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Meat Display Lighting

Introduction

The key to retail meat display is to present pork products in an attractive and saleable format. Effective sales depend on fresh appearance, acceptable product quality with an absence of abnormal traits including an unattractive color, excess drip (purge) in the package or dehydration. The role of lighting is to show the true quality of the pork product, without detracting from appearance or deceiving the customer about product quality. Lighting can speed up product discoloration but is essential for marketing and presentation of pork, both for traditional and for case-ready sales. The ESSENTIAL PHILOSOPHY is that satisfied customers are REPEAT and loyal customers. Display is defined as the offering of product under lighting in the retail case, usually under refrigeration. Display is not the same as storage, which implies keeping the product in the dark and usually not for sale. Some use the term storage when they really mean display.

This fact sheet discusses how lighting influences the perceived color of and quality of pork products.

Does Lighting Affect Discoloration?

Not all reports agree on whether light exposure causes meat discoloration. Most work in this area has been done with beef, as it's greater myoglobin content and more intense color makes it easier to see and characterize color changes. However, the results with beef can be used to help understand possible effects on pork.

Ramsbottom et al. (1951) found fluorescent lighting at 60 to 200 foot-candle intensity resulted in no loss of beef

color during 3-day display. Kraft and Ayres (1954) observed a steady change in color of fresh beef from bright red to dull red during 2 days exposure of fresh beef to 30 to 40 foot-candles of fluorescent light. Marriott et al. (1967) found beef short loin steaks stored in the dark at 27°F for 10 days changed only slightly in visual color. Steaks kept under 120 foot-candles of soft white fluorescent light discolored markedly after 5 days and continued to become progressively less desirable with

longer display. Steaks stored in the dark for 3, 5, or 7 days prior to display showed display life similar to those placed in display without any prior storage time.

Gould (1963) reported pork discoloration under lighting to be related to warmer product surface temperature, but light intensities that did not raise surface temperature did not affect discoloration of fresh pork chops.

Cured meat is very vulnerable to oxygen in the package and presents a different situa-

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tion than fresh meat.

Andersen et al., (1988) concluded that storing vacuum packaged ham in the dark for four days reduced in-package oxygen which resulted in excellent color stability when the product was displayed. Managing the cured product under this scenario helped overcome the undesirable effects that oxygen can have when products are exposed to display light.

Effects of Type of Lighting

Light types include incandescent, fluorescent, and metal halide which includes mercury vapor and high intensity sodium. Fluorescent lights vary widely in their influence on appearance of meat and their effect on display life and therefore should always be further identified by the special name of the lamp.

Display lighting effects on the appearance or rate of discoloration of meat could result from: 1) temperature elevation at the meat surface, 2) photochemical effects, and/or 3) differences in color rendition because of different spectral energy distribution patterns.

Temperature Elevation: Radiant heat from intense display lighting increases the

temperature on the meat surface. Temperature of the meat surface increases proportionally with increased light intensity under both incandescent and deluxe cool white fluorescent lights. An estimated 1°F temperature rise has been reported for each 10 foot-candles of incandescent lighting for display cases with a 70 cubic feet per minute air velocity. Higher temperatures at the meat surface speed up deteriorative influences on meat color such as oxidation and microbial metabolism and thus, temperature effects are critical. Deluxe fluorescent lights radiate about one-fifth as much heat as incandescent lamps. Other specially designed lamps also radiate much less heat than incandescent, for equal foot-candle intensities of lighting.

Recent studies on cold chain variables indicate that there are benefits to maintaining ground beef at 32°F (Mancini, 2001) during storage and display. This is in agreement with one major packer supplier of meat who emphasized critical importance of keeping temperatures no warmer than 32°F. Storage at 32°F, rather than at higher

temperatures, carries over into longer display life, even when the product is displayed under warmer temperatures.

