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The Influence of Tunable LED Lighting Systems on Consumer Food Label Perceptions

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Abstract

A study was conducted in a grocery store simulation lab at a large Mid-Western university to measure consumer perceptions of meat package label design variations under different LED lighting conditions. A quasi-experimental approach using a multi-group between-within subjects' post-test only design measured participants' responses to the novel meat labels. Philip's HUE consumer LED light bulbs were varied with different colors over beef steak package labels from 2700 K (RED) - 7000 K (BLUE). Goose neck lamps over the packages were used to create the display lighting simulations. The researchers determined that there was evidence of label and lighting interactions which influenced consumer perceptions of nutrition label information both between and within subject groups.

Keywords

Labeling, Lighting, Consumer Behavior, Nutrition

1. Introduction

New-to-market Philip's Hue LED lighting systems use network controls and modifiable lighting scenes which may offer differential advantages for retailers attempting to highlight important products or product information. Network controlled LED lights may interact with label design elements (e.g. text, graphics) when used in combination with label color variations that are distinct from black and white text common on meat labels. This study measured the effects of label design and light interactions on consumer perception of color and black and white label messages. The influence on consumers of perceived differences between labels under different LED lighting scenes may provide retailers with opportunities to increased attention to targeted label message compo-

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nents such as nutritional information for shoppers, locally produced brands, or food safety information. The effects on consumers of new-to-market LED lighting systems, such as Philips Hue light bulbs when controlled for Kelvin color temperature impact product, packaging, and labeling perceptions in simulated store environments, are not well understood.

2. Literature Review

Prior research has demonstrated the importance of label information to consumers evaluating meat products [1]. The role of colored label information compared to black text for influencing consumer decision making for meat purchases requires additional research pertaining to LED lighting. According to color theory, emotions can be influenced by certain colors, measured by wavelengths of visible light. The colors red and blue are posited to elicit specific emotional responses from consumers. Research has posited the emotional responses to color are stimulated by higher color saturation and lighter colors produce the opposite effect [2] [3]. Brand icon shape manipulations and red or blue color packaging variations have been demonstrated to influence consumer perceptions about brand personality and purchase intentions [4] [5]. Packaging variations incorporating angular versus rounded shapes have suggested greater consumer-perceived approachability of food items versus perceived confrontation [6]. Researchers have also found that visual cues such as large bulleted print, color, borders, and shapes are more likely to attract consumer attention [7]. The complex interplay of label information design, packaging, and the store environment or the system of meat retailing needs further study with the goal of understanding methods to increase consumer attention to product messages with the goal of influencing purchase intentions. Improving meat department lighting and labeling systems may offer differential advantages compared to relatively price inelastic commodities in grocery stores such as consumer packaged goods. To achieve this goal, researchers must better understand customers interpret the interplay LED lighting color variations and black and white versus colored label design components, and if color labels produce measurable effects on consumers.

Characteristics of light bulbs are described with various terminologies including: lumens, foot candles (LUX), color rendering index (CRI), and Kelvin color temperature. Lumens are defined as the amount of light that the human eye is able to see [8]. Foot candles are the measurement units indicating the amount of illumination produced by a source of one candle at a distance of one foot [9]. CRI describes the way objects appear under a given light source on a scale of 1 - 100. Low CRI light sources make objects illuminated by them appear unnatural and higher CRI light sources support a more natural appearance [10]. Color temperature (Kelvin) is defined as the measured temperature at which a black body emits light at a specific spectral distribution [11]. Low color temperature light sources make products illuminated by them appear warmer from the range of more yellow to red light emitted while higher color temperature sources appear colder from the blue to green light emitted from light bulbs.

