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THE EFFECT OF MEASUREMENT SITE ON THE EVALUATION OF TOM BREAST MUSCLE COLOUR*

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Measurement of colour is one of the methods for evaluating shortcomings in the quality of meat type PSE or DFD. There are no uniformly specified extreme values L* for the evaluation of faulty meat of gallinaceous poultry in the scientific literature. A uniform procedure for this measurement is also non-existent. The aim of this experiment was to determine the effect of colour measurements done in different sites of breast muscle (*pectoralis major*) on the evaluation of meat quality. The highest correlation coefficients between a trichromatic coordinate L* and defining muscle hydration capacity were found for the measurements taken inside the muscle with or without perimysium. None of the measurements done on the skin side show such correlations. The experimental results indicate that the measuring site of colour lightness L* of the breast muscle affect the classification of the meat as regular, faulty for PSE (bright) or DFD (dark).

INTRODUCTION

Type PSE meat results from a rapid glycolysis *post-mortem* at high carcass temperature [Sośnicki *et al.*, 1998]. Such meat becomes pale, soft, exudative, with decreased quality and production yield. It is characterized by low water-holding capacity and a structure of soft gel. Owens *et al.* [2000 b], while analyzing properties of PSE meat, found that meat brighter than normal exhibits properties typical of this fault. Bright meat occurs in 5–30% of birds and depends on the breeding conditions, season of the year, transporting conditions or stunning methods [Barbut, 1996, 1998; Sośnicki *et al.*, 1998; Lesiów & Kijowski, 2003].

Canadian scientists found DFD syndrome in the breast muscles of young and adult turkeys. The DFD fault is characterized by dark colour muscles, hard consistency and dry surface. According to their observations, the incidence of DFD fault in turkey has been increasing. This fault is frequently accompanied by cyanosis which causes the darkening of the carcass muscles during slaughter. Cyanosis is caused by an insufficient level of deoxymyoglobin in the body of a bird [Mallia *et al.*, 2000 a, b]. Meat exhibiting such irregularities of quality can be processed with the use of special recipes adjusted to meat properties on condition that quality shortcomings are found early enough [Owens *et al.*, 2000 b; Pospiech, 1997, 2000].

Based on the research into poultry meat, meat colour is determined by many qualitative properties. Meat colour in a biased evaluation by an observer is the result of two physical phenomena: dispersion and absorption of light projected on the surface. The light rays projected on the surface penetrate tissues and those not absorbed are reflected and reach the observer's eye. The intensity of light absorption depends on the depth to which light penetrates the tissues. The longer the distance of light penetration in the tissue, the more it is absorbed and the darker the colour is. The greater the refraction of light projected on the surface the brighter the meat colour. Greater hydration of muscular proteins also promotes deep penetration of light. High meat pH increases protein hydration. Factors inhibiting light penetration in meat decrease its transparency and cause a brighter meat colour. A low pH value accompanied by lower protein hydration is the basis of the correlation between pH and meat colour lightness. This means that as the content of free water increases in meat, the meat colour becomes brighter. Currently, there are two common systems for colour evaluation of meat and its products recommended by International Illumination Commission CIE L*, a*, b* and CIE L*, C*, H^o [Kłosowska & Olkiewicz, 2000; Klettner & Stiebing, 1980; Mussmann *et al.*, 1994]. Modern equipment allows a direct readout of L*, a*, b* values, which correlates well with colour visual sensation. A significant positive correlation was also observed for L* and drip loss. Higher free water content levels in meat were correlated to greater natural drip and lower water-holding capacity [Honikel & Hamm, 1994; after: Owens *et al.*, 2000 b].

The L* value measured as meat colour lightness is often used for the identification of PSE syndrome in meat. Publications by many authors showed that meat colour can be a very good criterion for the production classification of gallinaceous poultry meat [Allen, 1997; Sams *et al.*, 1997; Fletcher *et al.*, 2000; Owens, 2000 a, b; Barbut, 1993, 1995].

Recently, for the meat qualitative classification, the measurements of L* are more often made than pH readouts [Owens *et al.*, 2000 c; Buttles *et al.*, 2001; Qiao

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et al., 2000]. In the industry it is easier, faster and cheaper to evaluate meat based on its colour than with the use of glass electrodes that have to be replaced for each pH measurement. There is also the risk of breaking glass and the results are often encumbered with measuring errors [Barbut, 1996; Sante & Fernandez, 2000].

