Temperature and packaging film effects on colour stability of sliced turkey bologna during lighted display

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Summary

Temperatures of 5.6° to 16.7°C were evaluated for effects on surface colour stability of sliced turkey bologna vacuum-packaged in films with oxygen transmission rates (OTR) of 11, 30 and 72 cc/m^2/24hr (at 23°C, 0% RH, 1 atm). Surface colour measures in the Hunter LAB colour space were determined weekly over 4 or 5 weeks for packages displayed at a light intensity of 3200 lux. Surface lightness (Hunter L) and yellowness (Hunter +b) of all products had minimal increases (ΔL=3.8 and Δ+b=1.8 units, respectively) over the display period irrespective of temperature and OTR of packaging film. Redness (Hunter +a) loss increased due to increases in film OTR ($P<0.001$), display temperature ($P<0.001$) and time ($P<0.001$) in lighted display. Reflectance spectra of product at 0 and 4 weeks at 5.6°C appeared parallel with no major shifts except for bologna packaged in film with an OTR of 72 cc. Reflectance ratios (R570/R650) at 4 weeks increased ($P<0.05$) from initial ratios for product in film with OTRs of 30 and 72 cc. Overall, the shift in surface colour of the turkey bologna from a red to a red-yellow hue occurred with increase of time in lighted display, increase of the OTR of the packaging film, and increase of temperature of the lighted display.

Introduction

The first failure point in the shelf life of cured meat is generally loss of colour from the oxidation of nitrosylhemochrome, the pink to pink-red pigment viewed by consumers as an indicator of product freshness (Issanchou, 1996). The visual shift in colour toward a light tan, gray, or brownish hue has been termed “fading” or “discoloration”. Since the pigment is sensitive to light in the presence of oxygen (Andersen *et al.*, 1988), protection of sliced, cured poultry products such as frankfurters, bologna, ham and other luncheon items is normally done by proper packaging. The objective of this study was to determine the effects of temperature, oxygen transmission rate of packaging films, and time in lighted display on colour stability of sliced vacuum-packaged turkey bologna.

Materials and methods

Commercial unsliced turkey bologna was obtained that analyzed 59.7% moisture, 13.0% protein, 11.4% fat, and 2.8% ash (AOAC, 1995) and had a pH of 6.56. The bologna chubs were approximately 10 cm in diameter and weighed 2.3 kg each. The bologna was sliced 1 cm in thickness and each slice served as a sample. Each slice was vacuum-packaged at 72.4 cm Hg in films with an oxygen transmission rate (OTR) of 11, 30, or 72 cc/m^2/24 h at 23°C, 0% RH and 1 atm. Two to four bologna chubs were purchased on three separate occasions for each study replication. Packaged slices were displayed under 3200 lux of continuous lighting (Cool White™ fluorescent lights) with placement on white laminate surfaces below the lighting. Samples were displayed at 5.6° and 11.1°C for 5 weeks and those placed at 13.3° and 16.7°C were displayed for 4 weeks.

Colour evaluations were made directly on the packaged bologna slice surfaces initially and at weekly intervals. Tristimulus colour coordinates in the Hunter LAB Colour Space were determined using a HunterLab ColorQuest Model CT 1100 spectrocolorimeter after standardizing with a white ceramic tile. Surface reflectance scans were also recorded from 400-710 nm at 0 and 4 weeks of display for product displayed at 5.5°C. Reflectance ratios of R570:R650, indicative of hue shift from red to red-yellow (Hunt and Kropf, 1985), were calculated after scanning.

Random samples of the bologna chubs were taken for compositional analyses (moisture, fat, protein, ash) and the pH of sample homogenates also was determined.

Differences within colour characteristics (ΔL, Δa, Δb) from 0 week were analyzed statistically for main effects of temperature, time, and film OTR and their interactions using general linear model analysis of variance (SAS, 1996).