For retailers, understanding how more energy efficient and economical light sources such as LEDs may favorably influence consumer opinion of products in retail environments is critical to top and bottom line financial performance. LED sources have higher efficacies to produce light than incandescent and fluorescent sources currently used by retailers to illuminate grocery stores. Environmental concerns and economic benefits are fueling the rapid growth and replacement of older lighting technologies. By 2020, according to the Energy Independence and Security Act [12] light bulbs are required to be 70% more efficient. Evolving technologies, such as LED bulbs, are more economical than incandescent bulbs when cost/lumen and lumens/watt are compared. Linking light bulbs to computers via network control for modified lighting effects, including packaging/label/light interactions, offers retailers the potential of A) Reducing operating costs, B) Educating consumers about key food safety concerns such as nutritional content, brand messages, and safe handling instructions, C) Improving the inventory turnover and sales revenues of targeted products. The potential of new-to-market network-controlled LED systems and packaging interactions have little empirical research related to consumer behavior and yet technology is increasingly more cost-effective for lighting retrofits for smaller food retailers. Cost-effective modifications to lighting systems used in combination with targeted packaging and labeling designs may offer several retailer benefits. Through optimal label and lighting designs, consumers could benefit in numerous ways including: profit optimization, brand selection, better nutritional choices, and greater attention to proper product handling instructions.

Grocery stores devote considerable sales floor square-footage to beef products. To encourage consumers to purchase meat products, several tactics are currently used: promotional pricing, eye-catching signs, novel pack-

aging, labelling and display lighting to highlight key products. This study explored the latter two tactics aby measuring label and lighting interactions and their effects on consumers. A 2012 study of grocery shoppers found that meat perceived as high quality was most important, followed by a broad assortment [13]. On average, meat display cases occupy 82.2 meters in the U.S. and 4.5 meters for full service meat displays [14]. Methods for modifying lighting design and label information in store environments that work synergistically to influence consumer product attributions is a priority in the rapidly evolving world of display lighting and low cost color label printing. A summary of consumer research by the Beefboard.org [15] ranks beef product attributes influence on preferences and willingness to pay price premiums through factors such as safety, price, health, quality, sustainability, and nutrition provides a rich research agenda for measuring lighting and label variations on consumer perceptions of the meat products. Many food product consumer cues are evaluated during grocery shopping trips with labels providing a substantial source of information which influences purchases. This study measured the effects of varying colored nutrition label designs with two backgrounds (red and blue) within subjects and how the metal label designs influenced consumers. The researchers controlled for different display lighting schemes in three conditions of the label variations (control-white light, red light, and blue light between subject groups).

Much variation of in-store lighting is possible. Light bulb attributes may vary widely within and across grocery stores. New lighting systems, such as network-controlled LED variable bulbs need to be tested so that their appropriateness and influence on consumers may be revealed. Lighting system retrofits are substantial investments for stores, particularly in chain stores or within the fixed asset budget constraints of single location operations. A specific advantage of new-to-market network-controlled lighting systems is that they may be used to highlight specific products at the discretion of retail management, while not requiring high-cost lighting construction retrofits.

Packaging for the purpose of this study is described as the material which remains in constant contact with the meat products until it is removed for consumption. Packages serve many roles including: stabilizing, preserving, protecting, measuring, displaying and identifying retail products to consumers. The researchers propose that the packaging surrounding products influences attributions to the product within the package and differs from Underwood [16] who suggests that packaging is mutually exclusive to the ingredients. The appearance of products may interact with display lighting through reflection and absorption and reflection of visible light and the package. For the purposes of this study, white trays were used to maximize the reflective interaction of the LED light sources and the meat and label.

