EFFECTS OF PROMOLUX PLATINUM LED ON SHELF-LIFE OF GROUND BEEF PATTIES

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Abstract- The objective of this study was to determine the effects of three light sources, Promolux platinum LED (PPLED), fluorescent (FLS) lighting, and no light (control), on shelf-life properties of ground beef patties. Treatments were evaluated for % drip loss, pH value, % moisture content, visual and instrumental color (L*, a* and b* values), lipid stability (TBARS), aerobic plate count, yeast/mold, *Escherichia coli*, *Salmonella* spp. and *Listeria* spp. every 3 days for 9 days. Results showed that % drip loss was lower in the control treatment (6.72%) at day 9. No difference (P>0.05) was found in visual color appraisal between treatments based on evaluations by trained color panelists (N=7) from days 1 to 5. The redness a* value was slightly greater in the beef patties under PPLED lighting (8.16) than FLS (7.11) at day 9. The control treatment exhibited lower TBARS values (1.81 mg MDA/kg) than the remaining treatments over experimental period. At the end of display, the counts of APC in the beef patties under PPLED lighting (5.60 log CFU/g) were lower than FLS (5.77 log CFU/g). There was no yeast/mold, *E. coli*, *Salmonella* spp. and *Listeria* spp. found in this study from days 1 to 5.

Key Words – Light source, meat color, microorganism

I. INTRODUCTION

Color is an important factor in the marketing of meat because it influences consumers buying decisions [3]. During refrigerated display, fresh meat color changes and consumers discriminate against discolored meats [6]. Ground beef with an oxygen-permeable overwrapped film has a recommended shelf-life of 2-3 days [9]. The shelf-life of beef is of significant importance in the retail marketplace. Meat items with discoloration must be discounted or discarded, leading to up to $1 billion in revenue loss nationally for the meat industry [11]. Lighting type and intensity have a major impact on the appearance and shelf-life of fresh beef in refrigerated retail display [8].

Previous research [7] reported that beef short loin steaks stored in the dark at 27°F for 10 days changed only slightly in visual color, while steak kept under 120 foot-candles of soft whit fluorescent light discolored markedly after 5 days. Similarly results, demonstrated that beef display lighting at 254 nm and 3230 lux of UV radiation accelerates discoloration [4]. Therefore, newer technologies in lighting offer the ability to enhance meat color and to reduce other costly inputs for meat retail display. Promolux Platinum LED offers advantages for display because it is more energy-efficient and generates less heat than fluorescent lights. These advantages may be beneficial for fresh meat color stability. The objective of this study was to determine the effects of Promolux Platinum LED on visual and instrumental meat color and shelf-life properties of ground beef patties.

II. MATERIALS AND METHODS

Ground beef (80% lean and 20% fat) was obtained from the Center for Advancement of Meat Production and Processing (CAMPP) at McNeese State University in Lake Charles, Louisiana at 48 h postmortem. Beef patties (115 g) were made with a hamburger mold, placed in a foam tray with an absorbent pad, and wrapped with polyvinyl chloride (PVC) film. Patties were randomly assigned to three packaging treatments and stored in a 2.2°C cooler under three types of lighting conditions: 1) Control (no light), 2) FLS and 3) PPLED for 9 days. Three replicates of each treatment were analyzed for % drip loss, pH value, %