According to Sams *et al.* [1997] and Owens *et al.* [2000 c], the bracket values of the L* parameter in breast muscle classification (regardless of sex and age of turkeys) are as follows: regular meat L*<53, PSE meat L*>53. Mallia *et al.* [2000 a, b] classified regular meat at L*: 45–53 and DFD meat at L*<45. Barbut [1996], however, classified meat as regular at L*<50 and as PSE at L*>50.

The aim of this experiment was to determine the effect of colour measurements done in different sites of breast muscle (*pectoralis major*) on the evaluation of meat quality.

MATERIAL AND METHODS

The experimental material was breast muscle obtained from Big 6 toms (n=54). The birds were stunned by electrical shock (220 V, 50 Hz, 10 s). Scalding was carried out at 58°C. The carcasses were cooled by immersion and stored for 24 h in cool storage. Then, the cool carcasses were elemented. Surface breast muscles (*pectoralis major*) directly following their separation from the carcass and removal of skin, were analysed. Meat colour was evaluated within 15 min following skin removal. The meat colour evaluation was carried out externally (from the skin side) and internally (from the bone side) each time with or without perimysium [Mallia *et al.*, 2000 a]. One reading was made in the middle of the pectoralis muscle for each site. For the meat colour evaluation the DR LANGE SPECTRO COLOUR LMG-170 apparatus with a measuring opening of 8 mm in diameter was used. The apparatus was calibrated before use based on a white colour standard. The results were expressed according to the CIE system [Cydascale, 1978] as L*, a*, b*. Muscles selected for further analysis (n=9) were transported to the Department in insulated containers. In the ground muscles, the hydrogen ion concentration (pH) was measured with the use of an electrode combined with a PHM 201 RADIOMETER COPENHAGEN pH-meter.

In order to determine the water drip surface with the Grau Hamm method [Hamm, 1972], which is a measure of water retention, a 300 mg meat sample was placed on Whatman 1 filter paper between organic glass plates. The meat was treated at a pressure of 6630 Pa for 5 min. The juice area (cm^2) was measured with the use of an area Robotron Reiss integrator. The results were expressed as a percentage of free water in the muscle weight and as a percentage of free water in the total water content in the muscle [Pikul, 1993]. Drip loss was determined with the use of cubicoid muscle samples of similar dimensions and weights of 80–100 g [Honikel, 1998]. Thus, the prepared samples were weighed and kept for 4 days at 0–4°C on porcelain sieves (covered with aluminium foil). Mass decreases after 24 h, 48 h and 72 h (which were 48 h, 72 h and 96 h after slaughter) were given in percentage of the initial sample mass.

The experimental results were statistically analysed (correlation co-efficient, regression equation) with the use of Microsoft Excel. In order to determine whether the correlation between the analyzed variables is statistically significant, the critical values of a t-Student distribution were compared [Jóźwiak & Podgórski, 1998].

RESULTS AND DISCUSSION

Big 6 tom breast muscle colour was determined instrumentally by measuring it internally (from the bone side) with or without perimysium (respectively: L^*_1 and L^*_2) and externally (from the skin side; respectively: L^*_3 and L^*_4). A Pearson correlation coefficient (Table 1) was calculated to determine the strength of the correlations between the measured colour coordinates. Correlation coefficient significance was determined at the probability level of $\alpha=0.05$.

In evaluating the breast muscle (*pectoralis major*) colour lightness, a significant correlation was found between L* obtained from the measurement done at the bone side with or without perimysium $L^*_1 \times L^*_2$ (r=0.55) as well as for the measurements done on the skin side with or without perimysium $L^*_3 \times L^*_4$ (r=0.63). This does not determine a close connection between the analyzed colour coordinates

TABLE 1. Correlation coefficients for colour trichromatic coordinates of breast muscle (*pectoralis major*) of Big 6 turkeys (n=54).