Results and discussion

The main effects of temperature, weeks of lighted display, packaging film OTR, and the interactions of OTR with temperature and display time were significant factors for the increase of turkey bologna surface lightness (Hunter L) and yellowness (Hunter +b) and decrease in redness (Hunter +a) as determined from general linear model analysis of variance (Table 1). The lightness and yellowness increases, while statistically significant, may have no practical meaning to the overall surface colour change when viewed by consumers. ΔL maximum was +3.8 and Δ+b was +1.8 units. This is in contrast to the loss of redness with maximum Δ+a of -8.5 units for turkey bologna displayed for 4 weeks at 16.7°C in film with an OTR of 72 cc.

Surface redness (Hunter +a) shift of bologna packaged in film with an OTR of 11 cc was very slight with a maximum Δ+a of -0.80 unit occurring over all display temperatures (Figure 1). Bologna in film with an OTR of 30 cc does not appear to decline until week 3 at all temperatures. The maximum Δ+a decline for bologna in 30 cc film was -2.0 units. Rapid loss of surface redness for product packaged in 72 cc film occurred as a result of increase of display time and display temperature. Terlizzi *et al.* (1984) stated that films with an OTR of approximately 70 cc or less provide adequate colour protection for large deli-style cured meats that are generally stored in the dark prior to slicing. However, in the presence of light, other researchers (Anderson *et al.*, 1988; Kartika and Acton, 1998) have recommended OTRs in the ranges of 4-17 cc to minimize colour fading for vacuum packaged cured meats.

Surface reflectance spectra from 400-710 nm for turkey bologna in all packaging films at 0 week was the same as that shown in Figure 2 at 0 week for product in 72 cc film placed at 5.6°C. After 4 weeks of lighted display at 5.6°C, products packaged in 11 and 30 cc film were almost identical to that at 0 weeks. Bologna packaged in the 72 cc film at 4 weeks however (Figure 2) showed increased reflectance in the yellow portion of the spectrum (around 570 nm) and a decrease in the redness area (around 650 nm). Comparisons of the 0 week and 4 week R570/R650 ratios (Table 2) showed no differences ($P>0.05$) among initial ratios whereas at 4 weeks of light exposure, product packaged in film with an OTR of 72 cc had a higher ratio than product packaged in the other two films. Within film OTRs, increases ($P<0.05$) of the ratios were also found from 0 week to 4 weeks of lighted display for bologna packaged in films with OTRs of 30 and 72 cc.

The decreases of redness attributes (Hunter +a, R650) and the increases of yellowness (Hunter +b, R570) confirm a shift in surface hue from red to red-yellow with increase of product display time in light as packaging film OTR increased from 11 cc to 30 and to 72 cc. Northcutt *et al.* (1990) previously reported that colour fading followed an Arrhenius relationship of temperature dependency and Jydegaard *et al.* (2004) reported an Arrhenius-type dependency on light intensity. Kartika *et al.* (1998) found greater nitrosylhemochrome pigment retention and higher visual colour scores for turkey bologna when film OTRs were ≤14 cc during 5 weeks of lighted display at 3°C.

Overall, results of this study are in agreement with the findings of Kartika et al (1998) for oxygen barrier characteristics of packaging films and with the findings of Northcutt *et al.* (1990) regarding low temperature effects during display. Oxygen availability, as controlled by the OTR of the packaging film, directly affects the colour stability of sliced turkey bologna placed in lighted display.

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Table 1 Mean squares from general linear model analysis of variance of main effects and interactions on change of initial surface colour characteristics of vacuum-packaged turkey bologna displayed in lighting for 4 or 5 weeks.

Source	df	Mean Square		
		ΔL	Δ+a	Δ+b
Temp (T)	3	1.76***	7.35***	0.40***
Week (W)	5	13.38***	34.31***	2.39***
OTR	2	20.50***	264.37***	21.26***
Temp x Week	13	0.57*	0.47^{ns}	0.11^{ns}
Temp x OTR	6	2.37***	5.27***	0.20**
Week x OTR	10	1.93***	19.72***	1.34***
T x W x OTR	26	0.29^{ns}	0.48^{ns}	0.07^{ns}
R^2		0.81	0.94	0.91

***P<0.001, **P<0.01, *P<0.05, ^{ns}P>0.05
OTR = oxygen transmission rate of packaging films (11, 30, 72 cc/m^2/24 h).
T = temperature of lighted display (5.6, 11.1, 13.3, 16.7 ^{o}C).
W = week of lighted display (0, 1, 2, 3, 4, 5).