moisture content, visual and instrumental color (L*, a* and b* values), lipid oxidation (thiobarbituric acid-reactive substances (TBARS) protocol), aerobic plate count (APC), yeast/mold, *Escherichia coli* (*E. coli*), *Salmonella* spp. and *Listeria* spp. every 3 days for 9 days. Seven trained visual color panelists from McNeese State University evaluated beef patty color every 3 days for 9 days using hedonic 8-point scales unique to each product (1 = very bright red, 2 = bright red, 3 = dull red, 4 = slightly dark red, 5 = moderately dark red, 6 = dark red to tannish-red, 7 = dark reddish-tan, 8 = tan to brown). Moisture content was determined according to the method of [2]. Each 3 g sample was dried in an air oven (Model 26 Precision Thelco) at 102°C for 24 h. The total moisture content was determined by dividing the difference between the pre-dry and dry weights and dividing pre-dry weight. Drip loss (%) was calculated as the difference of final sample weight and initial sample weight divided by the initial weight for ground beef patties. Instrumental color was determined following the American Meat Science Association protocol [1]. On each sampling day, each package was opened and exposed to the air for a maximum of 10 seconds. Color was measured at three different locations and was averaged to obtain single values for each sample using a Minolta spectrophotometer (Model CR-10 portable) with an 8 mm aperture, 10° observer angle, D65 illuminant source in terms of L* (100 = white, 0 = black), a* (+40 = red, -40 = green), b* (+40 = yellow, -40 = blue). The 2-thiobarbituric acid (TBARS) method was used to measure the lipid oxidation for each sample designated for TBARS analysis [13]. Thiobarbituric acid reacts with the oxidation products of fat to form malonaldehyde, which was measured on a spectrophotometer in solution (Model 333182 Spectronic 20^{+}) at 530 nm). The TBA value was expressed by the mg malonaldehyde (MDA)/kg tissue. The microorganisms were determined following the standards of the Association of Official Analytical Chemists [2]. Buffered peptone water (BPW) was added as a diluent option for serial dilutions. All samples were plated on 3M™ Petrifilm to determine the enumeration (log CFU/g) of APC, yeast/mold and *E. coli*. *Salmonella* was isolated with xylose lysine deoxycholate (XLD) agar and ACTERO™ *Listeria* enrichment media agar was used for *Listeria* spp. Plates were incubated in a horizontal position, clear side up in stacks of no more than 20 plates at 37°C for 24-48 h. Results were obtained by selecting a countable plate (30-300 colonies) and the colonies were counted and reported as CFU/g. The Proc GLM procedures of SAS windows [10] were used to evaluate the significance of differences of the obtained data. The PDIFF option of LSMEANS was employed to determine significance among treatments. All data are presented as means with standard deviation (SD) and a significance level of $P<0.05$ was used for statistical analysis of means from treatments.

III. RESULTS AND DISCUSSION

Using the hedonic scale, seven trained visual color panelists from McNeese State University evaluated beef patty color every 3 days for 9 days (Fig. 1). No difference ($P>0.05$) was found in visual color appraisal between treatments based on evaluations by trained color panelists from days 1 to 5. Specifically, the average color scores ranged from 3.27 to 3.87 (dull red) at day 5. The discoloration of beef patty under PPLED and FLS had increased and showed similar results with a scores of 8.0 (tan to brown) at day 9.

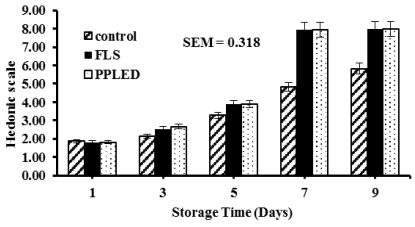


Figure 1. Least squares means for hedonic scales from trained panelists of beef patty at 2.2°C for 9 days

The percent drip loss of the beef patties was affected ($P<0.05$) by lighting treatments and storage time (Fig. 2). All treatments increased in % drip loss ($P<0.05$), but were lower in the control (6.72%) at day 9. This was due to the

absorption of energy generated by display lighting causing elevated temperatures at the meat surface leading to discoloration of displayed red meat [5].

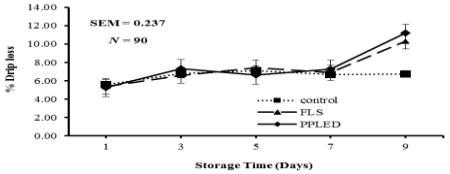


Figure 2. Least squares means for drip loss (%) of beef patty at 2.2°C for 9 days.

Similarly, the pH values for all treatments decreased (P<0.05) with storage time (Fig. 3). Specifically, our results showed that they were lower (P<0.05) in the beef patty under FLS lighting (7.38) than PPLED (7.46) at day 9.

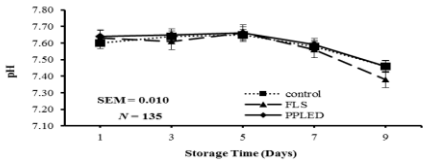
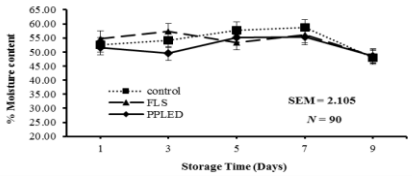


Figure 3. Least squares means for pH value of beef patty at 2.2°C for 9 days

The initial moisture content of the beef patties was 51.60%-54.82% (Fig. 4). For all treatments, no difference (P>0.05) were found for moisture content. The moisture content was similar and showed decline from days 1 through 9.



Fgure 4. Least squares means for moisture content (%) of beef patty at 2.2°C for 9 days

Over a 9 day experimental period, lighting type had an effect (P<0.05) on the instrumental color in terms of redness a* and yellowness b* values (Table 1). No difference (P>0.05) was found in the lightness L* values for all treatments. The redness a* and yellowness b* values declined during the experiment regardless of lighting technique. The redness a* value was slightly greater in the beef patties under PPLED (8.16) lighting than FLS (7.11). Compared with the yellowness b* value, samples under FLS (12.64) lighting had lower values than PPLED (13.07).