	L^*_1	a^*_1	b^*_1	L^*_2	a^*_2	b^*_2	L^*_3	a^*_3	b^*_3	L^*_4	a^*_4
a^*_1	-0.32*										
b^*_1	-0.32*	0.70*									
L^*_2	0.55*	0.06	0.05								
a^*_2	0.14	0.35*	0.09	-0.07							
b^*_2	-0.25	0.00	0.08	-0.57*	0.18						
L^*_3	0.23	-0.07	0.21	0.34*	-0.12	-0.14					
a^*_3	-0.16	0.13	0.19	-0.16	-0.05	0.05	-0.30				
b^*_3	-0.17	0.10	0.16	-0.20	-0.05	0.02	-0.32*	0.85*			
L^*_4	0.20	-0.08	0.06	0.23	-0.04	-0.25	0.63*	0.05	-0.04		
a^*_4	-0.06	0.13	0.00	-0.11	0.31	0.10	-0.32*	0.40*	0.28	-0.17	
b^*_4	-0.11	0.10	0.06	-0.13	0.21	0.18	-0.13	0.25	0.17	-0.03	0.80*

Results denoted with * are statistically significant (P=0.05); L^*_1, … – internal measurement with perimysium; L^*_2 , … – internal measurement without perimysium; L^*_3, … - external measurement with perimysium ; L^*_4, … – external measurement without perimysium.

for tom breast muscle with or without perimysium. It is related to, among others, a varied structure of epimysium and muscle fibers. The determination coefficient (r^2) defining this correlation was from 0.30 to 0.40. The calculated correlation coefficient (r=0.23), defining a correlation between colour lightness evaluated for breast muscle with perimysium from the bone side and from the skin side $L^*_1 \times L^*_3$ as well as without perimysium ($L^*_2 \times L^*_4$), did not indicate a specific correlation with the analyzed coordinates. It results from the fact that the measurement from the skin side can be affected by colour changes occurring after scalding particular turkeys.

The highest L* extreme values were obtained for the internal measurements for muscles with perimysium ($L^*_{1min\text{-}max}$: 33.44–58.98). For the remaining measurements the colour lightness readouts were lower and ranged from 25.88 to 46.35.

In analyzing the coefficients defining correlation between indicators of the instrumental colour measurement, it was found that the breast muscle colour lightness L^*_1 (measured internally with perimysium) is slightly negatively correlated with a^*_1 and b^*_1 values. It means that as the muscle colour lightness increases, a decrease in the remaining colour trichromatic coordinates can be expected (red and yellow colours). The value of L^*_2 (measurement done internally without perimysium) was more strongly negatively correlated with yellow colour (b^*_2). It means that the content of yellow colour decreases along with an increase in the colour lightness (L^*_2). A similar correlation was observed for the measurement of L^*_3 and b^*_3. A decrease in yellow colour along with an increase in the L* parameter according to Johansson [1991; after: Kłosowska & Olkiewicz, 2000] who studied pork can be caused by the decrease in oxymyoglobin level. Moreover, the temperature of the muscle during measurement is of significant importance. Obviously, at lower meat temperatures (0–5°C), the oxymyoglobin concentration is higher than at higher temperatures. It results from a greater oxygen availability to produce oxymyoglobin [Potthast, 1987].

On the basis of the analysis of the correlation coefficients, it was also observed that there is a highly significant positive correlation between the red (a*) and yellow (b*) values, determined for the three measurement variants (r=0.70÷0.85). Such a correlation was not observed between a^*_2 and b^*_2.

Owens *et al.* [2000 b, c] and Fletcher *et al.* [2000] found a significant correlation between lightness L* and pH in turkey meat. Greater L* values corresponded with lower pH values, whereas lower L* values corresponded with greater values of meat pH. In the described experiment, another negative correlation was found between L* colour lightness and meat pH, measured 24 h after slaughter (Table 2). It means that as L* value increased, the pH_{24} value increased in meat. However, the correlation coefficients obtained for particular measurements varied and were not significantly correlated. The linear correlation between L* and breast muscle pH_{24} was also confirmed by, among others: Allen *et al.* [1997, 1998] (r=-0.75, P<0.01), Mallia *et al.* [2000 a, b] (r=-0.64, P<0.05), Owens *et al.* [2000 b] (r=-0.64, P<0.05), who obtained similar correlation coefficients.

Based on the results of many researchers, the muscle colour lightness is significantly correlated with the properties of muscle production value. It is considerably related with the correlation between L* and meat pH. Barbut [1995, 1997] showed the correlation between L* colour parameter and meat production parameters such as: texture, pH and hydration capacity. Sams *et al.* [1997], in their studies into turkey breast muscles, showed that higher L* colour value was correlated to lower material production values.

This experiment included an analysis of correlations between the colour lightness measurement in selected muscle sites and the discriminants defining its hydration capacity (Table 2). The highest coefficients were determined for the measurements done internally with or without perimysium. None of the measurements done from the skin side showed such correlations. It could suggest that the measurement done externally is encumbered with a greater error resulting from the process of carcass scalding.

