Survey of skin pigmentation of yellow-skinned broiler chickens[1]

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ABSTRACT The appearance of whole carcass and skin-on cut-up products is an important attribute that deeply affects the consumer's choice. Skin pigmentation is affected mainly by genetics, concentration and dietary source of pigments, health status of the birds, and scalding-plucking conditions during slaughtering, although other factors might play an important role. Retailers request batches of broiler chicken carcasses characterized by uniform skin pigmentation to be sold as whole carcass or parts. The aim of this study was to evaluate the variability of skin color of yellow-skinned broilers reared under intensive conditions. For the study, a total of 2,300 medium size broiler chickens (2,300 to 2,500 g of live weight) from 23 flocks (100 birds/flock; n = 12 flocks of males and n = 11 flocks of females; n = 12 flocks of Ross 508 and n = 11 flocks of Ross 308) were randomly selected in a single slaughterhouse. The color measurements were carried out on both breast and thigh pterylae as well as on shank skin adopting the L* a* b* system and using a Minolta colorimeter CR 300. The overall range in measured yellowness (b*) was fairly large for all skin color measurement positions. For breast, a mean value of 22.77 (SD = 5.12) was observed, with values ranging from 7.45 to 39.12. Average values of thigh and shank were 20.23 (SD = 5.02; range 1.99 to 37.82) and 53.99 (SD = 8.13; range 24.22 to 78.65), respectively. A higher skin yellowness was observed in females in all body parts as well as in Ross 308. Yellowness values of breast and thigh were significantly correlated (r = 0.85; $P < 0.01$), suggesting that the color evaluation may be carried out only on one measurement position of the skin.

Key words: chicken, skin, pigmentation, color, yellowness

2010 Poultry Science 89:1556–1561
doi:10.3382/ps.2009-00623

INTRODUCTION

Appearance is one of the most important factors affecting the consumer's choice and sensory evaluation of the products. The consumer preferences for the skin color of broiler chickens varies in different part of the world and are generally based on historical and regional supplies (Fletcher, 1999). In Northern Italy, where maize (*Zea mays* L.), rich in yellow pigments, is cultivated, deeply yellow-skinned broilers are preferred, whereas in Southern Italy, where wheat, lacking in pigments, is cultivated, white or pale-skinned broiler are preferred. The main worldwide reared modern broiler strains exhibit the ability to deposit pigments in the skin; however, skin pigmentation is affected by genetics as well as by the amount and type of dietary pigments, health status of birds, sex, and processing, although other factors might play an important role (Bilgili et al., 1998; Fletcher, 1989, 2002; Petracci and Fletcher, 2002). Several experiments have been carried out to study the biological availability and the skin-coloring ability of several natural or synthetic pigments (Ouart et al., 1988; Pérez-Vendrell et al., 2001; Castañeda et al., 2005). The feed industry commonly adds pigments to the ingredients used for the production of yellow-skinned broilers to meet the consumer demand. Due to the different factors affecting skin color, the broiler carcasses are characterized by wide variations in color, but, on the other hand, consumers tend to evaluate in a positive way uniform products and negatively, or as a defect, nonhomogeneous products. For this reason, retailers request batches of birds with a uniform skin pigmentation. Indeed, even though an increasing amount of broilers are sold as skinless raw products or further-processed products, a large amount of birds are still sold as whole carcass or skin-on parts with main regard to thighs and drumsticks. Recently, Bianchi et al. (2007) also evidenced that the more yellow the color of the skin, the more yellow the color of raw breast meat.