Labeling research has demonstrated that significant differences exist between label perceptions based on shopper socio-demographic factors [17] [18]. The role of colored label and lights effects among different groups of consumers is less clear. Optimal label and lighting designs with broad appeal among consumer groups is an important concern for the increasingly diverse U.S. grocery market. Labels using bold text and colored text, whole numbers, and calories are preferred by customers in general [19]. We wish to expand the research of consumer perceptions of label design variations more thoroughly by controlling for specific lighting interactions with targeted text design using colored labels [20]-[24]. Stimulus organism response (SOR) theory has been proposed as a means for measuring consumer attributions such as perceived brightness, usefulness, appeal, ease of understanding, information importance, concern for information, and need for information [25] [26]. The current researchers previously used SOR theory to explore consumer perceptions of ground beef packages [27]. A pilot study in 2013 with ground beef packaging found that (static) LED light sources (2800 K + 5000 K) influenced favorable packaging perceptions and purchase intentions compared to fluorescent (2700 K control) bulbs. Philip's HUE consumer light bulbs and network control bridges offer researchers the opportunity to easily and quickly vary color temperature through a computer interface and network bridge. For this study, Kelvin color temperatures were varied from 2700 K (warm white) RED to 7000 K (cool white) BLUE to understand how consumers perceive the interaction of the lighting and label information.

3. Hypotheses

Color research has suggested that optimal background colors for meat departments are light blue or aqua with white meat trays and display fixtures to enhance the color of the meat while suggesting cleanliness and a cold (*i.e.* refrigerated/safe) environment [28]. Cool colors, *i.e.*, blue, have been demonstrated to stimulate purchase intentions [29]. For purposes of this study, the label variations use a single variant of a red nutrition background

(Label A) and blue nutrition background (Label B) in a novel label design to determine if consumers perceive the labels differently under the same control white LED light bulbs.

H1: Under the white light control, there will be no differences between label perceptions of: brightness, usefulness, appeal, ease of understanding, information importance, concern for information and need for information between the red and blue grounds of the nutrition portion of the label.

Other research has suggested that warm colors attract consumers more and may influence impulse buying compared to cool colors which are more appropriate for examining a product's package characteristics [30] [31]. Warmer color temperature incandescent bulbs have been demonstrated to produce higher preferences for meat products when compared to fluorescent and metal halide sources [32] [33]. Lighting research in casinos has demonstrated effects on consumers in which blue lights have been found to be conducive to shorter visits and red light to longer visits because of different perceptions of time passing under each type [34]. Blue light may have a relationship to impulse buying stemming from approach behavior and faster consumer decision making pertaining to label information on food products [35].

H2: Under red light, label variants with analogous harmonious colors in the nutrition panel (*i.e.* red, yellow, green-label B) will influence label design perceptions: brightness, usefulness, appeal, ease of understanding, information importance, concern for information and need for information.

H3: Under blue light, label variants with contrasting colors in the nutrition panel (*i.e.* red, yellow, green--label B) will influence label design perceptions: brightness, usefulness, and label appeal, ease of understanding, information importance, concern for information and need for information.

Beef and its color and appearance within standard Styrofoam deli packaging have been demonstrated to be the greatest factor in purchase behaviors [36] [37]. Product fit with the packaging design has been demonstrated with children who chose dark packaging for a dark chocolate candy bar and light packaging for a white chocolate candy; a statistically significant difference between the 1/3 of children who simply picked their favorite color to package the candy bar. Hershey has adopted the light/dark packaging scheme to simplify product selection for consumers [38]. Contrasting color label designs on meat packages may produce similar influences on consumers by adding product information cues interpreted differently than standard black and white meat labels.

Todorovic [39] suggests that the product, package, and its environment, including lighting, provide a unified experience for consumers considering alternatives. The researchers posit that consumers may select a steak according to the Gestalt of its presentation (*i.e.* display fixture color, package color, the product's appearance and light source interaction within a complex system) influencing perception. For this reason, we measured effects of the lighting on consumer perceptions using stimulus-organism-response theory to test multiple meat label attributions simultaneously. Ampuero and Vila [40] found that high price/status orientation products require dark/cold packaging such as black meat trays, utilitarian products require light/warm packaging and perceived safety was influenced by red packaging. Feelings about products, labels and packaging have been demonstrated to influence purchase intentions [41]. Similar results were found by Decre and Pras [42] in which warm color temperatures stimulated more positive reactions to retail environments and intention to buy compared to cooler color temperatures in simulated retail environments.

