COLOR STABILITY OF SUMMER SAUSAGE VACUUM-PACKAGED IN FILMS OF DIFFERENT OXYGEN TRANSMISSION RATES

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Background:

Summer sausage is a popular semi-dry, fermented sausage product in the United States. It is produced in various product diameters, made available in chub or sliced forms, and generally prepared from beef and pork or only beef depending on the processor. Protecting sliced cured meats, such as summer sausages, from oxygen is done by selection of the packaging material. With good microbial control, the first failure point in the shelf life of cured meats is generally loss of color from the oxidation of nitrosohemochrome. Lin et al. (1980), Yen et al. (1988), Andersen et al. (1990), Northcutt et al. (1990) and others have reported that low oxygen permeable films, known generally as "barrier films" are required for maintenance of cured color as measured by pigment and/or colorimetric methods.

Objectives:

The objective of this study was to determine the effect of oxygen transmission rate (OTR) of flexible packaging films on the rate of color fading for vacuum-packaged summer sausage. Films with OTRs providing stability against rapid color fading and films with OTRs not providing protection were included so that evaluations could be conducted in a rapid, short period of time.

Methods:

Fresh summer sausage chubs approximately 7 cm in diameter were sliced 3 mm in thickness, with each slice surface serving as a sample. Two slices (duplicates) were vacuum-packaged (72.4 cm Hg) in a flexible film pouch using a Turbovac packaging machine (Turbovac B.V., Netherlands). Six different films were utilized having the following oxygen transmission rates (OTRs): 4, 155, 2000, 4700, 7000 and 12,000 cc/m^2/24 hr at 23°C, 0% RH and 1 atm. Two packages representing each OTR were stored in the dark at 2 ± 1°C for 25 min and then initial color values (0 hour) were measured before they were removed from the dark environment. The packages were then placed on display under a continuous light intensity of 3175 lux (approximately 295 ft-c) for a total of 2.5 hr. The lighting was provided by Cool White fluorescent lights.

During the display period, surface color was measured at 30 min intervals. CIE L* (lightness), + a* (redness) and + b* (yellowness) values were measured at 5 randomly chosen spots on the surface of each slice using a Minolta Chroma Meter CR-300 (Minolta Corp., New Jersey). The CIE + a* and + b* values were used to determine sample chroma (CIE C*) which relates to color intensity and hue angle (CIE h*) which describes the color in the CIE L*a*b* color space. The Chroma Meter was calibrated using the manufacturer's white calibration plate and CIE Illuminant C was used as the source of illumination.

Statistical analyses consisted of determining the main effects of OTR of the packaging films and time (hr) of display and their interaction (OTR x time) on the color values by general linear model (GLM) analysis of variance (SAS, 1990), followed by conducting surface regression analysis with GLM (SAS, 1990) using the second order regression model (Khuri and Cornell, 1987): $y = B_o + B_1x_1 + B_2x_2 + B_{11}x_1^2 + B_{22}x_2^2 + B_{12}x_1x_2 + e$. In the model, y is the respective value of the specific color measure (L*, C* or h*), x_1 is the time (hr) of light display, x_2 is the OTR of the packaging film, B_i's are the respective regression coefficients and e is the random error.

Results and Discussion:

The OTR of the packaging film, time (hr) in light display and the OTR x time interaction were significant ($p<0.001$) factors affecting summer sausage color intensity (chroma, C*) and redness (hue angle, h*) as determined from general linear model analysis of variance. For lightness (L*), statistically significant effects were found due to film OTR and time, but not their interaction. The lightness change may have no practical meaning in detecting visible differences however because L* changes were, at maximum, only 1.5% of the 0 (black)-to-100 (white) CIE L* scale.

The regression coefficients (B_i's) from response surface regression analyses of the color data are given in Table 1. The second order model equation for lightness did not include the quadratic term for time x time as it was not significant ($p>0.05$). All other linear, quadratic and interaction coefficients were utilized in generating the surface graphs for L*, C* and h* (Figure 1). As the OTR of the packaging film increased, color loss for the slices of summer sausage was measured as a slight increase in lightness, a decrease in chroma or color intensity, and an increase in hue angle. The color loss is visually described as a shift from a red-maroon to a brownish-maroon to a grayish-brown. At the high light intensity utilized in this study to rapidly (2.5 hr) assess the effect of film OTR, only summer sausage packaged in film with an OTR of 4 cc/m^2/24 hr remained relatively unchanged. This was the only film OTR considered a true "barrier" film for restricting oxygen contact to the product surface.