Direct instrumental measurement has been proposed to evaluate broiler skin color for several years (Fry et al., 1969; Yacowitz et al., 1978; Janky, 1986), however,

Received December 23, 2009.
Accepted March 10, 2010.
[1]Some results of this survey have been presented as a poster at the 2nd Mediterranean Summit of WPSA, Antayla, Turkey, October 4–7, 2009.
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Table 1. Descriptive statistics of skin color coordinates of breast, thigh, and shank (n = 2,300)

Item	Mean	Minimum	Maximum	SD	Skewness	Kurtosis
Breast						
Lightness, L*	75.40	65.87	81.67	2.05	0.48	10.77
Redness, a*	1.16	−3.53	7.52	1.47	−0.10	−0.21
Yellowness, b*	22.77	7.45	39.12	5.12	0.01	−0.19
Thigh						
Lightness, L*	77.21	68.50	83.44	1.87	−0.22	0.36
Redness, a*	−0.04	−4.21	4.79	1.40	0.20	−0.19
Yellowness, b*	20.23	1.99	37.82	5.02	0.03	−0.07
Shank						
Lightness, L*	79.96	71.20	88.70	1.68	−0.44	1.45
Redness, a*	−3.47	−7.24	2.57	1.33	0.62	0.75
Yellowness, b*	53.99	24.22	78.65	8.13	−0.39	0.17

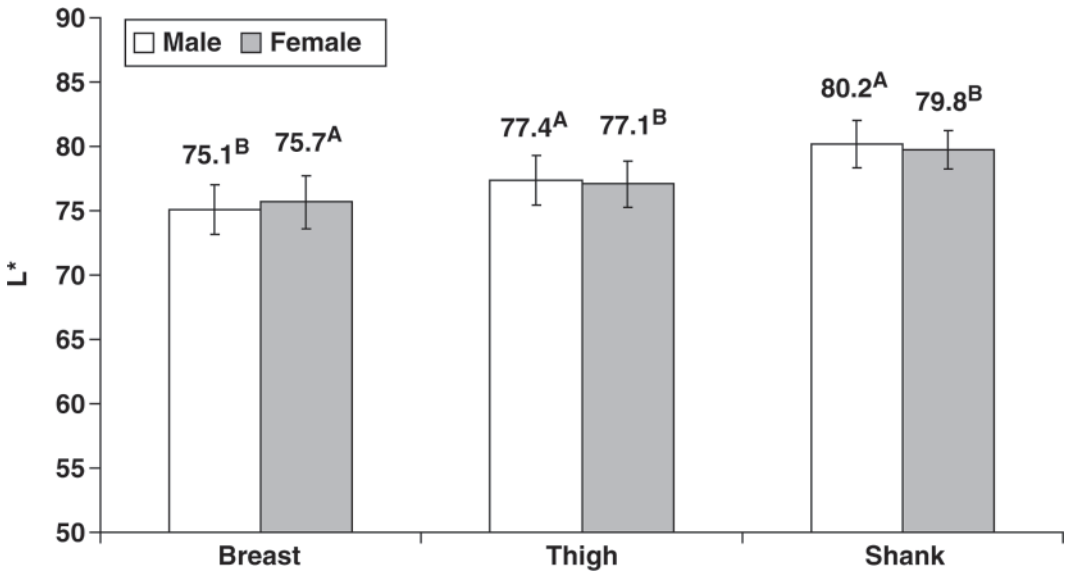

Figure 1. Effect of sex on lightness (L*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

