 0.05$).

[1]Percentages calculated based on 30 consumer observations on each of the 30 steaks per treatment group.

Table 3.11. Percent[1] of consumers willing to purchase each tray color, presented by packaging systems of beef eye of round steaks on d 1, 3, and 5.

	D 1	D 3	D 5
Traditional Overwrap Packaging			
Black Trays	39.7[b]	32.7[b]	27.1[a]
White Trays	35.7[b]	42.0[c]	38.5[b]
Yellow Trays	24.6[a]	25.3[a]	34.4[a]
Modified Atmosphere Packaging			
Black Trays	59.0[b]	55.9[b]	
White Trays	41.0[a]	44.1[a]	

[abc]Least squares means in the same column within a packaging system without common superscripts differ ($P < 0.05$).

[1]Percentages calculated based on 30 consumer observations on each of the 30 steaks per treatment group.

Table 3.12. Percent[1] of consumers willing to purchase each tray color, presented by packaging systems of beef top sirloin steaks on d 1 and 3.

	D 1	D 3
Traditional Overwrap Packaging		
Black Trays	33.3	34.3[b]
White Trays	31.0	26.3[a]
Yellow Trays	35.7	39.4[b]
Modified Atmosphere Packaging		
Black Trays	44.0[a]	
White Trays	56.0[b]	

[ab]Least squares means in the same column within a packaging system without common superscripts differ ($P < 0.05$).

[1]Percentages calculated based on 30 consumer observations on each of the 30 steaks per treatment group.

Table 3.13. Percent[1] of consumers willing to purchase each tray color, presented by packaging systems of beef tenderloin steaks on d 1 and 3.

	D 1	D 3
Traditional Overwrap Packaging		
Black Trays	31.7	60.0[c]
White Trays	34.0	27.4[b]
Yellow Trays	34.3	12.6[a]
Modified Atmosphere Packaging		
Black Trays	57.0[b]	
White Trays	43.0[a]	

[abc]Least squares means in the same column within a packaging system without common superscripts differ ($P < 0.05$).

[1]Percentages calculated based on 30 consumer observations on each of the 30 steaks per treatment group.

REFERENCES

Allen, D. M. 1968. Description of ideal carcasses. Proc. Recip. Meat Conf. 21: 284.

AMSA. 1991. *Guidelines for Meat Color Evaluation.* American Meat Science Association and National Livestock and Meat Board. Chicago, IL.

Barbut, S. 2001. Effect of illumination source on the appearance of fresh meat. Meat Science, 59(2), 187 -191.

Billmeyer, F. W. and Saltzman, M. 1966. Principles of Color Technology. Interscience Publishers, New York, NY.

Buege, J. A. and S. D. Aust. 1978. Microsomal lipid peroxidation. In Methods in Enzymology. 52: 302-310. Academic Press, New York, NY.

Carpenter, C. E., Cornforth, D. P., & Whittier, D. 2001. Consumer preferences for beef color and packaging did not affect eating satisfaction. Meat Science, 56(3), 291 - 299.

Cryovac. 2003. Profiling the U.S. retail meat department in 2002. A publication of Cyrovac Food Packaging Division, Sealed Air Corporation, PO Box 464, 100 Rogers Bridge Road, Duncan, SC

Danner, M.J. 1959. Beef preferences and purchasing practices. Ala. Agr. Exp. Sta. Circ. 131.

Dunsing, M. 1959a. Visual and eating preferences of consumer household panel for beef from Brahman-Hereford crossbreds and Herefords. Food Technol. 13: 451.

Dunsing, M. 1959b. Consumer preferences for beef of different breeds related to carcass

and quality grades. Food Technol. 13: 516.

Gill, C. O. 1996. Extending the storage life of raw chilled meats. Meat Sci. 43:S99-S109.

Gill, C. O. and T. Jones, The display of retail packs of ground beef after their storage in master packages under various atmospheres. J. Meat Sci. 37:281–295.

Gray, J. I., E. A. Gomaa, and D. J. Buckley. 1996. Oxidative quality and shelf life of meats. Meat Sci. 43: 111-123.

Issanchou, S. 1996. Consumer expectations and perceptions of meat and meat products. Meat Science, 43, S5-S19.

