COLOR STABILITY OF TRAY-PACKAGED FRESH PORK SAUSAGE LINKS IN LIGHTED DISPLAY

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Background

Fresh pork sausage is prepared with fresh or frozen pork, seasonings, and not more than 3% water or ice that may be added to facilitate chopping or mixing. Additionally, the finished product may not contain more than 50% fat (CFR, 2003). Manufacturers generally stuff the sausage in flexible films for linking as 0.45 kg chubs or in natural, synthetic, or collagen casings as small links that are typically utilized as a breakfast item. Fresh pork sausage also may be prepared in pattie form. An important step in preparation of this type sausage is maintaining a low temperature to prevent fat smearing when the fresh mix is coarsely ground or chopped and then stuffed. Particle definition of the lean and formation of oxymyoglobin are necessary to provide proper appearance in the finished sausage since it is marketed as a raw, uncooked product. With good sanitation programs and proper handling, low microbial counts are usually found (Surkiewicz *et al*., 1972). Most manufacturers ship the product frozen and thawing is conducted just prior to retail display. Shelf life expectations in display are generally in the range of 14-21 days (Anon., 2004, Sebranek *et al*., 2004).

Objectives

The purpose of this study was to evaluate the retention of fresh lean color of tray-packaged pork sausage links during lighted display as based on panel ratings and to provide an estimate of the range in shelf life when placed in display.

Materials and methods

Six fresh pork sausage mixes were prepared in a regional processing plant operating under USDA inspection. The mixes were stuffed in collagen casings yielding links of approximately 1.8 cm diameter and 9.3 cm in length. Individual links were then conveyed through a CO_2 freezer tunnel and frozen before being tray packaged. Fourteen links were arranged in a 7 link (column) x 2 link (row) array on foam trays and the trays were over-wrapped with film of high oxygen transmission rate (>10,000 cc/m^2/24 hr at 1 atm, 0% RH, 23^{o}C). Trays of frozen links from each mix were express shipped overnight from the plant to our laboratory, removed from the shipping container which contained dry ice, and placed in an onsite freezer (-16.2^{o}C) for 6 days. Each mix served as an experimental replicate (n = 6).

Two randomly selected trays from each coded sausage mix were placed in the dark at 2±1^{o}C and allowed to thaw for approximately 22 hr. The thaw period was designated day 0. After thawing, the 12 trays were placed in a display cabinet at 2±1^{o}C under 1615 lux of lighting provided by Cool White fluorescent lights. This day was designated as day 1. At 12 hr intervals, the trays were rotated between the lighted display and dark storage for the next 21 days. The last day of display was day 22.

Color evaluation was conducted by 9 panelists familiar with fresh pork sausage and prior evaluations for fresh meat color. Each panel member had previously been screened for color vision using the Farnsworth-Munsell 100 Hue test consisting of arranging 4 sets each of 25 colors in the correct hue sequence. Normal color vision observers make few mistakes in the arrangement. Two preliminary color evaluation sessions were also conducted using fresh and discoloured sausage link packages to familiarize panelists with the color rating system and display equipment. From day 1 through 22 within a 3 hr period (8 a.m. – 11 a.m.), each panelist rated the sausage color on an 8-point scale (8 = very bright red lean; 5 = slightly red lean; 4 = slightly dark red lean; 1 = extremely dark brown/grey of lean) and also selected the “best” 3 samples and “worst” 3 samples among the 12 trays. Color evaluations continued for the 22 day period excluding weekend days. Each day the 12 trays were randomly arranged in the display and assigned a new 3-digit numerical code, selected at random, to prevent panel members from associating any code with a particular sausage mix.

Preliminary statistical analyses involved general linear model analysis of variance (ANOV) (SAS, 1996). After establishing that the color rating fit a quadratic response over time as compared to a linear response, data were analyzed by least squares (LS) ANOV according to a randomized block split plot in time design. Polynomial regressions of rate on day were fitted for each sausage mix and the linear and quadratic coefficients (β_1 and β_2, respectively) were compared using linear contrasts. The regression used was as follows: $Y = y + \beta_1 (x - 11.022) + \beta_2 (x - 11.02)^2$ where Y = predicted color rating, y = LS mean of the sample color rating, β_1 = linear coefficient for "rate of change with time", x = day of sample display (from 1-22), β_2 = quadratic coefficient for "rate of change in the 'rate of change with time'", and 11.022 = day constant for days 1-22. LS means for the color rating for all sausages over all dates were also compared using linear contrasts.

Results and discussion

Preliminary analysis of the data by ANOV showed a significant ($P<0.001$) difference among panelists, sausage mixes, and days of display. Duplicate samples of the sausage mixes was not ($P>0.05$) a factor in color ratings over the evaluation period. Time (days of display) was the largest contributor to the sum of squares in the analysis. A number of interactions were significant (mixes*duplicates, mixes*days, mixes*duplicates*days), all involving the sausage mixes. Nonsignificant interactions were duplicates*days and panelists*mixes*duplicates, the latter serving as the error term for each component in the interaction.

The polynomial regressions coefficients for each mix are given in TABLE 1 with linear contrasts comparisons for significant differences determined using least significant difference (LSD) at $P = 0.05$. There was a significant difference ($P<0.05$) between the LS mean for color rating (y) for sausage mix 5 (highest LS mean of 6.10) compared to sausage mix 1 (lowest LS mean of 5.30). These extreme LS mean comparisons encompass the 22 day display period. Neither mix 5 nor 1 had a color rating different from the other mixes. This confirms that in following a sausage mix formulation involving different pork meat selections combined for mixing, seasoning, grinding, stuffing, packaging, storing frozen for shipping, thawing and then displaying for a 22 day period, five-of-six different production runs made for this study were not different in color ratings as judged by the panel members. The rate of change with time (β_1) shows that sausage mix 5 had the lowest rate of color loss ($\beta_1 = -0.151$) whereas mixes 1 and 4 had the highest rates ($\beta_1 = -0.242$ and -2.58, respectively). Other mixes (TABLE 1) were generally intermediate in rate in which color ratings decreased. No practical significance can be attached to the β_2 coefficient.