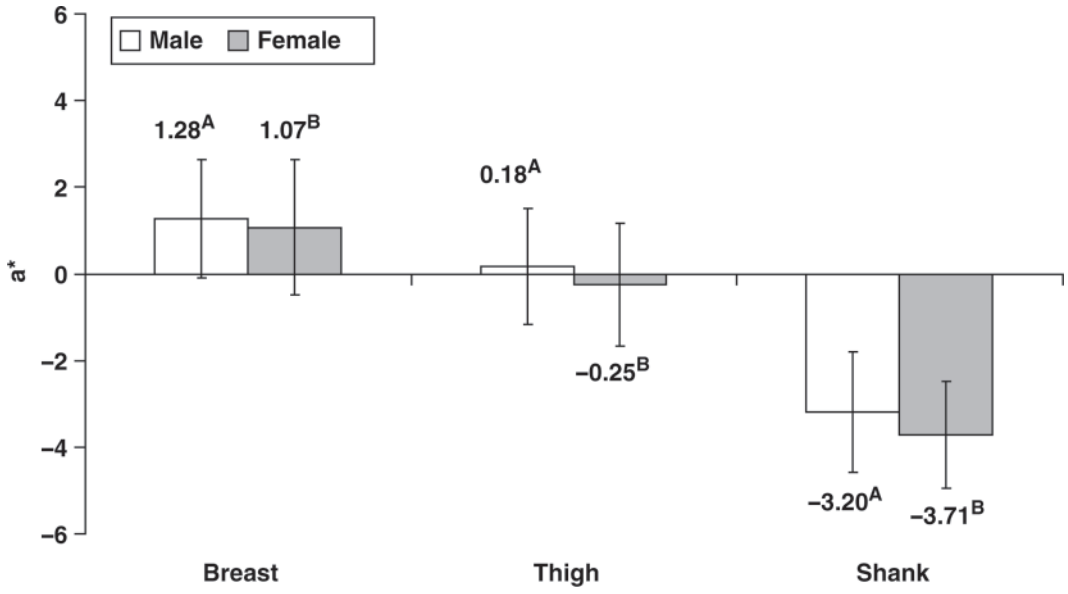

Figure 2. Effect of sex on redness (a*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

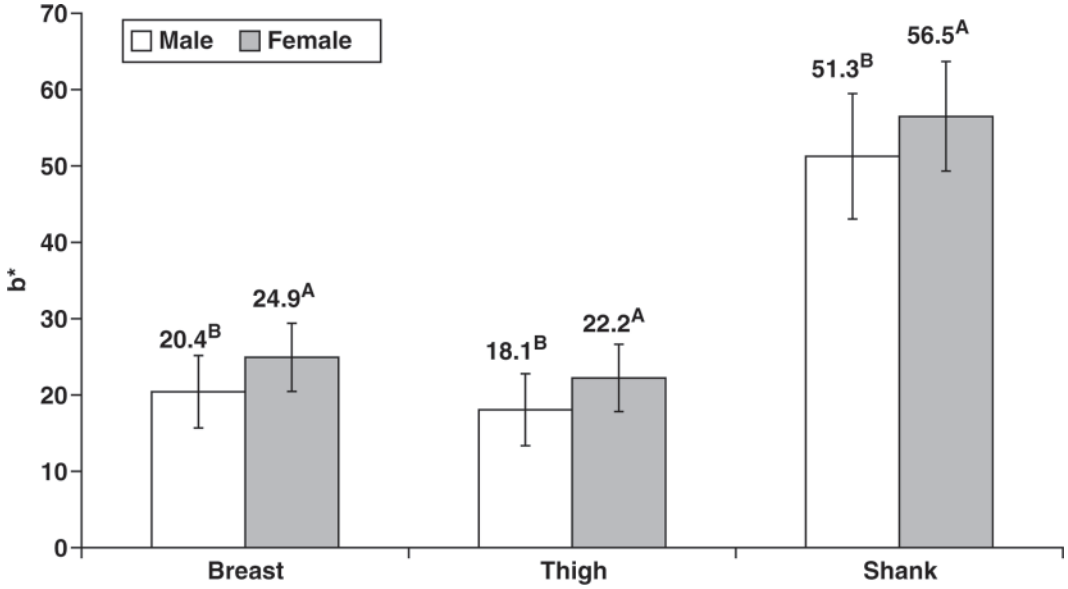

Figure 3. Effect of sex on yellowness (b*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

visual scoring systems are even today commonly used in poultry industries for evaluating broiler pigmentation.

The aim of this study was to evaluate the skin color variation of yellow-skinned broiler chickens under commercial conditions.