H4: Blue light will demonstrate a direct positive relationship to the white light control perceptions of label: brightness, usefulness, appeal, ease of understanding, information importance, concern for information and need for information.

H5: Red light will demonstrate a direct positive relationship to the control white light perceptions of label: brightness, usefulness, appeal, ease of understanding, information importance, concern for information and need for information.

H6: Red light will demonstrate a direct positive relationship to blue light perceptions of label: brightness, usefulness, appeal, ease of understanding, information importance, concern for information and need for information.

To create optimal lighting schemes for food labels based on existing store fixture infrastructure at retailers, we must better understand the differences between consumer perception of the food products based on labeling and lighting systems interactions.

4. Methods

This study was conducted at a large Midwestern university in Food and Agricultural Products Center (FAPC). The FAPC lab is a simulated grocery store environment including lighting and refrigerated display cases to pro-

vide our participants with a realistic meat department shopping experience. 156 subjects were recruited to participate in the study and received $20 financial compensation for their participation. Student participants were offered extra credit in the courses from which they are recruited. The characteristics of the sample are presented in **Table 1**.

Participants arrived at the food products lab, and completed paper informed consent documentation followed by a paper based pre-exposure survey including questions that assessed their label use when shopping. After completing the preliminary survey, participants we randomly assigned to one of the three experimental lighting conditions: red, white, or blue lighting. The Hue lights (3) illuminated the meat package labels in each color condition using gooseneck lamps presented 12 inches above the meat packages and attached to grocery store cases. Each lighting condition was isolated using opaque dividers to prevent cross-exposure between subjects. Mean light measurements from the surface of the meat package in LUX for the 7-day data collection period by lighting condition are presented in **Table 2**. The white light control package illuminance was approximately 1280 LUX. The red light package illuminance was approximately 583 LUX and the blue light package illuminance was 470 LUX. Illuminance variations were due to the targeted Kelvin ranges of 2800 to 7000 and limitations of the Hue bulbs. The label treatments were created using a Prima LX400 color label printer with reduced moisture labels to reduce ink bleeds from refrigerated case temperature variations (see **Figure 1**). Meat for the study and product packaging was purchased from a partnering meat department at a local grocery store. Upon

Table 1. Characteristics of the sample.

Measure	Blue Light Condition	%	Red Light Condition	%	White Light Condition	%
Gender						
Male	16	30	7	14	12	22
Female	37	70	42	86	42	78
Age						
18 - 29	15	28	19	39	20	37
30 - 39	1	2	3	6	2	4
40 - 59	29	55	17	35	26	48
60 and over	8	15	10	20	6	11
Household Income						
Below $20,000	11	21	15	31	11	20
$20,000 to $29,999	3	6	2	4	4	7
$30,000 to $39,999	4	8	2	4	3	6
$40,000 to $49,999	2	4	4	8	4	7
$50,000 to $59,999	6	11	4	8	6	11
$60,000 to $74,999	8	15	3	6	6	11
$75,000 to $99,999	5	9	7	14	5	9
$100,000 or more	14	26	12	25	15	28
Education						
High School Graduate	5	9	1	2	4	7
Some College	20	38	23	47	25	46
College Graduate	11	21	10	20	9	17
Graduate Work	17	32	15	31	16	30

Figure 1. Meat package lighting and label interactions.

Table 2. Mean daily Lux readings.

Package A/B Day	LUX	LUX	LUX
1	1320/1340	600/590	540/500
2	1260/1280	560/570	440/460
3	1260/1230	580/580	430/450
4	1320/1290	590/600	460/470
5	1270/1260	570/560	470/480
6	1280/1300	600/590	470/470
7	1270/1270	580/590	460/470

arrival, participants completed informed consent documents, examined packages of meat, and completed a paper based survey with questions about the label stimuli prior to receiving participant incentives and exiting the lab.

