Alternatives in Retail Display Lighting

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Why Explore Alternatives?

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(http://www.lrc.rpi.edu/programs/solidstate/assist/pdf/ar-colorguideforretaillighting-march2010.pdf)

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British study (2012) estimates that 2% of meat is rejected due to discoloration
(http://www.eblex.org.uk/wp/wp-content/uploads/2013/04/effects_of_losses_in_meat_chain_report_dec-2011-Report.pdf)

Fresh Meat Sales

Retail fresh meat prices increasing……so, consumers purchasing less

Nielsen Survey
41% consumers buying fresh meat less often due to higher prices
37% buying less-expensive cuts to offset increased $$

http://www.meatpoultry.com/articles/news_home/Trends/2015/05/Retail_woes_for_beef.aspx?ID=%7B93B11339-111B-451E-A6A8-71D049B45056%7D&cck=1

"If there's only one package of ground beef, even if it looks fine, but the rest of the case is rummaged over, you might think twice about picking up the very last package," he says. "Whereas, if it were Rice Krispies®, you'd think nothing of it because they're all exactly the same."
Kyle Miller, CAB executive account manager and chef
http://www.cattletoday.com/archive/2009/July/CT2000.shtml

 (Kropf, 1993, Djenane et al. 2001)

Factors Influencing Display Color

Once meat is in retail display, several factors influence fresh meat color

Display implies that meat is under lighting in a retail case, not in the dark such as in a storage cooler

- Muscle color stability
- Packaging: O_2 permeable or MAP (Raines 2008)

- Storage temperature: Lowering display color 3-5°C will retard discoloration (MacDougall and Taylor 1975)
- Surface microbial growth
- Lighting type (Kropf 2010)

Lighting Type

Plays a critical role in pigment photooxidaton by catalyzing MetMB formation (Renerre and Labadie 1993)

Incandescent

Tungsten Filament

Fluorescent (FLS)

Ultraviolet (UV)

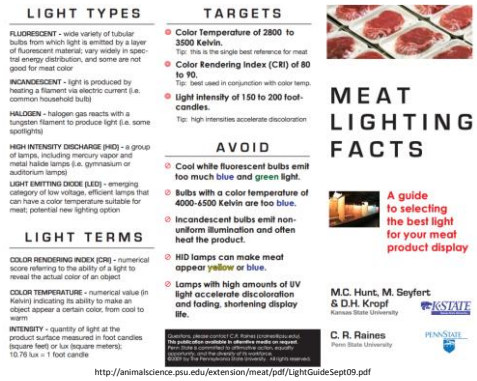
Light Emitting Diode (LED)

History-Does Light Discolor Meat?

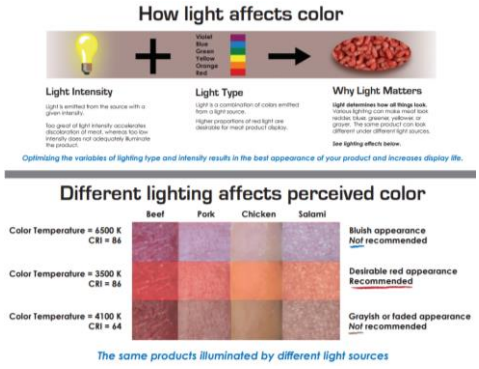
Product	Outcome	Year	Author
Fresh Meat	No difference with exposure to light or dark	1951 1954	Ramsbottom et al. Kraft & Ayres
	Not materially discolored up to 3 days, but may discolor with longer display	1954	Watts
Fresh Beef	Discoloration	1967	Marriott et al.
Frozen Beef LD & PM	Discoloration	1970 1976	Santamaria Leising
Frozen Beef	Progressive deterioration with display time	1972 1972	Fry Schafer
Lamb leg roasts	Became darker under 82 fc incandescent compared to dark	1972	Jeremiah et al.
Vacuum packaged rib chops	Color advantage up to 14 d when stored under light compared to dark	1972	Jeremiah et al.