MATERIALS AND METHODS

A total of 2,300 medium size (2,300 to 2,500 g of live weight) Ross 308 broiler chickens and 508 chickens from 23 flocks (100 birds/flock; n = 12 flocks of males and n = 11 flocks of females) were randomly selected in the same slaughterhouse. Before slaughter, broilers were subjected to a total feed withdrawal of 8 to 12 h, including a holding time at the processing plant of 2 to 3 h. The birds were subsequently processed under commercial conditions using electrocution (120 V, 200 Hz) as a stunning system. Birds were bled for 180 s, and then carcasses were conveyed through scalding tanks filled with water at a temperature of 51.8°C for 220 s and plucked by rotating rubber fingers. After evisceration, birds were air-chilled in a tunnel with a flow of cold air (−6°C) for 150 min to allow the carcass to reach 4 to 5°C at the core.

The CIE (1978) system color profile of lightness (L*), redness (a*), and yellowness (b*) was measured by a reflectance colorimeter (Minolta Chroma Meter CR-300, Minolta Italia S.p.A., Milan, Italy) using il-

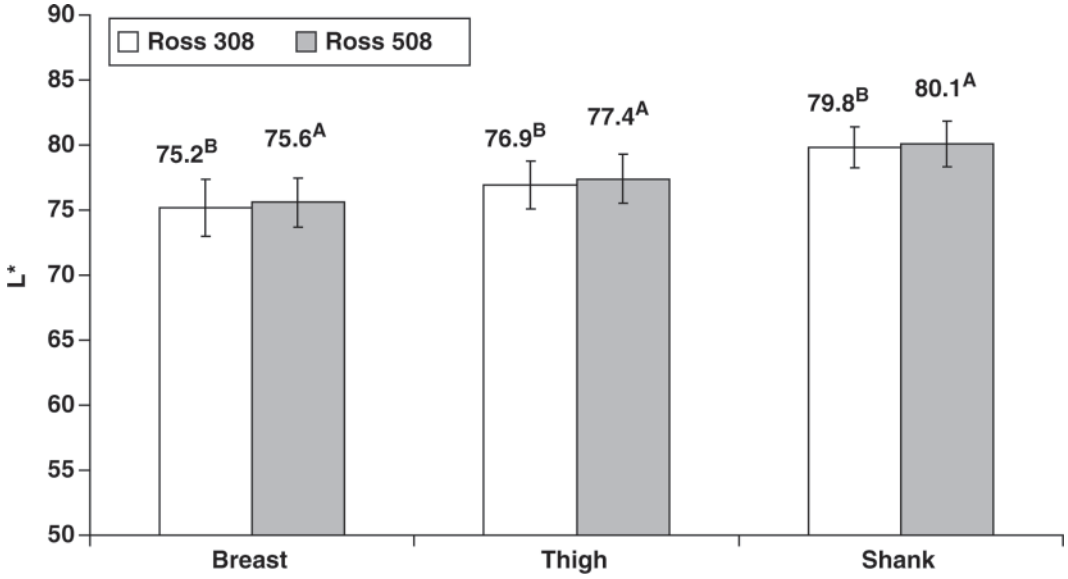

Figure 4. Effect of strain on lightness (L*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

