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Influence of housing system on selected quality characteristics of duck meat. Chapter 1. Pekin duck

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Abstract: *Influence of housing system on selected quality characteristics of duck meat. Chapter 1. Pekin duck.* The objective of this study was to determine the effect of housing system on the selected quality characteristic of breast muscles of Pekin (P-44) ducks. The ducks were divided into four experimental groups according to their sex and housing system: intensive system (IS) and outdoor system (OS). Analysis was performed for a total of 48 breast muscle (12 in each experimental group: 2 × gender; 2 × rearing system). For test samples of meat there were determined: chemical composition: moisture, protein, fat, ash and pH_{24}, cooking loss (%), shear force (N), color, flavor, tenderness, juiciness, stringiness and overall consumer acceptance. There was no effect of housing system on the proximate composition of breast muscles of both P-44 ducks. Rearing system of ducks P-44 had significant (P <0.05) effect on cooking loss, L*, tenderness, juiciness and overall acceptation. The meat of males vs females P-44, regardless of the rearing system, was characterized by significantly (P <0.05) higher L* value and lower a*. The Principal Component Analysis (PCA) showed, that meat of P-44 ducks from free range system is better perceived by the consumers than the meat of P-44 ducks from the intensive system, mainly for its greater tenderness and juciness.

Key words: Pekin duck, rearing system, meat quality

INTRODUCTION

Chicken and turkey broilers take the greatest share in the world production of poultry meat. In certain European countries, for instance in France or Czech Republic, similar to Asian market, an increase in the production of slaughter ducks is observed (Huda et al. 2011). Duck meat is highly appreciated as it combines the characteristics of red meat (containing, for example, high levels of phospholipids, precursors of aromas) and the dietetic characteristics of poultry meat (containing, for example, high levels of unsaturated fatty acids). Duck meat has higher fat content and also higher levels of heme pigments (hemoglobin and myoglobin) than chicken and turkey meat (Smith et al. 1993, Baéza 2006a, Witak 2008).

Qualitative properties of duck meat can be developed by the following factors: genotype, age, sex, feeding and keeping conditions (Baéza 2006a, Chartrin et al. 2006, Castellini et al. 2008). In Europe, the ducks most commonly used for the production of broilers are

the Pekin ducks. Rearing period of the Pekin ducks (males and females) lasts 7 weeks.

In Europe the leading housing system of poultry is the intensive system (Baéza 2006b). However, every year poultry production, especially of chicken broilers, increases in both the systems, free range and ecological, which, according to numerous authors (Pietrzak et al. 2006, Mikulski et al. 2011, Zhao et al. 2014), ensures better welfare of the birds and at the same time the meat obtained from them is characterized by higher quality. For consumers the welfare of the birds becomes an increasingly important factor taken into consideration while purchasing meat products (Napolitano et al. 2010, Norwood and Lusk 2011). Aim of the study was to determine the effect of the housing system on selected quality characteristics of Pekin (P-44) duck meat.

MATERIAL AND METHODS

Experimental materials and procedures

The study material consisted of the breast muscles of Polish Pekin ducks of the P-44 line (Kokoszyński et al. 2010). To 3 weeks of age all birds (180 males and 180 females) were kept according to the guidelines for intensive production system on deep litter and at a stocking density of 2.9 birds per 1 m^2. Thereafter, half the ducks and drakes were allowed to use free ranges, at a stock density of 0.08 birds per 1 m^2 (outdoor system – OS). The remaining birds were kept under conditions of intensive production (IS) throughout the rearing period. Production results of ducks related to the growth characteristics, fodder use, mortality and slaughter efficiency have already been published (Damaziak et al. 2014). The P-44 ducks and drakes were kept until 7 weeks of age. After rearing was finished, 12 males and 12 females with body weight similar to the mean for a given sex were selected for slaughter. Slaughter of ducks and post-slaughter processing were conducted using the industrial method, in accordance with the technical sanitary requirements of the poultry industry. Carcasses were chilled with the use of the air chilling method at a temperature of 4°C for 24 h. After cutting breast muscles (*pectoralis major*) from the carcasses, test samples were prepared in accordance with the methodology described by Murawska (2012).

Physico-chemical analysis

Percentage moisture, protein, fat and ash content were determined in meat samples according to the Association of Official Analytical Chemists (AOAC 2005). All chemical analyses were carried out in duplicate. Moisture content by drying a ca 5 g test sample at 105°C (±2°C) until reaching a constant weight; ash content by incinerating a ca 3–5 test sample in a muffle furnace at 550°C until light grey ash results; protein content by the classical marco-Kjeldahl method using Kjeltec System 1026 Distilling Until (Foss Tecator, Höganäs, Sweden); and fat content by petroleum ether ex-

traction using a Büchi Extraction System B-811 (Büchi Labortechnik AG, Flawil, Switzerland).