Liu, Q., M. C. Lanari, and D. M. Schaefer. 1995. A review of dietary vitamin E supplementation for improvement of beef quality. J. Anim Sci. 73:3131 -3140.

Mancini, R. A. and M. C. Hunt. 2005. Current research in meat color. J. Meat Sci. 71:100 -121.

Reicks, A., J. Brooks, J. Kelly, W. Kuecker, K. Boillot, R. Irion, and M. Miller. 2008. National Meat Case Study 2004: J. Anim. Sci. 86.(12):3593-3599.

Romans, J. R., Tuma, H. J., and W. L. Tucker. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. II. Muscle pigments and color.

Savell, J. W., Cross, H. R., Francis, J. J., Wise, J. W., Hale, D. S., Wilkes, D. L., and G. C. Smith. 1989. National consumer retail beef study: international of trim level,

price, and grade on consumer acceptance of beef steaks and roasts. J. Food Quality. 12: 251 - 274.

Smith, G. C., K. E. Belk, J. N. Sofos, J. D. Tatum, and S. N. Williams. 2000. Economic implications of improved color stability in beef. In E. A. Decker, C. Faustman, and C. J. Lopez-Bote (eds.), *Antioxidants in muscle foods: Nutritional strategies to improve quality* (pp. 397 -426). New York: Wiley Interscience.

Scheuplin, R. J. 1964. A survey of some fundamental aspects of the absorption and reflection of light by tissue. J. Soc. Cos. Chem. 15: 111 – 122.

U.S.D.A. 1965. Official United States standards for grades of carcass beef. Title 7, Ch. 1, Pt. 53, Sections 53, 102-106. June. U.S.C. & M.S.

Yankelovich, Skelly & White. 1985. The Consumer Climate for Meat. A report to the American Meat Institute, Washington D.C, and the National Live Stock and Meat Board, Chicago, Il. Yankelovich, Skelly & White, New York.

Zerby, H. N., K. E. Belk, L. R. Sofos, L. R. McDowell, and G. C. Smith. 1999. Case life of seven retail products from beef cattle supplemented with α-tocopheryl acetate. J. Anim. Sci. 77:2458-2463.

VITA

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Master of Science

Thesis: IMPACT OF RETAIL TRAY COLOR ON RETAIL CASE LIFE AND CONSUMER ACCEPTABILITY

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Title of Study: IMPACT OF RETAIL TRAY COLOR ON RETAIL CASE LIFE AND CONSUMER ACCEPTABILITY

Pages in Study: 34 Candidate for the Degree of Master of Science

Major Field: Animal Science

Scope and Method of Study: The present study was conducted to determine if tray color (yellow, black, or white) influences retail case life and consumer acceptability of strip loin steak, top sirloin steaks, tenderloin steaks, and eye of round steaks when packaged in traditional overwrap (TO) or modified atmosphere packaging (MAP). USDA Select Strip Loins, Eye of Rounds, Top Sirloins, and Tenderloins (n = 30/cut) were fabricated into 2.54 cm steaks and assigned to one of five treatment groups (tray color by package system). Steaks assigned to MAP were packaged with a common mixture of 0% CO, 25% CO_2, and 75% O, and held in dark storage for 7 d at 4°C. Steaks assigned to TO were overwrapped and placed immediately in retail display. Every Monday, Wednesday, and Friday during display, a consumer panel (n = 10 consumers/d) was conducted. Consumers scored steaks from each cut by package type (one white tray vs. one black tray vs. one yellow tray-if applicable-of the same cut) by indicating which steak they would purchase by circling the number associated with that steak.

Findings and Conclusions: Results of this study indicate when each cut (strip loins, eye of rounds, top sirloins, and tenderloins) were scored by a subjective color panel each cut was only affected significantly by time, rather than treatment or the interaction between time and treatment ($P < 0.05$). Consumer data revealed yellow was preferred on most cuts as time progressed ($P < 0.05$). Black was the most significantly favored color of tray for the tenderloin steaks each day ($P < 0.05$). Researchers believe that, given the intriguing results, more tray color data should be collected and analyzed to help satisfy and determine the preferences of the basic consumer eye.

ADVISER'S APPROVAL: Dr. Deb VanOverbeke