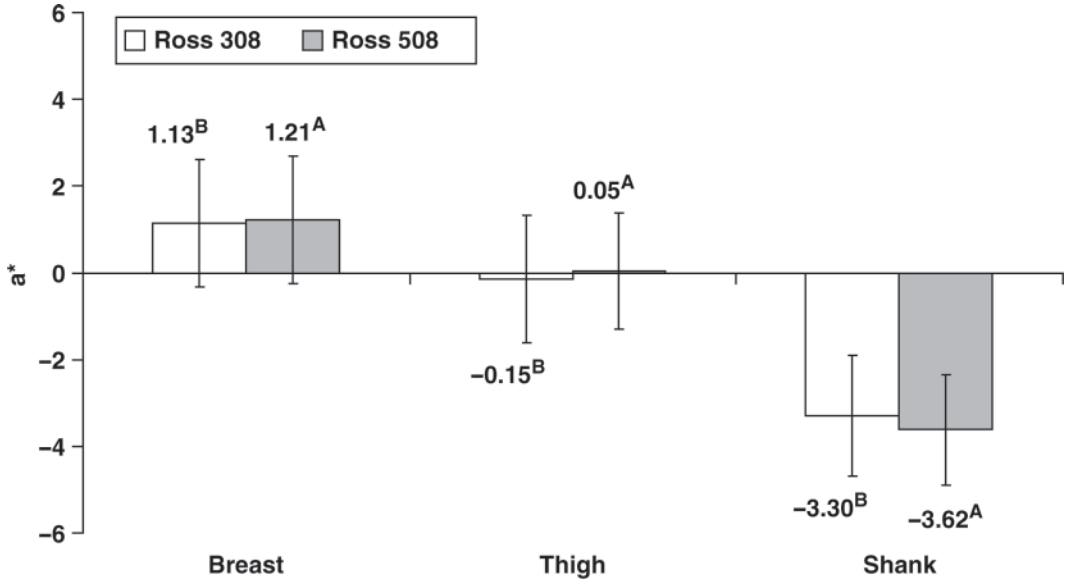

Figure 5. Effect of strain on redness (a*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

luminant source C and calibrated throughout the study using a standard white ceramic tile (reference number 1353123, Y = 92.7, x = 0.3133, and y = 0.3193). The color measurements were carried out averaging 3 measurements on both breast and thigh pterylae as well as on shanks skin of carcasses collected after chilling. The selected areas for color measurements were free from obvious defects (bruises, discolorations, hemorrhages, full blood vessels, picking damage, or any other condition that might have affected uniform color reading). Males and females received the same multiphase corn-soybean diets formulated according to the Italian regional market needs for yellow-skinned chickens with a total xanthophyll content ranging from 12 to 15 mg/kg of feed. The data were analyzed by descriptive statistics (mean, SD, minimum and maximum values, skewness, and kurtosis) for each color coordinate (L*, a*, b*) measured in the 3 measurement positions. The assumption of normality of the outcomes was assessed using stem-and-leaf plots and normal probability plots. The distribution of the lightness coordinate measured on breast and shank was leptokurtic; therefore, a square root transformation was applied. Subsequently, the raw or transformed data were analyzed by 2-way ANOVA with interaction of the GLM procedures of SAS software (SAS Institute, 1988) to test the effects of sex and strain of birds on skin color. Pearson correlation coefficients (r) and linear regression were calculated to evaluate the relationships between the color parameters of breast, thigh, and shank skin.

