

Effects of Broiler Breast Meat Thickness and Background on Color Measurements

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ABSTRACT Experiments were conducted to determine the influence of broiler and turkey breast meat thickness and background on breast meat color measurements. Broiler breast fillets were sliced into two 1 cm thick slices and the turkey breast fillets into three 1 cm slices. Color values for lightness (L^*), redness (a^*), and yellowness (b^*) were measured on the same top slice singly or while placed over the corresponding broiler and turkey slices. Color was measured in triplicate while the fillets were placed on the following backgrounds: plastic-coated white paper, white nylon, aluminum foil, black plastic, and a yellow commercial packaging tray (broiler only). Sample thickness significantly affected L^* , a^* , and b^* val-

ues of turkey and chicken. Increased breast meat thickness resulted in lower L^* , a^* , and b^* values. Increased turkey breast meat thickness from 1 to 2 cm resulted in lower a^* and b^* values; however, only lower L^* values were observed, with sample thickness increased from 1 to 3 cm. No differences in meat color were found when increasing turkey breast meat sample thickness from 2 to 3 cm. Background had a significant effect on single (1 cm) broiler and turkey breast meat color measurements but did not influence the color readings of the thicker multiple slice samples. These results indicate that the application of machine vision or in-line color measurement systems may have to take into account breast meat thickness, and in thinner samples, background color.

(Key words: broiler, turkey, meat color, thickness, background color)

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INTRODUCTION

In the last decade, a number of researchers have suggested the possibility of using color measurements to predict functional properties of poultry meat. Specifically, pale, soft, and exudative-like conditions and water-holding capacity are the most common functional properties mentioned (Barbut, 1993, 1996, 1997ab, 1998; McCurdy et al., 1996; Fletcher et al., 2000; Owens et al., 2000; Wilkins et al., 2000; Qiao et al., 2001). Relationships were also found between color and shelf life (Allen et al., 1997) and between color and composition (Qiao et al., 2002) of broiler breast meat. Some researchers have also indicated lightness values to be useful as an indicator of poultry breast meat quality for further processing (McCurdy et al., 1996; Barbut, 1997a; Owens et al., 2000).

Many of these studies are based on the use of commercial colorimeters, which express meat color in terms of a color difference (from a designated color standard as opposed to an absolute color determination) such as the International Commission on Illumination (CIELAB) sys-

tem of lightness (L^*), redness (a^*), and yellowness (b^*). Because of the nature of color difference measurements as well as differences in sample presentation and measurement conditions, comparisons of absolute color values between laboratories is difficult. Sandusky and Heath (1996) reported breast meat color measurement differences based on sample thickness and background color when measured by a dual beam scanning spectrophotometer and reflectance colorimetry, using Hunter standard white, pink, green, and gray as background tiles. Petracci and Fletcher (2002) reported that the color measurement of broiler skin and breast meat are greatly affected by early aging times during processing and postmortem aging.

In order to compare meat color studies by different authors and the potential use of computer-based vision systems using color discrimination criteria for evaluating meat quality in poultry processing plants, a better understanding of the influence of the measurement conditions on the color instrumental response is needed. Under practical industry conditions, breast meat size variation and background color (for example, belt surfaces or packaging material) would be factors affecting color difference or

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Abbreviation Key: a^* = redness; b^* = yellowness; CIE = International Commission on Illumination; L^* = lightness.