Ultimate pH (pH_{24}) was measured with a CP-411 pH-meter (Elmetron, Zabrze, Poland), with a glass-calomel electrode, after the homogenization of 10 g raw muscle with 10 mL distilled water. The pH-meter was calibrated in buffers of pH 4.00 and pH 7.00 at 20°C. All results were expressed as the average values obtained from two separate measurements. The L*a*b* color parameters (CIELAB color space; CIE, 1986) were determined on the surface of freshly ground duck meat with a Minolta spectrophotometer CM-2600d (Konica Minolta LTD, Tokyo, Japan: light source D65, observer 10°, a measuring head hole 8 mm) calibrated to the white plate (L* = 99.18, a* = −0.07 and b* = −0.05). The color parameters were represented on the CIE color scales in terms of L* (lightness per darkness), a* (redness per greenness) and b* (yellowness per blueness). Each measurement was performed in five replicates, taking the mean value as the assay result. For the calculation of absolute color difference (between color of breast muscles in IS and OS ducks) the following formula was used:

$$\Delta E = \sqrt{(L^*_1 - L^*_2)^2 + (a^*_1 - a^*_2)^2 + (b^*_1 - b^*_2)^2}$$

where:
ΔE – absolute color difference;
L^*_1, a^*_1, b^*_1 – breast muscle color parameters in IS ducks;
L^*_2, a^*_2, b^*_2 – breast muscle color parameters in OS ducks.

In the elaboration of the results the criterion adopted by the International Commission on Illumination was used, according to which absolute color differences (ΔE) are classified as perceived by the human eye. It was assumed that absolute color differences between 0 and 2 are undistinguishable, from 2 to 3.5 distinguishable by an experienced observer, and over 3.5 the clear differences between colors are easily observed (Heidelberg-Anonim 1999).

The cooking loss of intact fillets were determined by weighing the fillets and then cooking in a convection oven on aluminum trays at 180°C to an internal temperature of 75°C. The fillets were drained, allowed to equilibrate to room temperature, and weighed. Cooking loss was determined by expressing cooked sample weight as a percentage of precooked sample weight following the procedure of Bianchi et al. (2005). Twenty-four hours after heat treatment, from each muscle five samples with cross section (1 × 1 cm) were cut out along the muscle fibers. They were used for the measurement of share force with the use of the research device Zwicki 1120 (Zwick, Germany), equipped with the Warner-Bratzler shear device. Maximum share force (F_{max}) was read at the head speed of 0.83 mm/s. The experiment was conducted until the decrease of the share force, after cutting the sample, reached 75% F_{max}. As the result of the determination mean from five measurements was

adopted. Sensory evaluation of the breast muscles was conducted by a 12-member team with the appropriate qualifications. Equal bite size from each treatment was coded, replicated thrice and served in odorless plastic plates. Each sample was evaluated independent of the other. The samples were evaluated on a nine-point hedonic scale for color, flavor, tenderness, juiciness, stringiness and overall acceptability (9 is extremely desirable and 1 is extremely undesirable).

Statistical analysis

Prior to the statistical analysis, data were checked for normality by the Shapiro–Wilk test. The homogeneity of variance across treatments was assessed by Levene test. The statistical analysis was conducted with the Software System Statistica ver. 10 (StatSoft Inc. 2011). For the critical level of significance $P<0.05$ was adopted. Differences of determined characteristics were analyzed with the use of two-way analysis of variance including the housing system and sex, according to the following model:

$$Y_{ij} = \mu + P_i + U_j + (PU)_{ij} + e_{ij}$$

where:
Y – trait;
μ – general mean;
P_i – effect of i-th sex, $i = 1.2$;
U_j – effect of j-th housing system;
$(PU)_{ij}$ – effect of interaction between sex and housing system;
e_{ij} – random error.

To estimate statistical difference between average values the Tukey test was applied. Furthermore the results were developed using the Principal Component Analysis (PCA). This method makes it possible to study the relationships between hierarchical variables and their graphical presentation in the form of data points (retaining a maximum amount of information), whose mutual arrangement is the result of the analysis.

RESULTS AND DISCUSSION

Keeping conditions and gender did not significantly influence the proximate chemical composition of the breast muscles (Table 1). Similar results were obtained by Witak (2008) and Erisir et al. (2009), who studied the effect of housing system and gender on the chemical composition of Pekin Star 52 duck meat.