The researchers used a quasi-experimental approach including a multi-group between-within subjects post-test only design or in other words, a two-way mixed design. The proposed experiment measured the effects and interaction of packaging and lighting variations on six dependent variables based on SOR theory: brightness, usefulness, and label-appeal, ease of understanding, information importance, concern for information, and need

for information [25]. This study increased our understanding from a pre-pilot study in which we tested the effects of evolving lighting technologies including compact fluorescent lighting (CFL) and LED light bulbs on ground beef package perceptions and consumer preferences [27] [43]. In this prior study, consumers preferred meat products presented under warmer red LED light sources compared to cooler blue bulbs. This study added analogous and contrasting colored nutrition fields on meat label to better understand interaction effects of lighting and label designs.

5. Analysis

T-tests were utilized to test the hypotheses and theoretical assumptions in two phases followed by a repeated measures split plot ANOVA. A within and between subjects' comparison tested the effect of the lighting treatments on consumer label perceptions. In the first analysis, within subject t-tests were used to compare label variants until the same lighting condition (red, blue, white) **Figure 1**. Significant differences were found in participant comparisons of package A and package B for the white light condition for brightness M = 2.96, SD = 1.02 and M = 4.47, SD = 0.749, t(52) = −9.52, $p < 0.001$, usefulness M = 4.13, SD = 0.708 and M = 4.51, SD = 0.541, t(52) = −4.18, $p < 0.001$, ease of understanding M = 4.28, SD = 0.904 and M = 4.55, SD = 0.695, t(52) = −2.94, $p < 0.01$, information importance M = 3.97, SD = 1.02 and M = 4.15, SD = 0.896, t(52) = −3.26, $p < 0.01$, and need for information M = 2.33, SD = 0.911 and M = 1.89, SD = 0.839, t(52) = 4.12, $p < 0.001$. Therefore, hypothesis 1 is not supported. This finding suggests that consumers may have reacted to the blue ground nutrition panel differently than the red ground nutrition panel which was varied in the control condition. This finding may support the findings of the effects of color contrasts on consumers [28] [29], but require more research.

No significant differences were found in the red light condition indicating that analogous harmonies from the red light source and red label nutrition panel elements (*i.e.* red, yellow, green) did not influence consumer attention to label design variations. Hypothesis 2 is not supported. This finding suggests that under red light analogous harmonious colors presented in the serving information variations were not perceived differently than white fields in the nutrition panel. Red, green, yellow and orange colors under red light may be less effective for highlighting information on the nutrition label in favor of contrasting color label designs that differentiate product information for consumers through color contrasts or saturation effects to highlight product information.

The blue light treatment emphasized blue nutrition label background and red, yellow, green color contrasts (**Table 2** and **Table 3**). Significant differences were found in the blue lighting condition for participant comparisons of package A and package B: brightness M = 3.13, SD = 1.26 and M = 4.55, SD = 0.567, t (52) = −7.87, $p < 0.001$, usefulness 4.26, SD = 6.55 and M = 4.49, t (52) = −3.26, $p < 0.01$ SD = 0.541, appeal M = 4.49, SD = 0.750 and M = 4.72, SD = 0.533, t (52) = −3.06, $p < 0.01$. Therefore, Hypothesis 3 is partially supported.

Next, the data was analyzed using independent samples t-tests to compare how participants evaluated label treatments (Labels A and B) under lighting treatment groups (Red, Blue, Control). Significant differences were found for package A between the blue and white lighting groups for appeal M = 3.47, SD = 0.97 and M = 3.41,

Table 3. Split plot repeated measures ANOVA comparing within subject's effects by label variant and lighting treatment.