Photochemical Effects: Photochemical effects are caused by certain wavelength energies that excite one or more molecules and initiate or catalyze such reactions as oxidation which leads to a change in the meat pigment, myoglobin, causing discoloration. Wavelengths that are absorbed cause photochemical effects, resulting in greater "destruction" of heme pigments, but wavelengths that are primarily reflected should have produce less of a photochemical effect. Fluorescent light sources are frequently characterized by spikes of energy emission at certain wavelengths. Proteins, including meat pigments, are characterized by Soret bands, certain wavelengths at which light is strongly absorbed. If the wavelengths from an energy source (in this example, fluorescent lights) happen to be the same as the wavelengths of the Soret bands for myoglobin (the protein referred to as meat pigment), undesirable effects

on meat color can result. For many years, ultraviolet wavelengths were stated to result in photo-oxidation, but little evidence was available to support this hypothesis. Ramsbottom et al. (1951) reported that ultraviolet from a 60 foot-candle light exposure caused discoloration that was not caused by other components of fluorescent light. Bertelsen and Skibsted (1987) reported on the comparative effects of certain wavelengths upon photo-oxidation of solutions of oxymyoglobin. Their work provided convincing evidence that ultraviolet wavelengths strongly encourage discoloration. Therefore, reducing the amount of ultraviolet wavelengths that come in contact with the actual surface of the meat product can result in improved display life. Two ways to accomplish this objective are to use an ultraviolet barrier in the packaging film and/or commercial lamps that are designed to have reduced emission of ultraviolet wavelengths.

Color Rendition: Color rendition means how closely the spectral energy distribution of the lighting matches the color (light reflecting pattern) of the meat. Light sources with

a closer "fit" to the reflecting pattern for a meat product will come closer to bringing out the true appearance of that product. Light sources that have relatively low emission in the red part of the spectrum and high emission in the blue part will result in an undesirable, bluer, less red pork cut color. Conversely, a display light producing too high of a proportion of red emission may contribute to a deceptively red appearance of meat. Unhappy customers may not return to a store if they feel they have been deceived.

Barbut (2001) noted that beef inside round steak appeared more red under incandescent lighting than fluorescent (specific information not given) or metal halide lighting, with each used at a 70 foot-candle (760 lux) light intensity. The same trend was true for pork chops and skinless chicken breast but was less pronounced because these products contained lower concentration of myoglobin.

Light sources are characterized by several systems as to their color rendering properties. Color rendering index (CRI) is based on emissions

at eight specific wavelengths and is a widely accepted system. Since some of the wavelengths do not relate well to meat color, this system has limited value in describing appropriate meat display lighting, even though the Lighting Handbook (IESNA, 2001) suggests use of fluorescent lamps with high CRI plus a "strong content of red wavelengths". Work in the author's laboratory has found color temperature, in degrees Kelvin, to be a more meaningful indicator of recommended display lighting. A rather wide range of degrees Kelvin, from 2600 (describing a warm light with a higher proportion of red) to 4200 (describing a colder appearing, bluer, less red light), is appropriate for meat display lighting. However, more ideal results are achieved between 2900 and 3750.

Measured watts and percentage of the total wattage in each of six sections of the visible light spectrum, plus ultraviolet and far red, are identified for nine light sources (Kropf, 1980). That data shows incandescent to be lower in blue and green, while cool white, deluxe cool

white and deluxe warm white were higher in green. Yellow ranged from 2.3% for standard grolux to 18.3% for cool white. Red emission has an important bearing on meat color, and this ranged from 8.5% for cool white to 41.6% for Standard grolux. These two light sources respectively range from very poor to misleadingly red for red meat. Studies have shown good color rendition for lamps with 21.4 to 34.4% red. Such information may not be readily available, but bulb manufacturers should make color temperature (degrees Kelvin) available.

Red or pink muscle appearance are usually a priority, but a light such as soft white will cause a pinkish appearance of fat and bone, while deluxe warm white and incandescent contribute to a yellowish color of fat and bone. Even a slight yellowish tinge to fat color presents a severe marketing problem.

Effects of Specific Light Wavelengths

A number of studies summarized by Kropf (1980) have attempted to determine effects of specific regions of the color spectrum upon meat

color stability. Results vary widely with some studies reporting an undesirable influence of green, blue, yellow or orange wavelengths on meat color. Archer and Bandfield (1950) filtered out low 400 nanometer (violet and blue) wavelengths which delayed the onset of discoloration.

