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COLOUR MEASUREMENTS AS A METHOD FOR THE ESTIMATION OF CERTAIN CHICKEN MEAT QUALITY INDICATORS

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ABSTRACT

The research work presents an attempt at determining relations between the colour of breast and thigh muscles in broiler chicken, measured by objective methods (reflex and digital image analysis) and chosen indicators of their technological value. The results obtained indicate that the protein content in meat is significantly related to colour lightness of mature meat, measured by the reflex method (L*) and to component G, determined by way of digital image analysis (DIA). Relations were also observed between colour lightness and both pH and the water holding ability of mature meat and between b* value (reflex method) and B (DIA method) ant the total content of hem pigments. This indicates the possibility of using those measurements for the estimation of certain indicators of chicken meat quality.

Key words: chicken meat, technological value, meat colour, digital image analysis

INTRODUCTION

The tendency to lower production costs and thus to intensify poultry production methods results in a deterioration in meat quality, expressed principally by a poorer water holding ability and water binding capacity, too light colour, its varied saturation and poorer palatability. For economic reasons it is of considerable importance to find a certain and reliable method of detection, directly after slaughter, of meat of poor technologic value [4, 18].

The meat industry is currently testing the possibility of using various methods for the estimation of meat quality as well as for the detection of various defects. Among them are laboratory and palatability methods and such that may by introduced directly at the slaughter line: pH measurement, measurement of conductivity, optical properties (colour components). In the case of large scale production of special importance are methods which render it possible to perform measurements “on line” and which are simultaneously quick and non-invasive [6, 15, 20]. Among such methods is counted the objective measurement of colour components.

Receving the effect of colour its the result of two physical events: diffusion and absorption of light striking the surface. With greater diffusion of light the colour is lighter when with increased absorption the colour is darker [21]. A character of colour depends on three factors : access of light, presence of pigments (their amount and chemical state) and properties of bedding on which pigments are settle, making more difficult or easier penetration of light inside product, affecting the coefficient of light refraction and the amount of light absorb or reflected by product [8].

An analysis of the appearance of meat, including its colour and lightness, is being performed already for a long time. However, it consists principally of a visual appraisal, performed by trained specialists.

A visual evaluation of meat is burdened by the subjectivism of the classifier. Moreover, the possibilities of using it in the production process is limited. However, with the development of visional cameras and computer technique it became possible to substitute the human eye with an optical system [10].

One of the methods of objective evaluation of meat colour is measuring the colour components by the reflex method. It is an objective method for colour evaluation by measuring reflectance spectrum of the surface at characteristic light wave lengths. Values a*, b* and L*, thus obtained, are well correlated with the visual colour evaluation [1, 8, 14]. There are well known correlation between red meat colour lightness (L*) and its technological value. Measurement of lightness enable to differentiate normal from PSE or DFD meat. Recently there is a growing number of research projects using this method for evaluation of the quality of poultry meat. The preliminary results shows some similarity to red meat, there are several correlation between physicochemical properties and lightness of meat.

Another objective method of colour determination is a digital analysis (DIA). This method renders it possible to objectivise the visual evaluation by, among much else, obtaining quick, repeatable results. It is being increasingly often used in the processing industries as a method of “on line” measurement or as a quick and simple measurement method 9, 11, 12].

Investigations on the use of the digital analysis are increasingly often introduced into meat technology. Using this method one may analyse the whole course of meat processing as it renders it possible to characterise the raw material and the results obtained are an alternative for chemical analyses. Moreover, it comprises information about the range of changes within the structure of the muscle tissue under the influence of different mechanisms and additives [11, 12]. KAO method can be used for post mortem evaluation of carcasses, both beef and pork. The results of the measurement can be used for decision making about different use of meat - for culinary or processing [17]. This method is recently introduced (or implemented) in the poultry industry for evaluation of chick or turkey carcass muscling. There is little information but growing interest for using KAO for quick estimation of technological properties of meat.

PROJECT OBJECTIVES

The correlation between colour of poultry meat (measured by objective methods) and selected quality characteristics were studied. If such correlation can be proved then the colour measurements can be used for quality estimation and programming of the most economical use of available raw materials in the poultry processing plant.