No significant effect of housing conditions on pH_{24} of breast muscles of P-44 (Table 2) ducks was determined. The mean pH value of duck meat is generally between 5.7 and 5.9 (Larzul et al. 2006, Witak 2008). The amount of cooking loss during heat treatment of breast muscles of P-44 OS ducks was significantly higher ($P<0.05$) than in P-44 IS. No effect of housing conditions on breast muscle texture of P-44 (Table 2) ducks was determined. Breast muscles of P-44 IS ducks were characterized by darker color than in P-44 OS, which is evidenced by significantly ($P<0.05$) lower values of the L* color parameter (Table 2). However, the calculated absolute color differences indicate that these

TABLE 1. Effect of housing system and sex on the chemical composition of the breast muscles of P-44 ducks (each value is presented as mean ±*SD*; *n* = 12)

Specification	Sex	Chemical composition (%)			
		moisture	protein	fat	ash
Intensive system	males	76.5 ±0.2	20.2 ±0.1	1.8 ±0.1	1.5 ±0.1
Outdoor system		76.8 ±0.1	20.0 ±0.1	1.7 ±0.1	1.5 ±0.1
Intensive system	females	76.3 ±0.2	20.3 ±0.4	1.9 ±0.2	1.5 ±0.1
Outdoor system		76.8 ±0.3	19.7 ±0.1	2.0 ±0.1	1.5 ±0.1
Housing system		NS	NS	NS	NS
Sex		NS	NS	NS	NS
Housing system × sex		NS	NS	NS	NS

NS – not significant ($P > 0.05$).

TABLE 2. Effect of housing system and sex on the physico-chemical properties of the breast muscles of P-44 ducks (each value is presented as mean ±*SD*; *n* = 12)

Treatment	Sex	pH_{24}	Cooking loss (%)	Shear force (N)	Color			Δ*E*
					lightness L*	redness a*	yellowness b*	
Intensive system	males	5.9 ±0.0	20.5 ±0.3	30.7 ±1.4	38.6 ±1.1	11.4 ±0.6	13.3 ±0.1	1.4
Outdoor system		5.9 ±0.0	24.3 ±0.7	29.1 ±3.6	39.9 ±0.9	11.3 ±0.2	13.8 ±0.6	
Intensive system	females	5.9 ±0.0	19.9 ±0.7	32.3 ±3.7	34.5 ±1.6	12.0 ±0.5	13.5 ±0.2	3.2
Outdoor system		5.9 ±0.0	24.8 ±0.3	30.6 ±0.9	37.5 ±0.3	12.9 ±0.6	13.4 ±0.3	
Housing system		NS	**	NS	**	NS	NS	×
Sex		NS	NS	NS	**	**	NS	
Housing system × × sex		NS	NS	NS	**	NS	NS	

** Difference significant; NS – not significant ($P > 0.05$).

differences can only be distinguished by an experienced observer (Heidelberg-Anonim 1991). In the sensory evaluation, scores for the color of breast muscles of P-44 IS and P-44 OS ducks were determined at a similar level (Table 3). Regardless of the housing conditions, the breast muscles of P-44 female ducks showed significantly ($P < 0.05$) lower values of the L* color parameter and higher a* color parameter than of the males.

Color is one of the more important meat quality characteristics from the consumer's viewpoint. It is also an important indicator of the technological applicability of meat as a raw material, which can then be directly sold or sent for further processing (Wołoszyn et al. 2009, Mikulski et al. 2011). In the sensory evaluation (Table 3) breast muscles of P-44 OS ducks received significantly ($P < 0.05$) higher scores for such charac-

TABLE 3. Effect of housing system and sex on the sensory attributes of the breast muscles of P-44 ducks (each value is presented as mean ±*SD*; *n* = 12)

Specification	Sex	Color	Flavor	Tenderness	Juiciness	Stringiness	Overall acceptance
Intensive system	males	5.3 ±0.1	5.3 ±0.1	5.8 ±0.1	5.0 ±0.1	5.0 ±0.3	5.6 ±0.1
Outdoor system		5.3 ±0.3	5.3 ±0.1	6.4 ±0.1	5.1 ±0.1	5.4 ±0.3	6.1 ±0.1
Intensive system	females	5.3 ±0.1	5.3 ±0.1	6.2 ±0.2	4.9 ±0.1	5.0 ±0.2	6.0 ±0.1
Outdoor system		5.3 ±0.2	5.4 ±0.2	6.4 ±0.2	5.3 ±0.2	5.1 ±0.3	6.1 ±0.1
Housing system		NS	NS	**	**	NS	**
Sex		NS	NS	**	NS	NS	**
Housing system × sex		NS	NS	**	**	NS	**

** Difference significant; NS – not significant ($P > 0.05$).

teristics as tenderness, juiciness and overall acceptability, compared to P-44 IS.