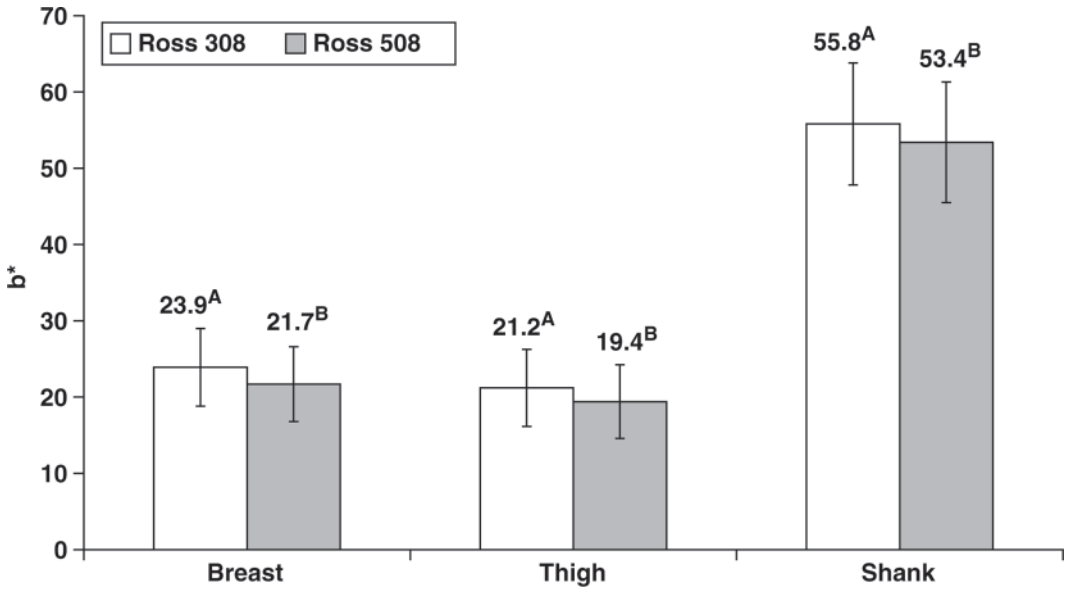

Figure 6. Effect of strain on yellowness (b*) values (mean ± SD) on the skin of breast, thigh, and shank (A,B = $P \leq 0.01$; n = 2,300).

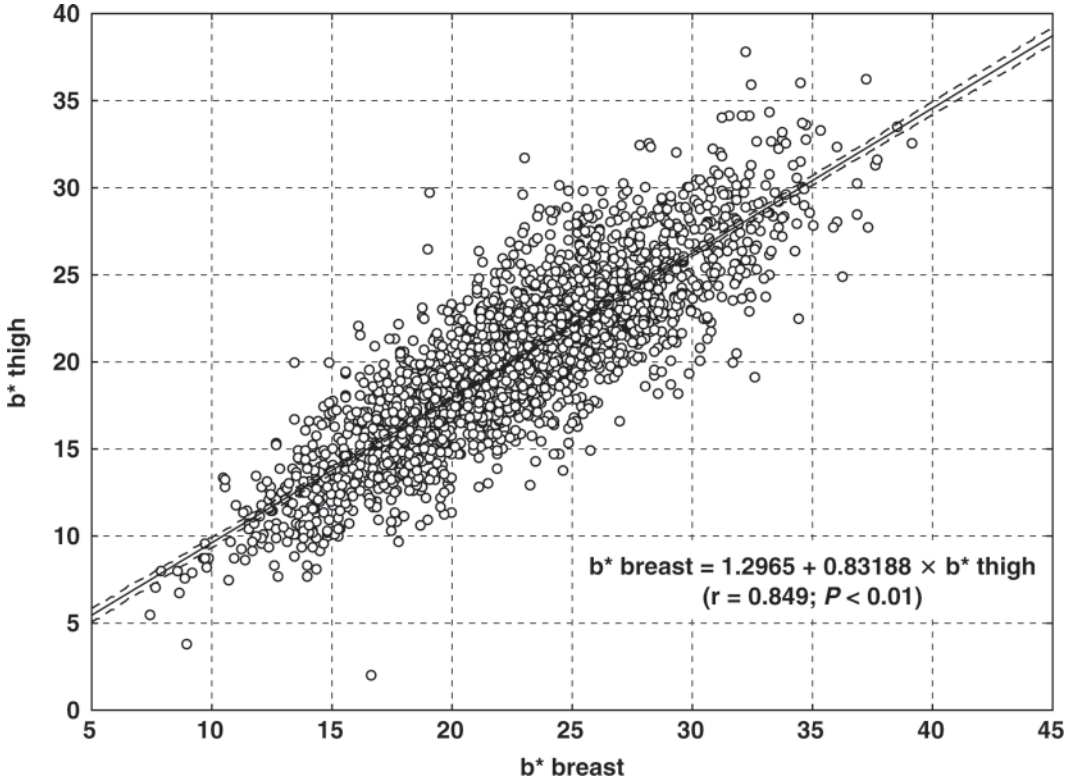

Figure 7. Correlation between yellowness (b*) values of breast and thigh skin (n = 2,300).