Simple linear regression equations for the rate of color fading for L*, C* and h* of sausage packaged in the 155 to 12,000 cc films, with the respective coefficients of determination (R^2), are given in Table 2 and plotted in Figure 2. Excellent logarithmic fit was found for C* and h*. The lower the OTR of the packaging film, the greater the degree of protection of nitrosohemochrome from destruction by oxidation. Further study and testing would be necessary to establish minimums of packaging film OTR and maximums of color change where the summer sausage would remain acceptable to the consumer.

Conclusions:

The comparative color stability provided by films differing in OTR may be assessed in a short time (2.5 hr) when using high light intensity (3175 lux) and measuring the rate of surface changes in chroma (C*) and hue angle (h*). The results confirmed that decreasing the oxygen permeation of the packaging film by decreasing its OTR has a positive effect on the color stability of sliced summer sausage.

Literature:

Andersen, H.J., Bertelsen, G., Ohlen, A. and Skibsted, L.H. 1990. Modified packaging as protection against photo degradation of the colour of pasteurized, sliced ham. Meat Sci. 28:77.

Lin, H.S., Sebranek, J.G., Galloway, D.E. and Lind, K.D. 1980. Effect of sodium erythorbate and packaging conditions on color stability of sliced bologna. J. Food Sci. 45:115.

Northcutt, J.K., Bridges, W.C., Jr., Dick, R.L. and Acton, J.C. 1990. Kinetics of the light-induced color fading of vacuum-packaged turkey bologna. J. Muscle Foods 1:169.

Yen, J.R., Brown, R.B., Dick, R.L. and Acton, J.C. 1988. Oxygen transmission rate of packaging films and light exposure effects on the color stability of vacuum-packaged dry salami. J. Food Sci. 53:1043.

Table 1. Coefficients of regression (B_i) for CIE lightness (L*), chroma (C*) and hue (h*) of vacuum-packaged summer sausage as determined by response surface regression analysis

Regression[1]	L*	C*	h*
Intercept	53.270***	22.464***	30.158***
Linear:			
OTR	$-8.2x10^{-5}$***	$-3.8x10^{-4}$***	$7.06x10^{-4}$***
Hour	-0.4016***	-1.7921***	2.72886***
Quadratic:			
OTR*OTR	$1.06x10^{-8}$***	$2.78x10^{-8}$***	$-5.70x10^{-8}$***
Hour*Hour	0.03862^{ns}	0.5290***	-0.6927***
Interaction:			
OTR*Hour	$2.08x10^{-5}$**	$-1.04x10^{-4}$***	$2.35x10^{-3}$***

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; ^{ns} $p>0.05$

[1]Second order model as given in Methods.

Table 2. Simple linear regression equations for rate of change in lightness (L*), chroma (C*) and (h*) due to OTR of the packaging film

CIE Value	Regression Equation	
Lightness	L* = -0.64 + 0.13 log (OTR)	$R^2 = 0.84$
Chroma	C* = 0.99 + 0.61 log (OTR)	$R^2 = 0.99$
Hue	h* = -2.32 + 1.39 log (OTR)	$R^2 = 0.97$

Range of OTR: 155 to 12,000 cc/m²/24 hr at 23°C, 0% RH, 1 atm.