MATERIALS AND METHODS

The material consisted of chicken breast and drumstick muscles. It was obtained from the SuperDrob S.A. poultry meat processing plant in Karczew. Samples from 45 chicken carcasses were analysed.

The carcasses were removed from the production line directly after evisceration and placed in the plant laboratory. Within 25 minutes after slaughter (“hot” meat) the carcasses were marked, the skin was separated from one breast muscle and one drumstick muscle and the pH measurement was taken (using a CP-315

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pehameter with a composite glass-calomel electrode). Later on the measurement of colour values (a*, b*, L*) were taken by reflectance method using Minolta, with similar to red meat parameters (e.g. standard observer 2°, light D_{65}). Colour measurements were made also by way of a digital image analysis (DIA). With this aim the carcasses were placed in a stand standardising the lighting conditions (halogene lighting 3 x 20W) and the distance between the sample and the lens (50 cm), and photographed against a black background (digital camera Olympus C1400L). The image obtained, after conversion by a graphic card and subjection to a mathematical and statistical analysis, was used for determining colour components R, G and B (red, green and blue) of meat.

After completing the measurements described the carcasses were placed in an air cooler and cooled for 55 minutes (temperature 4±2°C). After cooling the carcasses were covered with comminuted ice and transported to the Department of Meat Technology, Warsaw Agricultural University, where they were stored in a refrigeration room for 24 hours (at a temperature of 4±2°C). Next the second breast and drumstick muscles were uncovered (cold meat) and the same measurements were made (pH, colour components by the reflex method and a digital camera photograph). After completing the measurements a breast and drumstick muscle was separated from each carcass. The samples were minced twice in a laboratory grinder (plate 5 mm) and next thoroughly mixed. In material thus prepared the following analyses were made: cooking loss (30 g of meat were heated in a covered beaker at a temperature of 72°C for 30 min), water holding ability (Grau and Hamm method), content of water (according to the Polish Norm PN-73/A-82110), protein content (total nitrogen by the Kjeldahl method according to Polish Norm PN-75/A-04018 calculated into protein by multiplying by 6.25) and level of total hem pigments (Hornsey's method (1956)). The second breast and drumstick muscles were covered again with the skin and stored in a refrigeration room for further 24 hours (at a temperature of 4±2°C). Forty eight hours after slaughter pH was measured in whole muscles as well as colour components (reflex method) and digital camera photographs were taken. On the remaining, not minced breast muscle, measurements of cutting force were made. For this measurement a ZWICKY machine was used with a Warner-Bratzler device. The maximum cutting force (Fmax) was read at a head movement of 50 mm/min on samples 20×40×20 mm (the results were calculated per 1 cm^2 of sample cross-section). The measurements were made on a muscle cured in brine (1% NaCl, 24 h), heated (85°C, 50 min) and next cooled (4°C, 24 h). The results obtained were subjected to a statistical analysis using the Startgraphic 4.1 programme – analysis of correlation and Student t test for $\alpha = 0.05$.

RESULTS AND DISCUSSION

Characteristics of the material

An examination of the technological value of poultry meat showed that it is characterised by indicators typical for this type of material (Table 1). It was ascertained that the breast and drumstick muscles used for investigations differed significantly as regards both the content of water, protein, total hem pigments and the chosen indicators of technological value. Breast muscles, as compared to the drumstick muscles, were characterised by a higher content of water and protein and contained about half the hem pigment that the drumstick muscles contained. Moreover, in breast muscles was observed a lower pH, higher cooking loss and higher drip loss as compared to drumstick muscles. The indicators of technological value analysed for individual muscles proved to be linked with their pH.