SOR Dimension	White Light	White Light	Red Light	Red Light	Blue Light	Blue Light		
Bipolar Scale Item	Mean Label A	Mean Label B	Mean Label A	Mean Label B	Mean Label A	Mean Label B	F (2, 152)	η^2
Dull-Bright	2.79	4.41	3.65	3.7	2.78	4.36	15.52***	0.17
Useless-Useful	4.2	4.45	4.47	4.47	4.2	4.25	6.60**	0.08
Unappealing-Appealing	3.23	4.24	3.78	3.9	3.26	4.09	8.41***	0.1
Hard to Understand-Easy to Understand	4.37	4.33	4.46	4.54	4.41	4.68	0.773	0.01
Non Essential-Essential Information	4.32	4.31	4.35	4.46	4.44	4.57	1.743	0.02
Of No Concern to Me-Of Concern to Me	3.69	4.02	3.78	3.71	4.15	4.36	2.77	0.04
Not Needed-Needed	4.28	4.53	4.4	4.31	4.35	4.46	1.18	0.02

SD = 1.074, t (140) = 2.06, $p < 05$, indicating that package A under the white (control) light was more appealing. Significant differences were also found for ease of understanding between blue and white lighting conditions for package B, M = 4.72, SD = 0.533 and M = 4.43, SD = 0.797, t (140) = 2.15 $p < 0.05$. This finding indicates that package B was easier to understand under the blue lighting condition and was likely influenced by the contrasting colors on the nutrition label panel background panel which differed between Label A and Label B. This finding suggests that contrasting color elements in the label background of the nutrition facts panel may have made the label seem easier to understand. More research is needed to test the assumptions of effects of label color fields on consumer perception of label information. Therefore, hypothesis 4 is partially supported.

Comparisons of the red light condition to the white light control group were conducted and significant difference were found for package A in brightness M = 3.78, SD = 1.05 and M = 3.88, SD = 1.11, t (100) = 3.98, $p < 0.001$, usefulness M = 4.51, SD.649 and M = 4.51, SD = 0.649 t (100) = 2.80, $p < 0.01$, and appeal M = 3.86, SD = 0.913 and M = 4.04, SD .999, t (100) = 2.28 $p < 0.05$. These findings suggest that the label on package A under the red light was perceived as brighter, more useful, and appealing than the identical label under the control condition white light in spite of lower illuminance (1230 LUX vs 580 LUX). For package B significant differences were found between the red and white light conditions for perceived label brightness M = 2.96, SD = 1.02 and M = 4.47, SD = 0.749, t (100) = −3.19, $p < 0.01$, suggesting there were differences in how consumers perceived labels with analogous harmonious color interactions between red light and the red background color of the nutrition information panel compared to contrasting blue background nutritional label design. Therefore, hypothesis 5 is partially supported.

In the comparison of the blue and red lighting condition groups, significant differences were found for brightness for both packages A and B. Package A comparisons for perceived brightness M = 3.13, SD = 1.26 and M = 2.96, SD = 0.1.02 t (100) = −2.80, $p < 0.01$ suggest that participants considered the red lighting condition label was brighter than the blue lighting condition label. Similar results were found for Package A for label appeal under the red lighting condition M = 3.47, SD = 0.973 and M = 3.41, SD = 1.07, t (100) = −2.06, $p < 0.05$, suggesting that for package A, the red light and label content interaction was more appealing. For package B, a converse relationship was demonstrated for each lighting source M = 4.45, SD = 0.667 and M = 4.47, SD = 0.749, t(100) = 3.20, $p < 0.01$, suggesting that package B was perceived brighter, despite lower illuminance (580 vs. 470 LUX) under the blue lighting condition which may have been influenced the contrasting color fields in the background of nutrition facts panel compared to the analogous red color background panel present in package B. However, additional research is needed to verify this supposition. Similar results were found for package B in the concern for label information perceptions between the blue and red lighting conditions M = 4.47, SD = 0.772 and 4.15, SD = 0.886, t(100) = 2.51, $p < 0.05$, suggesting that participants were more concerned about the information presented under the blue lighting conditions for label B which contained a contrast red background nutrition facts panel. Therefore, hypothesis 6 is partially supported.