RESULTS AND DISCUSSION

In Table 1, the descriptive statistics of skin color coordinates of breast, thigh, and shank measured on overall birds are reported. The average of lightness (L*) in the different body parts increased from 75.40 (SD = 2.05) to 77.21 (SD = 1.87) and 79.96 (SD = 1.68), respectively, for breast, thigh, and shank. The range of variation of lightness for all body parts was 15 to 17 units. The lightness of skin breast showed a leptokurtic distribution (kurtosis = 10.77), whereas thigh and shank exhibited a normal distribution. Values of redness, decreasing from breast to thigh and shank, were variable particularly in breast and thigh (SD = 1.47 and 1.40, respectively).

The overall range in measured yellowness (b*) was fairly large for all skin color measurement positions. For breast, a mean value of 22.77 (SD = 5.12) was observed, with values ranging from 7.45 to 39.12. Average values of thigh and shank were 20.23 (SD = 5.02; range = 1.99 to 37.82) and 53.99 (SD = 8.13; range = 24.22 to 78.65), respectively.

Overall results evidenced a high variability of skin color, especially for yellowness (b*), even if total xanthophyll content of the feeds was rather homogeneous (from 12 to 15 mg/kg of feed) among flocks. This result indicates that in addition to the pigment concentrations, other factors can play an important role in determining the final skin color of the birds.

The mean values found in this study are similar to those previously found by Bilgili et al. (1998) and Petracci and Fletcher (2002) in yellow-skinned broiler carcasses. Yellowness values were considerably lower than the findings by Pérez-Vendrell et al. (2001), which used birds fed a diet with higher xanthophyll content.

Regarding the effect of sex, females showed significantly ($P \leq 0.01$) higher values of lightness in breast and lower L* values in thigh and shank than males (Figure 1). As for redness, females exhibited significantly lower values in all body parts (Figure 2). Although the differences were statistically ($P \leq 0.01$) different, they are low in terms of absolute values; thus, they are of relatively little practical or industry importance.

The parameter that better describes the visual differences observed in skin color is yellowness, which was statistically ($P \leq 0.01$) higher in females than males in either breast (24.9 vs. 20.4), thigh (22.2 vs. 18.1), or shank (56.5 vs. 51.3) skin (Figure 3). The higher level of yellowness observed in female broilers can be due to their higher s.c. fat; indeed, broilers deposit a portion of adsorbed dietary pigments into the fat other than in the skin (Fletcher, 1992).

The results on the effect of strain on skin color of the different carcass parts are reported in Figures 4, 5, and 6. Lightness appeared slightly higher in Ross 508 birds either in breast, thigh, or shanks. The Ross 508 strain also had higher values of redness in breast and thigh and lower in shank, whereas Ross 308 birds appeared more yellow in all body parts. In this trial, we monitored the skin color on 2 commercial strains characterized by slight genetic differences, which are responsible for the presumably different ability to absorb

and deposit the carotenoid pigments in the skin and for the color differences observed this study.

Yellowness values of breast and thigh were significantly correlated ($r = 0.85$; $P < 0.01$; Figure 7). In addition, redness of breast and thigh showed a positive correlation ($r = 0.52$; $P < 0.01$), suggesting that the skin color evaluation may be carried out effectively regardless of the measurement position.

This study indicated that a high degree of skin color variability exists under commercial conditions with potential detrimental effects on the consistency of skin-on products' appearance. Both sex and genotype of the birds are important factors for this variability. Finally, to control the skin color consistency among different flocks, measurements of skin color with a colorimeter can be easily carried out in 1 of the 3 locations examined in this study. This objective color measurement may also represent a useful tool for evaluating broiler pigmentation in commercial slaughterhouses in substitution of visual scoring systems, which are commonly used today.

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