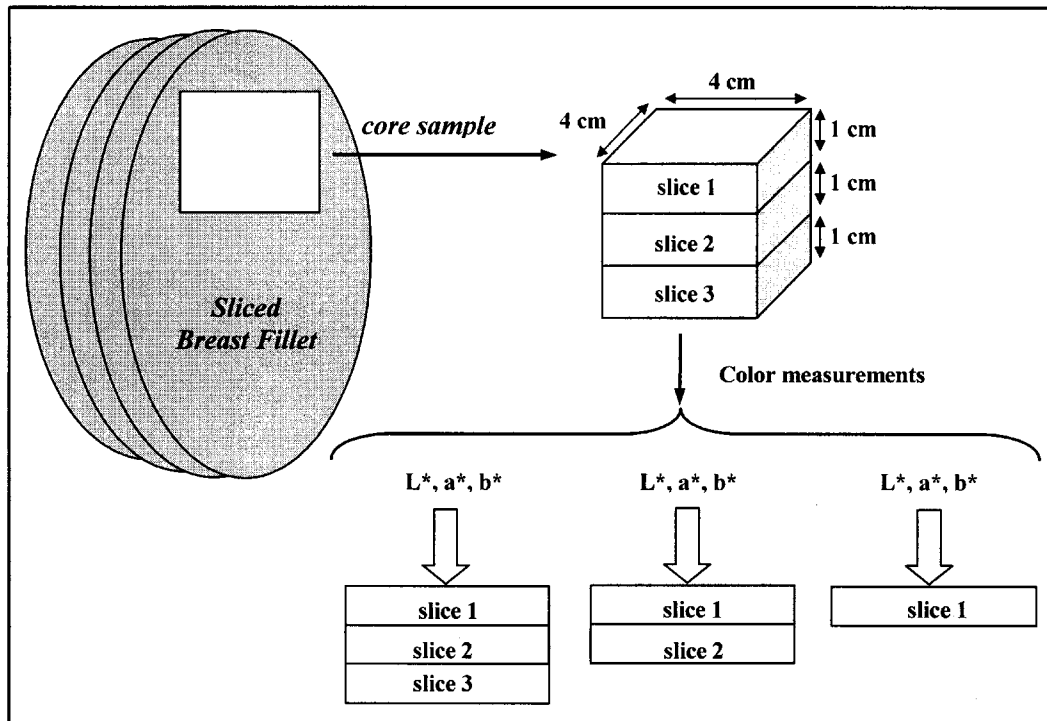


FIGURE 1. Meat sample preparation (4 × 4-cm section) scheme for turkey breast meat (Slices 1 to 3) and broiler breast meat (Slices 1 and 2, only).

absolute color measurement. The purpose of this study was to determine the influence of broiler and turkey breast meat thickness and background color on color measurement, using a commonly used commercial colorimeter.

MATERIALS AND METHODS

Breast Meat Samples

Breast meat samples were obtained from 40 turkeys and 72 broilers. Live birds were obtained from commercial sources, slaughtered in a pilot plant facility, eviscerated, chilled, and held for 24 h packed in ice. Individual breast fillets (pectoralis major) were removed from the carcasses and chilled at -2 to -4 C to facilitate lateral slicing at 1-cm thickness using a standard circular blade deli-style meat slicer. The first, or most distal slice, with the overlying epimysium, was discarded to eliminate surface irregularities and possible discoloration due to scalding. The subsequent 1 cm thick slices were designated as Number 1 for the 'top,' or more distal, surface slice; Number 2 for the middle turkey slice or bottom chicken slice; and Number 3 for the bottom turkey slice. After being cut, the slices were maintained in their original natural configurations and were trimmed to 4 × 4-cm sections and identified to allow consistent reassembly for multiple color measurements, as shown in Figure 1. After slicing and reorientation, all samples were covered with plastic

wrap to avoid surface drying and were held at 4 C prior to immediate color measurements made the same day.

Color Measurement

The CIELAB (1976) color values for L^* , a^* , and b^* were measured using a portable reflectance colorimeter² and illuminant source C. The colorimeter was standardized throughout the study using the standard white ceramic tile (Reference number 1353123. $Y = 92.7$, $x = 0.3133$, and $y = 0.3193$). All calibrations and color readings were taken using the colorimeter-supplied optically inactive glass aperture cover to ensure a consistently flat sample surface. This cover was cleaned after each sample reading. The meat samples were equilibrated to room temperature and the plastic wrapping was removed just prior to color measurement.

Color was always measured on the distal surface of slice Number 1, either singly or while placed over slice Number 2 for chicken and turkey, or while placed over slices Number 2 and 3 for turkey (to determine the effect of sample thickness on color). To determine the effect of background color, each thickness color measurement was made in triplicate using the following background surfaces: plastic-coated white paper, a white nylon cutting board, aluminum foil (shiny surface), black plastic and, for the chicken only, a yellow commercial polystyrene packaging tray. The color values for these backgrounds are presented in Table 1.

Statistical Analyses

The triplicate readings per sample thickness and background were averaged. The main effects of sample thick-

²Minolta Chroma Meter CR-300, Minolta Corp., Ramsey, NJ.

TABLE 1. Background surface color values of lightness (L*), redness (a*), and yellowness (b*) for the plastic-coated white paper (white paper); white nylon cutting board (white nylon); aluminum foil, shiny surface up (Al foil); black plastic; and a commercial yellow chicken tray (yellow tray)

Background	Color		
	L*	a*	b*
White paper	95.1	-0.2	1.2
White nylon	71.1	-2.4	-6.5
Al foil	86.4	-0.7	0.3
Black plastic	25.2	0.5	0.6
Yellow tray	81.8	-4.1	64.3

ness and background color and the first level interactions were analyzed using the ANOVA option of the general linear models procedures of SAS software (SAS Institute, 1988) using the residual error (variation between breast meat samples). When the sample thickness by background color interaction was significant, the interaction mean square error was used to determine the significance of the main effects. Means were separated using the Duncan's multiple range test option of the general linear models procedure and using the appropriate error term, as described (SAS Institute, 1988).