Table 2 Surface reflectance ratios (R570/R650) of turkey bologna packaged in film with difference oxygen transmission rates and displayed in light for 4 weeks at 5.5 ^{o}C.

Packaging Film OTR	Reflectance Ratio (R570/R650)	
	Week 0	Week 4
11	0.40^{ax}	0.40^{ax}
30	0.39^{ax}	0.41^{ay}
72	0.40^{ax}	0.59^{by}

$^{a-b}$ Column means having a different letter superscript are different (P<0.05).
$^{x-y}$ Row means having a different letter superscript are different (P<0.05).

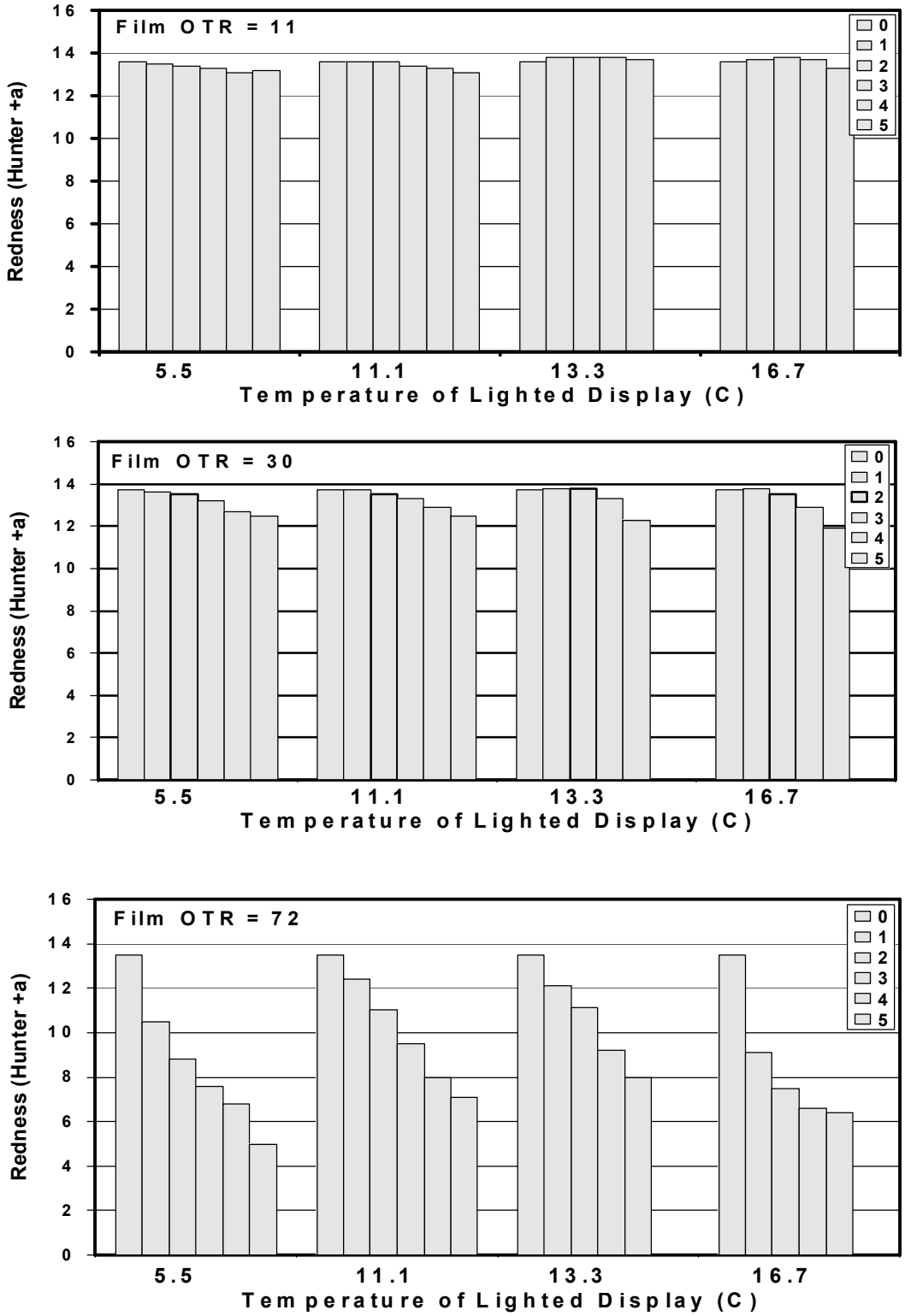

Figure 1 Surface redness (Hunter +a) of turkey bologna packaged in films with oxygen transmission rates of 11, 30, and 72 cc/m^2/24 h and displayed in lighting for 1 to 4 or 5 weeks at various temperatures.

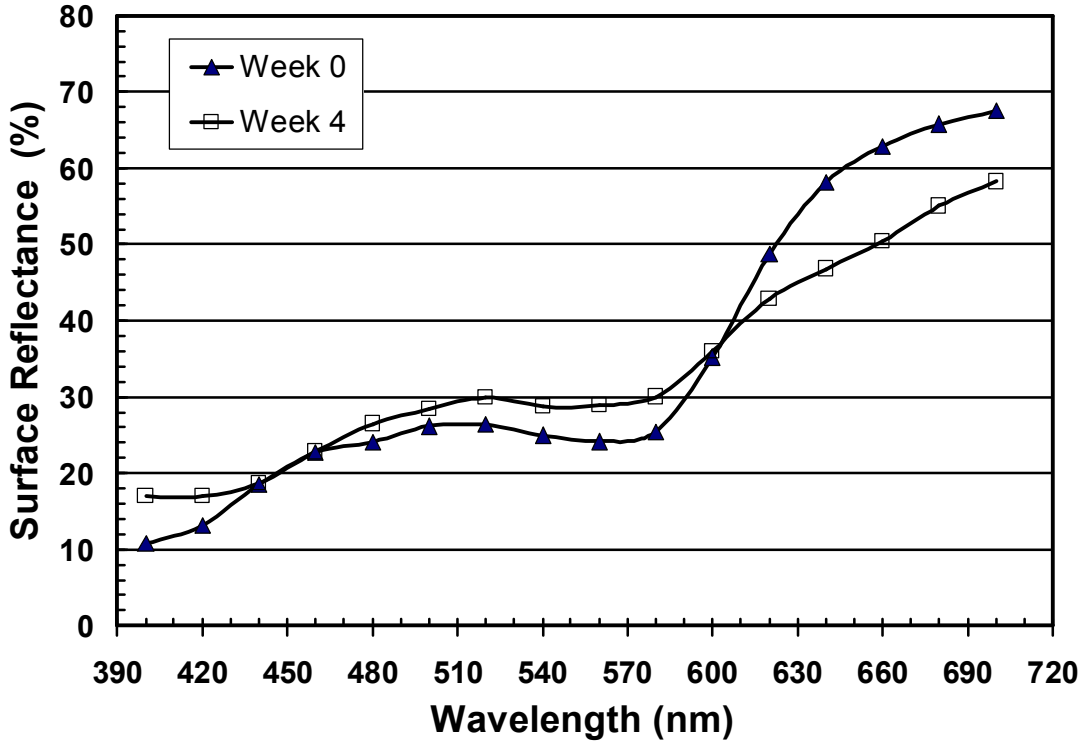

Figure 2 Spectral surface reflectance of turkey bologna packaged in film with an oxygen transmission rate of 72 cc/m^2/24 h and displayed in lighting for 4 weeks at 5.6°C.