Adapted from Kropf 1980

Kropf (1980) concluded:
"Light affects muscle pigment state & color, but the eye may not be sensitive enough to detect these changes early in display"



http://animalscience.psu.edu/extension/meat/pdf/LightGuideSept09.pdf



History: Effect of Ten Commercial Light Sources on Color of Frozen Beef Muscles

Light Source	Color Balance[a]	Color Stability[b]
Deluxe Warm White (Slight yellow fat color)	++	+
Grolux Wide Spectrum	++	++
Incandescent Fluorescent (slight yellow fat color)	++	++
Standard Grolux (too red, misleading)	+++	+
Deluxe Cool White	-	0
Verda-ray	++	0
Cool White	--	-
Soft White	-	-
Incandescent Holophane (Uneven intensity)	++	0
Cool Beam (Uneven intensity)	++	0

[a]Color Balance +++ reddest, ++ excellent, + good, - poor, -- exceptionally poor
[b]Color Stability ++ best, + good, 0 fair, - poor

From Kropf 1980

Light Emitting Diode Lighting

- 1960's: First commercial production
- Higher efficacies than incandescent and FLS
- Longer operating life, lower operating temperatures, and lower maintenance costs

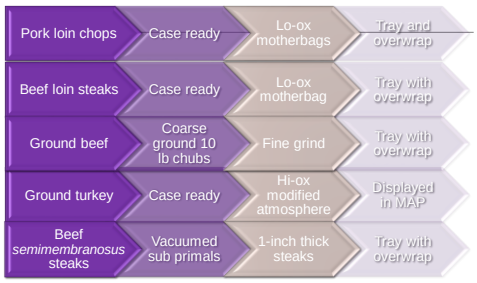
(DOE, 2009; Arik & Setlur, 2009; DOE, 2008)

Shelf Life of Five Meat Products Displayed Under Light Emitting Diode or Fluorescent Lighting

Determine the effects of LED and FLS lighting on fresh meat color and shelf-life properties of five fresh meat products displayed in two retail display cases running at similar temperature profiles

(Steele 2011)

Study Design



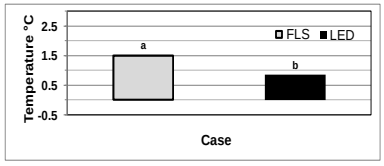
Experimental Design

(Photo courtesy of Dr. M. C. Hunt)

Analyses

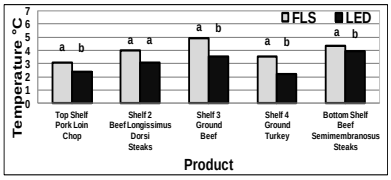
Initial pH	Visual color
Gas concentrations	Instrumental color
Condenser cycling	Odor
Case temperature	Oxidative Rancidity (TBARS)
Internal product temperature	APC & EB

Case Temperature Pooled from 30 locations



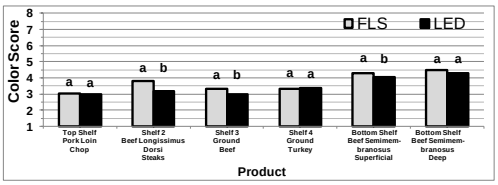
[ab] Lsmeans with different superscript letters differ (P<0.05). Standard error = 0.40.

Internal Product Temperature



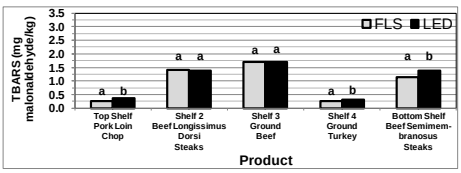
[ab] Lsmeans within each product having a different superscript letter differ (P<0.05). Standard error: Pork loin chop = 0.08, beef *longissimus dorsi* steak = 0.82, ground beef = 0.81, ground turkey = 0.79, beef *semimembranosus* steak = 0.19.

Visual Color Scores



[ab] Lsmeans within each product having a different superscript letter differ (P<0.05). Standard error: Pork loin chop=0.03, beef *longissimus dorsi*=0.16, ground beef=0.10, ground turkey=0.05, beef *semimembranosus* superficial=0.08, beef *semimembranosus* deep=0.07.

