

Alternatives in Retail Display Lighting

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SIXTY-EIGHTH
RMC
RECIPROCAL
MEAT CONFERENCE



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Why Explore Alternatives?

“Color is not a physical property of objects, but rather a human perception enabled by light”

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



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British study (2012) estimates that 2% of meat is rejected due to discoloration

(http://www.abn.co.uk/wp-content/uploads/2013/04/reflect_of_bone_in_meat_chain_report_dec-2012-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=7893&1189-1118-451E-46A8-71D049845056%7D&ck=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/CI2000a.html>



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: O₂ 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 photooxidation by catalyzing MetMb formation (Renner 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	Ramsbottom et al.
		1954	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	Santamaria
		1976	Leising
Frozen Beef	Progressive deterioration with display time	1972	Fry
		1972	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.

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

LIGHT TYPES

FLUORESCENT - wide variety of tubular bulbs from which light is emitted by a layer of fluorescent material, very widely in spectral energy distribution, and some are not good for meat color.

INCANDESCENT - light is produced by heating a filament via electric current (i.e. common household bulb).

HALOGEN - halogen gas reacts with a tungsten filament to produce light (i.e. some spotlights).

HIGH INTENSITY DISCHARGE (HID) - a group of lamps, including mercury vapor and metal halide lamps (i.e. common on auditorium lamps).

LIGHT EMITTING DIODE (LED) - emerging category of low voltage, efficient lamps that can have a color temperature suitable for meat, potential new lighting option.

LIGHT TERMS

COLOR RENDERING INDEX (CRI) - numerical score referring to the ability of a light to reveal the actual color of an object.

COLOR TEMPERATURE - numerical value (in Kelvin) indicating its ability to make an object appear a certain color, from cool to warm.

INTENSITY - quantity of light at the product surface measured in foot candles (square feet or lux (square meters): 10 lux = 1 foot candle).

TARGETS

• Color Temperature of 2800 to 3500 Kelvin.

• Color Rendering Index (CRI) of 80 to 90.

• Light intensity of 150 to 200 foot-candles.

*Tip: high intensities accelerate discoloration.

AVOID

• Cool white fluorescent bulbs emit too much blue and green light.

• Bulbs with a color temperature of 4000-6500 Kelvin are too blue.

• Incandescent bulbs emit non-uniform illumination and often heat the product.

• HID lamps can make meat appear yellow or blue.

• Lamps with high amounts of UV light accelerate discoloration and fading, shortening display life.

• Cool white fluorescent bulbs emit too much blue and green light.



MEAT LIGHTING FACTS

A guide to selecting the best light for your meat product display

M.C. Hunt, M. Seyfert & D.H. Kropf
Kansas State University

C. R. Raines
Penn State University

How light affects color



Light Intensity

Light is emitted from the source with a given intensity.

The greater the light intensity, the greater the discoloration of meat, whereas too low intensity does not adequately illuminate the product.

Light Type

Light is a combination of colors emitted from a light source.

Higher proportions of red light are desirable for meat product display.

Why Light Matters

Light determines how all things look.

Meat lighting can make meat look unappealing (blue, greenish, yellow, or grayish). The same product can look different under different light sources.

Use lighting effects wisely.

Optimizing the variables of lighting type and intensity results in the best appearance of your product and increases display life.

Different lighting affects perceived color



The same products illuminated by different light sources

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

^aColor Balance +++ reddest, ++ excellent, + good, - poor, -- exceptionally poor
^bColor 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



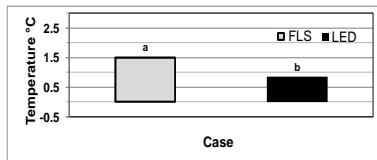
68TH RECIPROCAL MEAT CONFERENCE (Photo courtesy of Dr. M. C. Hunt)

Analyses

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

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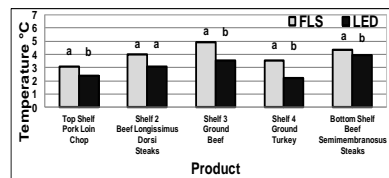
Case Temperature Pooled from 30 locations



^{ab} Lsmeans with different superscript letters differ (P<0.05). Standard error = 0.40.

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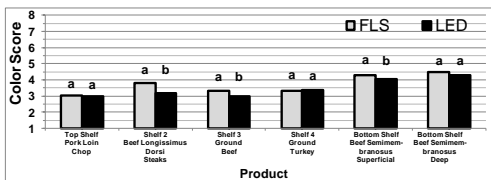
Internal Product Temperature



^{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.

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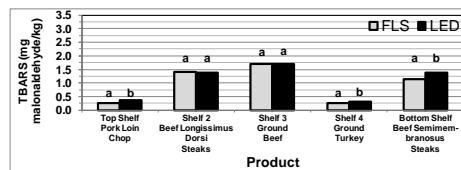
Visual Color Scores



^{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.

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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.

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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

Day	Fluorescent	LED	Control (No Light)
1			
3			
5			
7			

<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 O₂) 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% O₂ (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/#VXILQNVh8c>



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?