Table 1 Least squares means for HunterLab L*, a*, and b* values of beef patties at 2.2°C for 9 days

Parameter/	Storage time (d)				
Treatment	1	3	5	7	9
L* value					
Control	47.29^{a}	47.43^{a}	49.24^{a}	49.57^{a}	44.78^{a}
FLS	49.33^{a}	48.01^{a}	49.44^{a}	51.70^{a}	42.56^{a}
PPLED	45.77^{a}	47.83^{a}	48.60^{a}	51.69^{a}	41.71^{a}
a* value					
Control	26.78^{a}	26.53^{a}	21.92^{a}	19.57^{a}	16.39^{a}
FLS	25.47^{a}	24.56^{a}	20.48^{a}	9.14^{b}	7.11^{b}
PPLED	27.64^{a}	23.88^{a}	20.64^{a}	9.32^{bc}	8.16^{bc}
b* value					
Control	17.56^{a}	17.38^{a}	15.39^{a}	15.20^{a}	12.92^{a}
FLS	17.72^{a}	16.71^{a}	15.06^{a}	12.82^{b}	12.64^{a}
PPLED	17.81^{a}	16.09^{a}	14.87^{a}	12.62^{bc}	13.07^{a}

^{a,b,c}LSMeans with different superscripts within a same column is significantly different (P<0.05).
SEM for L* value = 0.972, SEM for a* value = 0.712, SEM for b* value = 0.346

As expected, TBARS values increased (P<0.05) throughout the storage time (Fig. 5), which is similar to the previous studies [12]. However, control treatment exhibited lower TBARS values (1.81 mg MDA/kg) than the remaining treatments at day 9.

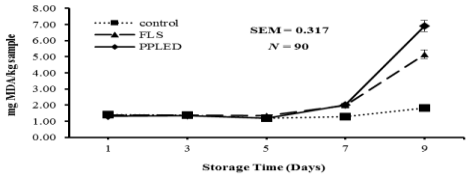


Figure 5. Least squares means for TBARS (thiobarbituric acid-reactive substances) values of beef patty at 2.2°C for 9 days.

The microorganism populations increased as display time increased for beef patty (Table 2). Specifically, the counts of APC in the beef patties under PPLED lighting (5.60 log CFU/g) were lower than FLS (5.77 log CFU/g). At the end of display, the beef patty under FLS lighting had lower number of *E. coli*, *Salmonella*, *Listeria* and yeast/mold as

compared to PPLED. No *E. coli*, *Salmonella*, *Listeria* and yeast/mold found in this study from days 1 to 5.

Table 2 Least squares means for microorganisms of beef patties at 2.2°C for 9 days.

Bacteria	Treatment	Storage time (d)				
		1	3	5	7	9
APC	Control	3.30[a]	3.39[a]	3.00[a]	4.29[a]	4.87[a]
	FLS	3.20[a]	3.50[a]	4.76[b]	4.83[ab]	5.77[b]
	PPLED	3.00[a]	4.24[b]	4.78[b]	4.99[b]	5.60[b]
E. coli	Control	ND	ND	ND	ND	ND
	FLS	ND	ND	ND	1.67[a]	3.82[a]
	PPLED	ND	ND	ND	2.13[b]	3.59[b]
Salmonella	Control	ND	ND	ND	4.25[a]	5.18[a]
	FLS	ND	ND	ND	5.59[b]	6.59[b]
	PPLED	ND	ND	ND	5.53[b]	7.18[c]
Listeria	Control	ND	ND	ND	3.90[a]	3.99[a]
	FLS	ND	ND	ND	5.30[b]	5.79[b]
	PPLED	ND	ND	ND	5.30[b]	5.99[c]
Yeast/mold	Control	ND	ND	ND	3.31[a]	4.18[a]
	FLS	ND	ND	ND	4.60[b]	5.60[b]
	PPLED	ND	ND	ND	4.49[c]	6.00[c]

[a,b,c]LSMeans with different superscripts within a same column is significantly different ($P<0.05$).
ND = nondetectable. SEM for APC = 0.208, SEM for *E. coli* = 0.050, SEM for *Salmonella* = 0.013, SEM for *Listeria* = 0.004, SEM for yeast/mold = 0.013.

IV. CONCLUSION

Our preliminary finding suggests that PPLED lighting is an effective light source for maintaining color stability.

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