Finally, to test the effects of the lighting treatments among all three groups of participants simultaneously, a one-way repeated measures split-plot ANOVA was conducted to compare the effects of label variants (Labels A and B) within subjects and between lighting treatments. The data set was normalized for the repeated measures split-plot ANOVA using a natural logarithmic conversion which was then back converted to the transformed means for reporting purposes (**Table 3**). Homogeneity of variance tests indicated that the samples met the assumptions for performing a split-plot repeated measure ANOVA. Mauchly's test of sphericity was not significant, $\varepsilon = 1.00$, indicating that the assumptions to conduct a repeated measures split plot ANOVA were met. For label Brightness F (2, 152) = 15.52, $p < 0.001$, Usefulness F (2. 152) = 6.60, $p < 0.01$, and Appeal F (2, 152) = 8.41. $p < 0.001$ significant results were found between lighting conditions. This finding suggests that the contrasting color panels produced measureable differences within and between subjects with higher reported means for contrasting colors. The variation of nutrition label information using color variations may influence consumer perceptions of label information to some degree, contingent on lighting effects from network controlled color variations of LED light bulbs. For the current study, reported means varied among changes to nutrition panel information across (lighting variation) and within groups (label variation). The findings may indicate a novelty or Hawthorne effect produced by participant identification of label design variations during the experiment that confound lighting effects on user preferences [44].

6. Conclusions

The purpose of this study was to examine the impact of new LED lighting systems on consumer perception of

labels both within and between subject groups. Within subjects two label variants (A and B) were tested between subjects under different lighting conditions (white, red, and blue). Significant differences were found for brightness, usefulness, appeal, information importance, and need for information among the label variants. Red light produced no significant difference in the perceptions of the manipulated nutrition label design between labels A and B. However, subjects in the blue and white lighting conditions perceived the labels differently. Label B which included contrasting colors in the nutritional label field under blue light produced a positive effect on consumer perception of the label information. A similar effect was found for the blue nutrition field B under the white light condition, suggesting a consumer preference for the blue nutrition label background in general compared to the red background. This finding suggests that contrasting and analogous color may influence consumer perception of information conveyed within labels based on the display lighting design.

Between subject effects were also found when comparing label perceptions based on lighting conditions (white, red, and blue). Of particular note were the differences in perceived brightness within label designs A versus B for blue light versus red lighting conditions. Participants found label A brighter under red light and label B brighter under blue light, which suggested label elements' interactions from contrasting colors introduced to label B under blue light produced measurable differences in consumer perception of the label. Under the control condition under which red and blue nutrition label backgrounds were compared, label B was perceived as offering additional information in spite of the only variability was the background color of the nutrition label. The use of blue display lighting in meat departments may influence consumer perceptions of food label elements through analogous and contrasting colored label elements and may be useful for differentiating meat products to shoppers. Packaging designers' attention to the confluence of store lighting and packaging may provide a basis for product differentiation and revenue maximization in future store atmospherics and assortments. However, appearance of meat products in traditional deli packaging may not be enhanced under blue light for products such as beef steak and product appearance may more strongly influence purchase intentions than packaging designs. In enclosed packages such as cartons, the relationship of lighting design and label messages remain a key concern and highlight the need for additional research.

In addition to identifying label and lighting interaction effects found in this study, LED lights remain cool compared to thermal effects from older fluorescent and metal halide technologies while reducing energy costs. LED lighting systems with substantial color variability will increase in importance and use in retail store lighting designs in the future. Study of targeting LED lighting effects' (e.g. red, green, blue) influence on consumer perception of retail products offers industry opportunities to improve health communications, safety concerns, or support other retailer marketing communications. However, this research area remains largely unexplored in the literature for the most important factor in human health, food products. This study provided some interesting preliminary evidence of effects from colored lights on label perceptions between and among consumers measuring a key source of information about food nutrition labels.

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