Effects on Pork of Specific Type of Display Lighting

Studies on effects of lighting on fresh pork are few in number. One project studied one-inch thick fresh pork chops from each of four pork loins of normal color displayed at 34°F and 200 foot candles for 18 hours before evaluation of color. The chops were placed on foam white trays and wrapped with an oxygen permeable film and displayed under deluxe cool white fluorescent light, cool white Surlyn coated fluorescent lights, warm white fluorescent lights or cool flood incandescent light. Panelists evaluated the loin eye muscle of the chops for color desirability. Chops under deluxe cool white were rated most desirable, followed by cool flood incandescent. The least desirable color rating resulted from the other two types of

lights (Calkins et al., 1986).

A second phase of the study used 40 frozen pork loin chops. All of the chops were in retail display under the same four light sources for five days, but were subdivided into 12 or 24 hour per day light exposure. Chops under the cool flood incandescent lights had the most rapid increase in metmyoglobin, resulting in a more undesirable color. This type of light also generated enough heat to elevate the surface temperature of the chops from 3.6 to 14.4°F. This temperature increase, which was not observed for the other light sources, could be responsible for the accelerated rate of metmyoglobin formation. Under the cool flood incandescent lights, the percentage of oxymyoglobin, the desirably colored pigment on the surface of the chops, decreased from 63 percent at 12 hours to 40 percent after five days. This decrease was compared to a change from 73 percent initially to 63 percent for chops under the other lights at 12 hours display time.

Another research study used loin eye samples from seven pork loins to determine

display color stability when packaged in oxygen permeable polyvinylchloride (PVC) film or when packaged under vacuum in an oxygen barrier film. All chops were visually evaluated by four experienced evaluators under their assigned display light which included GE Natural, Sylvania Grolux Wide Spectrum, NAFA, Sylvania Incandescent Fluorescent, GE Deluxe Warm White, GE Deluxe Cool White or GE Cool White. All chops were also evaluated under one common light source, GE Deluxe Warm White. The first five light sources listed match the color reflectance of the pork muscle quite well. Deluxe cool white is a slightly cooler, bluer light. cool white, a light widely used for general store lighting, is very cool and blue for pork display. No visual differences were noted between lights when samples were evaluated under the common light source or reflectance measurement differences. This means the lights did not differ in photochemical effect, but the different color scores were due solely to color rendition. Similar results were found when vacuum packaged pork chop muscles were eval-

uated (Kropf et al., 1987).

Other Studies About Type of Lighting

Ten different light source effects on color stability of frozen beef longissimus and psoas major (tenderloin) were compared when displayed under 100 foot candles at either -5 or -15°F and visually scored at 0 time and after 1, 3, 7, 21, and 35 days of display. Color scoring was done under the display lighting and also under deluxe cool white and incandescent lamps to visually determine if differences were due to color rendition or "real color deterioration". Fewer color differences were noted when all were evaluated either under deluxe cool white or incandescent, and brighter color was found under incandescent. Generally, less desirable color was noted for lights with a higher color temperature (Fry, 1972).

Thirty different light sources were evaluated for "typicalness of beef color" compared to color under a 3200° Kelvin (3200 K) reference light source by eight experienced panelists for both longissimus (rib eye, a whiter muscle) and psoas major (ten-

derloin, a redder muscle), packaged in oxygen permeable film or vacuum packaged in an oxygen barrier film. Most notable was a too red color for Sylvania Standard Grolux and GE Plant Light. A too blue or dark color was scored under Cool White and Daylight. Other light sources performed relatively well for the bright red color in the PVC film and for the purplish red color of the vacuum packaged steaks.

Display life comparisons of effects of thirteen light sources on both packaging systems found lamps with reasonable color to cause similar display life, both by visual scores and reflectance measurements (Kropf et al., 1992).

Lamp technology is changing rapidly so that consultation with lamp manufacturers or with the Lighting Handbook (IESNA, 2001; Glass et al, 1984) is advocated. Efficiency of converting electric power into light energy is very important and becomes more so as energy costs rise or electrical shortages occur. Tradeoffs between good color rendition and efficient lighting should

be guided by the perceived requirements for marketing meat products.