The correlation between changes defining hydration capacity and colour lightness L^*_1 was not linear. The analysed correlations are more precisely defined by power and exponential equations (Figure 1). The values of determination coefficients defining changes in meat hydration capacity along with increases in colour lightness were slightly higher than for the linear equation. The correlation of changes defining meat hydration capacity and colour lightness expressed as L^*_2 is more precisely defined by a linear equation (Figure 2).

TABLE 2. Pearson's correlation coefficients defining correlation between the sites of measurements of meat lightness L* and the indicators of its hydration capacity (n=9).

		L^*_1	L^*_2	L^*_3	L^*_4
pH_{24}		-0.11	-0.27	-0.43	-0.50
Juice area		0.43	0.74*	0.16	0.18
Free water [%]		0.49	0.78*	0.11	0.12
Water [%]		0.67*	0.75*	-0.27	-0.08
Free water/ total water [%]		0.48	0.77*	0.12	0.13
Drip loss [%]	48 h	0.66*	0.64*	-0.15	-0.06
	72 h	0.65*	0.65*	-0.10	-0.01
	96 h	0.62*	0.67*	-0.06	0.05

* – significant at p=0.05

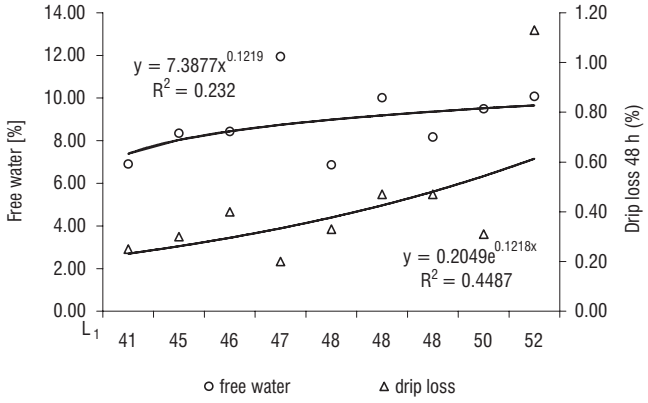

FIGURE 1. Correlation between colour values of lightness L^*_1 and hydration capacity of Big 6 turkey breast muscles.

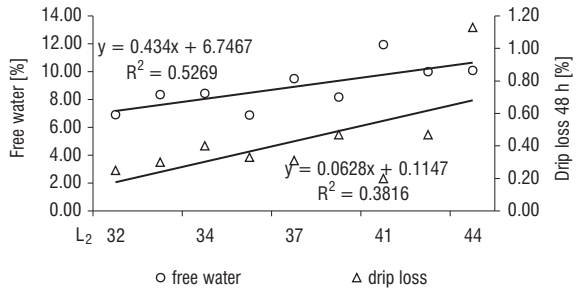

FIGURE 2. Correlation between colour values of lightness L^*_2 and hydration capacity of Big 6 turkey breast muscles.

CONCLUSION

The results indicate that the measuring site for the evaluation of breast muscle (*pectoralis major*) colour lightness L* determines the meat classification as regular, PSE (bright) or DFD (dark).

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WPŁYW MIEJSCA POMIARU NA OCENĘ BARWY MIĘŚNIA PIERSIOWEGO INDORÓW

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Pomiar barwy jest jedną z metod określania wad jakości mięsa typu PSE czy DFD. Z danych literaturowych wynika, że przyjęte wartości graniczne L* dla określenia wad mięsa drobiu grzebiącego nie są jednoznacznie określone. Brak jest jednolitej metody postępowania podczas dokonywania takiego pomiaru. Celem badań było określenie, w jakim stopniu odczyty barwy dokonane w różnym punkcie mięśnia piersiowego (*pectoralis major*) wpływają na ocenę jego jasności. Najwyższe współczynniki korelacji pomiędzy współrzędną trójchromatyczną L*, a wyróżnikami określającymi zdolności hydratacyjne mięśnia uzyskano dla pomiarów dokonanych od wewnętrznej strony mięśnia po usunięciu omięsnej, jak również z omięsną (tab. 1). Żaden z pomiarów przeprowadzonych od strony skóry nie wykazywał takich zależności. Wyniki badań wskazują, że miejsce pomiaru jasności L* mięśnia piersiowego indorów ma wpływ na zakwalifikowanie surowca mięsnego jako normalnego, z wadą PSE (jasne) czy DFD (ciemne).