Data on panel selections for "best" and "worst" samples among the 12 packages evaluated over the 22 day period (TABLE 2) are consistent with the other findings in that sausage mix 5 was selected more frequently in the "best" category (29.9% of responses) and less frequently in the "worst" category (9.4% of responses). Opposite findings are present for sausage mix 1 which had the lowest LS mean for color rating and one of the highest rates of color change.

The average daily color ratings over all panelists from evaluations of the duplicate packages of sausage mixes 5 and 1, as examples of the extremes for fresh color retention, were plotted against the day of evaluation (FIGURE 1). The plot was then visually extrapolated to the approximate maximum number of days each sausage mix had an average color rating of 5.0 or higher (5 = slightly red lean). This provides an estimate of the range in shelf life for this product. Sausage mix 5 maintained a rating of 5.0 or higher for 16-17 days whereas mix 1 maintained the rating for 12-13 days. Other mixes would have expected color retention for time periods between the findings for these two mixes. Most manufacturers expect a display life of 14 days with a few additional days in the consumer's home for fresh pork sausage prepared and held as given in this study.

Conclusions

Fresh pork sausage links from 5 of 6 different production runs did not differ in rate of color loss over a 22-day lighted display period. Redness retention of the lean particles as rated by a trained panel indicated a product color life of 12-13 days to 16-17 days.

References

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TABLE 1. Polynomial regression coefficients for panel color ratings of fresh pork sausage links displayed in light for 12 hr each day over a 22 day display period.

Sausage Mix	Color Rating (LS Mean)	Coefficients	
		B_1	B_2
1	5.30b	-0.242ab	-0.0090bc
2	5.72ab	-0.224bc	-0.0119ab
3	6.10a	-0.193d	-0.0147a
4	5.46ab	-0.258a	-0.0089bc
5	6.14a	-0.151e	-0.0114ab
6	5.43ab	-0.214cd	-0.0068c
(LSD at P = 0.05)	(0.70)	(0.024)	(0.0041)

Regression model: $Y = y + \beta_1 (x - 11.022) + \beta_2 (x - 11.02)^2$ where Y = predicted color rating, y = LS mean of the sample color rating, β_1 = linear coefficient for "rate of change with time", x = day of sample display (from 1-22), β_2 = quadratic coefficient for "rate of change in the 'rate of change with time'", and 11.022 = day constant for days 1-22.

a-e Column means and coefficients having a common letter are not different (P>0.05).

TABLE 2. Selection of the "best three" and "worst" three packages for fresh sausage color by panel members among 12 packages displayed in light for 12 hr each day over a 22 day display period.

Sausage Mix	"Best" Color Choices		"Worst" Color Choices	
	Responses	(Percent of Responses)	Responses	(Percent of Responses)
1	40	(9.9)	108	(26.7)
2	48	(11.8)	49	(12.1)
3	89	(21.9)	46	(11.3)
4	61	(15.1)	92	(22.7)
5	121	(29.9)	38	(9.4)
6	46	(11.4)	72	(17.8)
(Total)	405	(100)	405	(100)

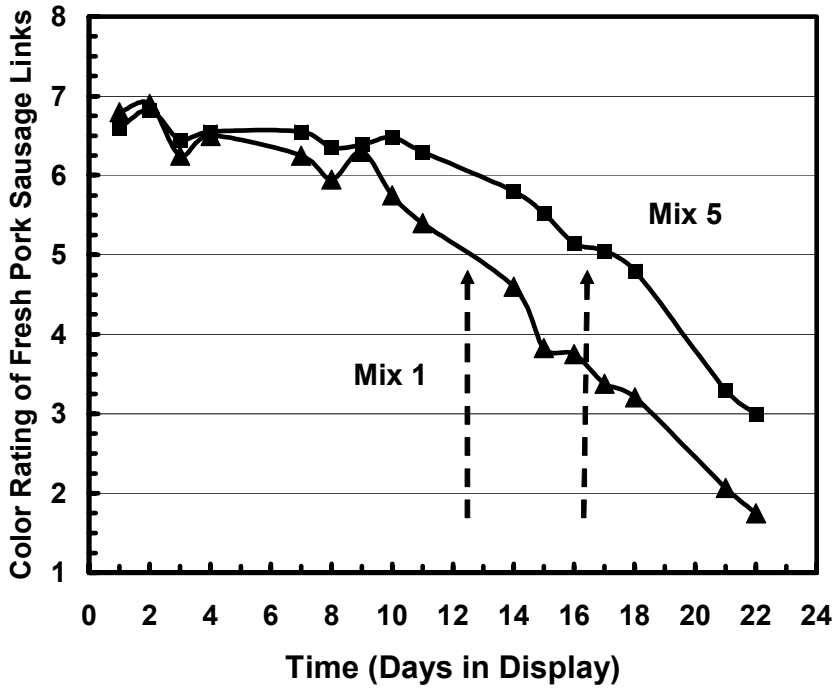

FIGURE 1. Panel color ratings of fresh pork sausage links from mixes with the highest (Mix 1) and lowest (Mix 5) rates of color change when displayed in light for 12 hr each day over a 22-day display period. The dotted arrow lines indicate the approximate days of shelf life for color retention based on panel ratings of 5.0 or higher.