Many of the light sources named above have been replaced or modified. Table 1 shows a lamp summary from Philips, a commercial producer of lamps (bulbs).

Cured Color Fading

The Lighting Handbook (IESNA, 2001) indicates that fading of cured product is proportional to magnitude (intensity) times duration of light exposure and may begin at 200 foot candle hours. The Handbook suggests "no published data is available about which colors accelerate or reduce light induced fading or if filtering out ultra violet wavelengths affects fading of cured color." Lighting effects on wafer-sliced cooked and cured beef in a nitrogen flush package were studied (Schwab, 1981). Product fading was evaluated after 6, 12, 24, 48, and 72 hours of continuous display under deluxe warm white, supermarket white, incandescent fluorescent, or natural lamps at four lighting intensities and three display temperatures (34, 40, and 46°F). Product under supermarket white (a relative-

ly blue light of about 4100°K) consistently was visually scored as more faded (loss of pink cured color) but this was not confirmed by reflectance data. The visual differences could be due to poorer color rendition and actual fading may not have resulted.

Lighting Effects on Oxidation

Model studies using beef, lamb or pork myoglobin (Satterlee and Zachariah, 1972) led them to conclude that "low wavelength light" encouraged oxidation. Therefore, rate of discoloration would increase. But wavelengths of 625 nm or longer are less absorbed by oxymyoglobin, which means they would be less prone to promote discoloration. Iversen (1985) reported that film with all wavelengths below 550 nm blocked out was effective in slowing oxidation and discoloration, but this situation would present meat with a very red misleading color.

Display Lighting Intensity

Display lighting intensity can have an important influence on product display life. The effect of different intensi-

ties (100, 150, 200 and 300 foot candles) of display lighting on color fading of wafer sliced cooked and cured beef slices in nitrogen flush packages was studied (Schwab, 1981). Visual evaluation at 12, 24, 48 and 72 hours and reflectance measurements established that discoloration was closely related to foot-candle intensity times length of light exposure time. Chilled and frozen meat studies have found similar results.

In several surveys, light intensity over retail meat display ranged from 105 to 260 foot candles (Satterlee and Hansmeyer, 1974), from 22 to 350 foot candles (Rice, no date) and from 22 to 250 foot candles (Schwermann, 1979). Barbut (2001) reported meat display lighting in five surveyed meat counters to range from about 60 to 100 foot candles. More intense lighting is likely used now, partly because of use of multi-shelf meat display cases with lights at all levels. Use of high intensity lighting may result in more and faster meat sales, but if sales do not keep pace with discoloration, loss of profit may result.

TABLE 1 LAMP INFORMATION				
Lamp Name	Atmosphere	Light Output %	CRI	Kelvin Color Temp.
Daylight	Cool	83	79	6500
Cool White	Cool	100	67	4100
Deluxe Cool White	Cool	70	89	4200
Colortone 50	Cool	70	92	5000
SPEC 41	Cool	103	70	4100
Ultralume 41	Cool	105	85	4100
AdvantageX41	Cool	117	80	4100
White	Neutral	102	58	3500
SPEC 35	Neutral	105	73	3500
Ultralume 35	Neutral	105	85	3500
AdvantageX35	Neutral	117	80	3500
Warm White	Warm	102	53	3000
Deluxe Warm White	Warm	68	79	3000
Natural	Warm	66	81	3000
Ultralume 30	Warm	105	85	3000
SPEC 30	Warm	105	70	3000
AdvantageX30	Warm	117	80	3000
Soft White	Warm	68	79	3000
Ultralume 27	Warm	105	82	2700
Incandescent	Warm			2600 to 3100

Light output refers to efficacy of lamps to convert electricity to footcandles of light. CRI is Color Rendering Index. (Philips Lighting, 1988)

Summary

A number of lighting systems are satisfactory for pork display. Those with a color temperature of 2900 to 3750° Kelvin are most recommended. A display light intensity of 75 to 150 foot-candles is recommended. Marketing advantages of brighter display lighting must be weighed against more rapid color deterioration under more intense lighting.

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