Table 1. Mean values for the analysed chicken meat quality indicators

	Breast muscles X±S	Drumstick muscles X±S
Water content [%]	74.7 ± 0.64	73.4 ± 1.04
Protein content [%]	23.1 ± 0.69	19.0 ± 0.75
Total content of hem pigment [ppm hemin]	23.1 ± 6.54	48.9 ± 5.93
pH_1 (measured 25 min after slaughter)	6.46 ± 0.12	6.51 ± 0.13
pH_{24} (measured 24 hours after slaughter)	5.69 ± 0.09	6.33 ± 0.14
pH_{48} (measured 48 after slaughter)	5.64 ± 0.11	6.28 ± 0.11
Thermal drip [%]	3.0 ± 1.23	8.3 ± 1.97
Water holding ability [cm^2/g]	15.3 ± 3.29	12.9 ± 3.02
Cutting force [N]	6.0 ± 1.10	-

X – mean value, ±S – standard deviation

The value of chicken meat colour as measured by the reflex method for the evaluation of its quality

Meat colour is one of the basic indicators of meat technological and culinary value and an important criterion deciding about its value and purchase [7, 19].

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In the present work colour was measured by the reflex method on "hot" (25 min after slaughter) and cold (24 and 48 hours after slaughter) meat. The analysis covered the breast and drumstick muscles. The mean results obtained are presented in Table 2.

In a majority of the cases analysed it was observed that both the muscle type and the length of time from slaughter after which the measurement was performed, significantly affected the values obtained for individual colour components.

Table 2. Mean values for colour analyses of chicken muscles conducted using the reflex and DIA method

Colour components		Breast muscles X ± S	Drumstick muscles X ± S
Reflex method			
	a^*_1	1.04 ± 0.64	4.94 ± 1.33
Measurement 25 min after slaughter	b^*_1	1.38 ± 0.94	2.25 ± 1.64
	L^*_1	49.06 ± 2.00	51.80 ± 3.33
	a^*_{24}	0.86 ± 0.87	3.81 ± 1.72
Measurement 24 hours after slaughter	b^*_{24}	3.90 ± 1.66	2.94 ± 2.04
	L^*_{24}	58.49 ± 2.66	55.92 ± 3.15
	a^*_{48}	1.25 ± 0.81	4.37 ± 1.34
Measurement 48 hours after slaughter	b^*_{48}	4.29 ± 1.66	3.51 ± 1.79
	L^*_{48}	56.92 ± 2.39	54.61 ± 2.53
DIA method			
	R_1	206 ± 2.78	203 ± 4.65
Measurement 25 min after slaughter	G_1	112 ± 5.95	108 ± 8.81
	B_1	86 ± 6.41	88 ± 7.93
	R_{24}	211 ± 2.65	207 ± 4.37
Measurement 24 hours after slaughter	G_{24}	137 ± 6.00	119 ± 8.98
	B_{24}	104 ± 6.46	94 ± 7.79
	R_{48}	213 ± 3.19	209 ± 4.66
Measurement 48 hours after slaughter	G_{48}	134 ± 5.76	120 ± 9.34
	B_{48}	100 ± 6.60	95 ± 8.83

X – mean value, ±S – standard deviation

In order to determine the relations between colour components a*, b* and L* in the breast and drumstick muscles of chicken and chosen indicators of technological value correlation coefficients were calculated as well as regression equations for significant relations.

A statistical analysis demonstrated that the highest number of information about the quality of breast and drumstick muscles in chicken may be obtained by determining their colour lightness (L*). With this trait, measured for breast and drumstick muscles, was significantly correlated protein content (muscles with a lighter colour had a lower protein content) and water binding ability (muscles with a lighter colour showed a higher drip loss). Moreover, an inversely proportional relation was observed between the L* colour component and pH in cold breast muscles. The correlation between poultry meat colour lightness and its technological quality were reported by other authors. Barbut [2] showed significant correlation between lightness of turkey breast muscles and his pH value and water holding capacity. Later on this author [3] proved the possibility of using measurement of colour values for detection of clear-out evidence of PSE meat. Curdy et al. [13] showed connection between lightness and cooking loss and tenderness of turkey meat.

For the estimation of total hem pigments in the chicken muscles examined also the b* colour component may be used (with the increasing concentration of pigment the values for colour component b* decreased).

In a majority of the cases analysed higher values for correlation coefficients were observed when the colour was analysed in a cold muscle and not directly after slaughter. Higher values were also obtained for the breast muscles than for drumstick muscles. Measurements of colour of matured poultry meat in order to evaluate its quality can be made during operation of cutting into parts and removing of breast muscles from the corps. The first step of this process should be partial removing of skin from the muscle thus enable measurements of colour by reflectance method.