RESULTS AND DISCUSSION

For the broiler and turkey samples, thickness significantly affected L* and b* values. There was a significant thickness-by-background interaction for redness, which when used as the test error for main effects resulted only in thickness affecting redness. Therefore, the main effect of thickness on broiler and turkey meat color, averaged using the different backgrounds, is presented in Table 2. As sample thickness increased from 1 to 2 cm, broiler meat resulted in significantly lower L* (51.8 vs. 52.1), a* (0.1 vs. 1.5), and b* (8.4 vs. 8.8). The increase in turkey meat thickness from 1 to 2 cm resulted in significantly lower a* (3.3 vs. 4.0) and b* (1.6 vs. 2.0), whereas a lower L* was observed with sample thickness increasing from 1 to 3 cm only (50.0 vs. 51.5). No differences in meat a*

TABLE 2. Means and standard error of the means for color values of lightness (L*), redness (a*), and yellowness (b*) and probabilities for broiler and turkey meat sample thickness (1 or 2 cm for broiler; 1, 2, or 3 cm for turkey)

Meat	Slices (cm)	Color		
		L*	a*	b*
Broiler ¹	1	52.1 ± 0.1	1.5 ± 0.1	8.8 ± 0.1
	2	51.8 ± 0.1	0.1 ± 0.1	8.4 ± 0.1
P		0.0185	0.0001	0.0001
Turkey ²	1	51.5 ^a ± 0.3	4.0 ^a ± 0.1	2.0 ^a ± 0.1
	2	50.7 ^{ab} ± 0.3	3.3 ^b ± 0.1	1.6 ^b ± 0.1
	3	50.0 ^b ± 0.3	3.1 ^b ± 0.1	1.5 ^b ± 0.1
P		0.0013	0.0001	0.0002

^{a,b}Means within column with differing superscripts are significantly different from each other ($P < 0.05$).

¹Broiler, n = 360.

²Turkey, n = 160.

and b* were found when increasing turkey meat sample thickness from 2 to 3 cm.

These results suggest that sample thickness less than 2 cm may be an important criterion in the measurement of broiler breast fillets or sliced turkey breast meat. Also, multiple measurements on a single fillet of varying thickness (e.g., from cranial to caudal areas of broiler breast fillets) may need to be averaged for an overall breast meat color evaluation. This was also suggested by Goshaw et al. (2000) in a previous study on the relationship between broiler breast meat color measurement position and color value.

Although the main effect of background color was not significant across the varying sample thicknesses, when analyzed for only 1 cm thick samples, there was a significant effect on color measurements. Thus, background color did not affect meat color measurements for the thicker samples (2 and 3 cm for turkey, or 2 cm for broiler). The results for the 1 cm broiler and turkey samples measured on the different background surfaces are presented in Table 3. For the broiler meat samples, background had no effect on L* and b* but did have a significant effect on a*. For the turkey meat, background had no effect on L*, but did have a significant effect on a* and b*.

These results are consistent with those for thickness, in that background color was only important in the thinner samples. Sandusky and Heath (1996) reported that background color significantly affected the meat color when a 0.5 cm thick broiler breast meat slice was used, whereas only few differences were found by testing a thicker meat sample (1.0 and 1.5 cm). In the present study, the 1 cm thick broiler meat slices resulted in a more red color when the white paper and yellow polystyrene were used as backgrounds and were less red when the black plastic was used. The 1 cm thick turkey meat slices were more red when the white paper was used as background and less red and less yellow when the black plastic was used (Table 3).

These results indicate that under practical conditions, broiler and turkey meat color measurements are more influenced by sample thickness than by background color. Background color is only important during measurement of thinner samples. These results are important in evaluating and reporting breast meat color. Also, these results also indicate that the development and application of on-line machine vision or color systems to measure and sort broiler and turkey breast meat prior to further processing may have to account for variations in thickness, location of color readings on the fillet, and background (transfer belt) surface color.

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TABLE 3. The influence of background color; plastic-coated white paper (white paper); white nylon cutting board (white nylon); aluminum foil, shiny surface up (Al foil); black plastic; and a commercial yellow chicken tray (Yellow tray) on 1 cm thick broiler and turkey breast meat color (mean \pm standard error of the mean) for lightness (L*), redness (a*), and yellowness (b*)

Background	Broiler			Turkey		
	L*	a*	b*	L*	a*	b*
White paper	52.2 \pm 0.2	2.1 ^a \pm 0.1	9.2 \pm 0.2	51.8 \pm 0.5	4.9 ^a \pm 0.1	2.4 ^a \pm 0.2
White nylon	52.1 \pm 0.2	1.4 ^b \pm 0.1	8.9 \pm 0.2	51.5 \pm 0.5	3.9 ^b \pm 0.1	1.9 ^{ab} \pm 0.2
Al foil	52.2 \pm 0.2	1.6 ^b \pm 0.1	9.1 \pm 0.2	51.5 \pm 0.6	4.3 ^b \pm 0.1	2.1 ^a \pm 0.2
Black plastic	52.0 \pm 0.2	0.5 ^c \pm 0.1	8.6 \pm 0.2	51.0 \pm 0.5	2.8 ^c \pm 0.2	1.5 ^b \pm 0.2
Yellow tray	52.0 \pm 0.2	1.9 ^a \pm 0.1	9.0 \pm 0.2	—	—	—
P	0.9122	0.0001	0.3451	0.8006	0.0001	0.0128

^{a-c}Means within column with differing superscripts are significantly different from each other ($P < 0.05$).

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