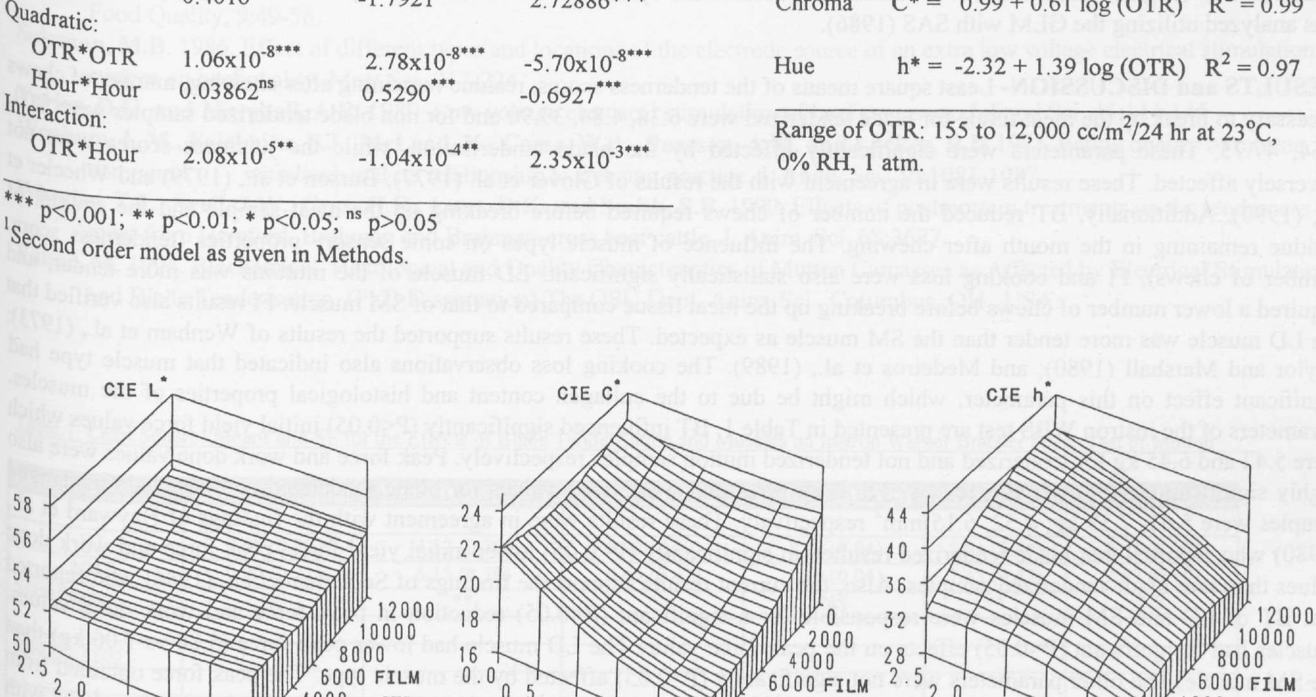

Figure 1. Response surface graphs for lightness (L*), chroma (C*) and hue angle (h*) of slices of summer sausage vacuum-packaged in films with OTRs of 4 to 12,000 cc/m²/24 hr and displayed under a light intensity of 3175 lux at 2°C.

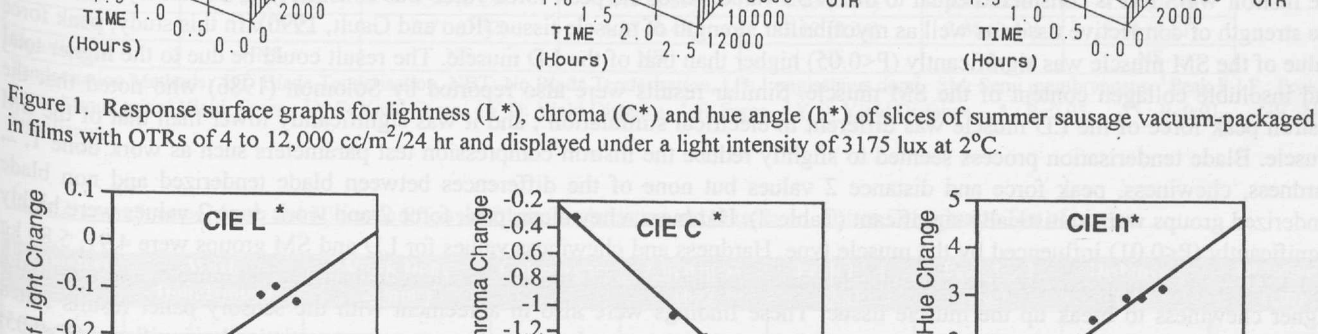

Figure 2. Rate of change in lightness (L*), chroma (C*) and hue (h*) for slices of summer sausage vacuum-packaged in films with OTRs of 155 to 12,000 cc/m²/24 hr and displayed under a light intensity of 3175 lux at 2°C.