The values obtained for the more important correlation coefficients are presented in Table 3.

Table 3. Chosen, significant correlations between colour components determined by way of the reflex or DIA method and indicators of the technological quality of breast and drumstick muscles in chicken

Muscle	Correlation examined		Correlation coefficient	Linear regression equation
	Variable X	Variable Y		
Breast	L^*_{24}	Protein content	-0.43^{aa}	y=-0.11x+29.66
Drumstick	L^*_{24}	Protein content	-0.28^{a}	y=-0.07x+22.69
Breast	b^*_{1}	Total content of hem pigment	-0.40^{aa}	y=-2.20x+31.11
Breast	b^*_{48}	Total content of hem pigment	-0.33^{aa}	y=-1.31x+28.73
Breast	L^*_{24}	pH_{24}	-0.64^{aa}	y=-0.02x+6.62
Breast	L^*_{48}	Water holding ability	0.52^{aa}	y=0.71x-25.15
Drumstick	L^*_{24}	Water holding ability	0.35^{aa}	y=0.37x-6.17
Breast	G_{48}	Protein content	-0.33^{aa}	y=-0.03x+26.79
Drumstick	G_{24}	Protein content	-0.28^{a}	y=-0.02x+21.60
Breast	B_{1}	Total content of hem pigment	0.40^{aa}	y=0.37x-7.30
Drumstick	B_{1}	Total content of hem pigment	0.28^{a}	y=0.21x+30.33

aa – correlation significant at $\alpha = 0.05$, a – correlation significant at $\alpha = 0.1$

The value of chicken meat colour as measured by digital analysis for the evaluation of its quality.

A digital image analysis is a method, which may be used for determining the basic morphological traits and colour of the sample [10].

In the present work the colour components (R, G, B), determined by a digital analysis, were determined three times, i.e. in "hot" meat within 25 minutes after slaughter and in cold meat – 24 and 48 hours after slaughter. Mean values for individual colour components are presented in Table 2.

Similarly as in the case of colour measurement by the reflex method, in a majority of cases significant differences were observed for colour components R, G, and B between breast and drumstick muscles and between "hot" and cold meat.

The statistical analysis conducted demonstrated, that colour values determined by way of a digital image analysis render it possible, due to the regression equations calculated, to estimate the protein and total hem pigment content (Table 3). Protein content was correlated with colour value G (an inversely proportional correlation), while the level of total hem pigment with colour value B (the relation was directly proportional). The lack of a univocal relation between colour values R, G and B and the remaining indicators of the technological value of chicken meat limits the possibility of using the digital image analysis for evaluating those parameters. Use of KAO method for estimation of quality of poultry meat is a new idea and there are some difficulties to compare obtained results with observation of other authors.

There is more information available on using this method for quality estimation of red meat. Sakowski et al. [16] and Dasiewicz et al. [5] suggest that this method can be used for estimation of technological quality of beef. The colour values correlated with several important technological quality factors e.g. amount of proteins, pH of "hot" and "mature" meat, water holding capacity, cooking loss, hardness and results of sensory evaluation of taste and tenderness.

CONCLUSIONS

1. Significant correlations exist between colour value L* and G, determined for mature breast and drumstick muscles and the protein content, what indicates a possibility of using those traits for the estimation of protein content in chicken meat.
2. The observed significant correlations between colour value b* in "hot" or cold breast muscles and component B in "hot" breast and drumstick muscles and the total level of hem pigments indicates the possibility of using those measurements for estimating the level of total hem pigments in chicken meat.
3. The significant correlations observed between colour lightness (L*) and water holding ability of breast and drumstick muscles and the pH of mature breast muscles indicate that it is possible to use this measurement for estimating the technological value of chicken meat.
4. The higher correlation coefficients observed in most cases between the mature meat quality indicators and colour components measured by the reflex method than by the digital image analysis indicate that the former method may be used for estimating the quality of mature chicken meat.

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