Oxidative Rancidity (TBARS)



[ab] Lsmeans within each product having a different superscript letter differ (P<0.05). Standard error: Pork loin chop= 0.03, beef *longissimus dorsi* steak= 0.09, ground beef= 0.06, ground turkey= 0.02, beef *semimembranosus* steak= 0.06.

Summary

Less condenser cycling with LED lighting

Lower case and internal product temperatures under LED lighting

Less visual discoloration for beef products under LED lighting

Slightly less off-odor for pork chops under LED; lighting type did not affect off-odor for remaining products

For pork loin chops, ground turkey and beef inside round steaks, TBARS were slightly higher under LED lighting.

Conclusion

LED lighting will save retailers money through efficiency in operation and delaying visual discoloration particularly for fresh beef products

Ground beef color under FLS and LED lighting

Research from the University of Missouri

Dr. Bryon Wiegand and Dr. Carol Lorenzen

Control-no light exposure

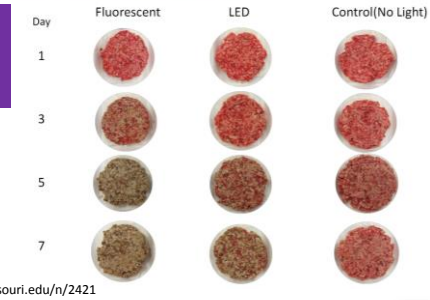
Red color retained better in Control

Ground beef under LED turned brown slower than under FLS

http://extension.missouri.edu/n/2421

Retail Display Lighting Changes Ground Beef Color

Change in ground beef color under FLS and LED lighting



http://extension.missouri.edu/n/2421

LED and Frozen Beef Color Stability

Research from the University of Wisconsin

Dr. James Claus and Michael O'Halleran

Evaluated color stability of pre-bloomed (air or pure O_2) vacuum packaged beef strip loin steaks displayed frozen under LED and FLS

Design: Steaks allowed to bloom packaged in PVC (air bloomed) or in a vacuum package injected with 100% O_2 (oxygen bloomed).
After bloom, steaks removed from packaging, and repacked using vacuum, then frozen and stored in dark for 6 days.
Displayed in open top freezer case under LED or FLS.

http://minds.wisconsin.edu/handle/1793/48520

Conclusions

LED extended color stability of oxygen bloomed steaks compared to FLS

UV radiation was not the sole reason for photooxidation of myoglobin in frozen beef, and energy spectrums of display lighting plays an important role

UV Lighting

UV encourages metmyoglobin (MMb) formation

UV-C has shorter wavelength than UVA or UVB
- Used for disinfecting/sanitizing

MMb is dependent on the light intensity and wavelength distribution, in combination with the light permeability of the packaging material.

UV light produced serious discoloration in product displayed at 5°C and even at 0°C (Hood 1980)

Even a short exposure to UV light was found to be detrimental to meat color (Renerre 1990)

http://www.meatupdate.csiro.au/UV-light.pdf

http://www.foodsafetynews.com/2014/01/pasteurization-does-ultraviolet-mean-ultrasafe/#.VXILQNJVhBc

UV Lighting: Safety vs Display

Elimination of UV radiation by using either the UV filter or a low-UV lamp can significantly extend the display life of meat, to one similar to that of meat held in the darkness (Djenane et al 2001)

"Use of ultraviolet lamps to slow growth of bacteria, and to delay the onset of microbial spoilage of meat, may actually shorten the meat's retail display life. Even the smallest amount of UV radiation should be avoided in lighting devices for the retail display of fresh meat. Where UV lights are used in holding chillers to extend the storage life of carcasses and primal cuts, it is important to replace the tubes after the time specified by the suppliers. In most situations they should be replaced at least annually. If they are not, their bactericidal effectiveness will have dramatically diminished but they will continue to have a detrimental effect on meat colour."

http://www.meatupdate.csiro.au/UV-light.pdf

What is Next?

Continue to explore LED
- Is there an effect of LED on lipid oxidation of meats containing less myoglobin such as poultry and pork?

What can be done to increase display life if UV is used as an antimicrobial?