Table 4 contains the loadings for the first three principal components (PCs) with their variances of the breast muscles of P-44 ducks (male and female). The PC1 explained for 33.12% of the total variance and was associated with tenderness, overall acceptability, cooking loss and stringiness. The PC2 accounted for 25.63% of the total variance and was associated with juiciness and L*. On the other hand, PC3 explains 19.85% of variance and was formed by share force and fat. Distribution of meat samples of P-44 (male and female) ducks kept in intensive and outdoor system is shown on the PCA map (Fig.). Proximate position of the meat samples on the PCA map demonstrates their similarity, the distance demonstrates their differences. P-44 duck meat samples coming from different housing systems were heterogeneous. Breast muscles of male and female P-44 ducks from the OS system formed a cumulative group located on the right side of the PCA map. They were characterized by greater overall acceptability, especially due to greater tenderness than P-44 from the IS system (located on the left side of the PCA map). PCA demonstrated that meat of female P-44 ducks from the IS system was better perceived by consumers than the meat of males, primarily due to greater tenderness and juiciness. The sensory quality of IS ducks' meat was strongly dependent on its stringiness. This trait was the reason of worse (lower) consumer evaluation (Fig.).

TABLE 4. Loadings for the first three PCs of the breast muscles of P-44 ducks (male and female)

Traits	PC1	PC2	PC3
Tenderness	0.261	0.006	0.008
Juiciness	0.021	0.253	0.152
Stringiness	0.189	0.171	0.035
Overall acceptance	0.209	0.068	0.013
Cooking loss (%)	0.261	0.081	0.305
Lightness L*	0.019	0.295	0.001
Fat	0.001	0.053	0.443
Share force	0.037	0.081	0.305

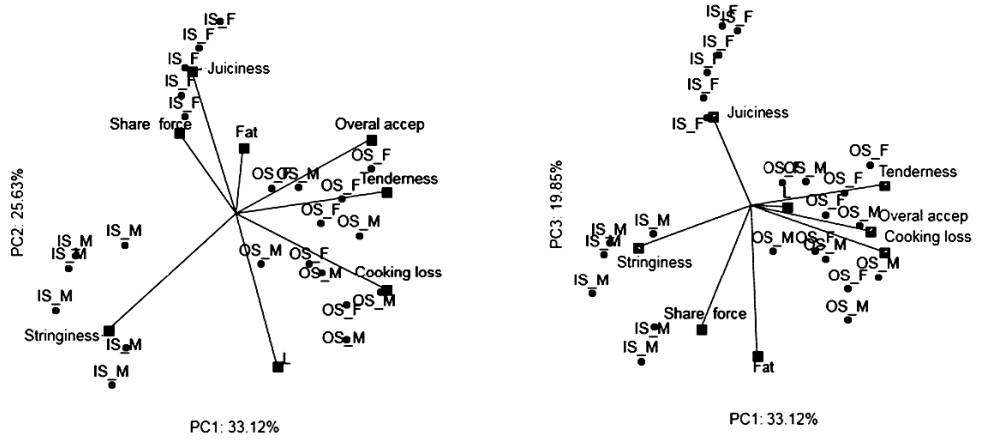

FIGURE. PCA biplot of breast muscle samples of P-44 ducks: IS_F – females, IS_M – males kept in intensive system; OS_F – females, OS_M – males kept in outdoor system

CONCLUSIONS

This study demonstrates that to obtain high quality meat, P-44 ducks can be successfully kept in the outdoor system. Such meat might be an interesting proposition for consumers, who, while purchasing meat products, pay attention not only to their high quality, but also to the welfare of the birds before slaughter. Future research should be broadened to include the interaction of origin, age, sex and housing system of ducks. Rearing system of ducks had no significant effect on chemical composition, pH_{24} and cutting force, but influenced meat color. The meat of ducks from free range rearing system were brighter than the meat from the intensive rearing. Free range rearing system brought a positive effect on the examined traits of P-44 ducks' meat. Better tenderness and juiciness were the features of the meat from the ducks reared in free range system than the ones fed intensively.

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Streszczenie: *Wpływ system utrzymania na wybrane cechy jakościowe mięsa kaczek. Część 1. Kaczki Pekin*. Celem niniejszych badań było określenie wpływu systemu utrzymania na wybrane cech jakościowych mięśni piersiowych kaczek Pekin (P-44). Kaczki podzielono na cztery grupy doświadczalne w zależności od płci i systemu utrzymania: system intensywny (IS) i system z dostępem do wybiegu (OS). Analizy przeprowadzono łącznie dla 48 mięśni piersiowych (po 12 dla każdej grupy doświadczalnej: 2 × płeć; 2 × system utrzymania). Dla badanych prób mięsa oznaczono: skład chemiczny: zawartość wody, białka, tłuszczu i popiołu, pH_{24}, wyciek termiczny (%), siłę cięcia (N), barwę, smak, kruchość, soczystość, sprężystość i ogólną akceptację konsumenta. Nie stwierdzono wpływu systemu utrzymania na skład chemiczny mięśni piersiowych kaczek P-44. System chowu kaczek P-44 miał znaczący (P <0,05) wpływ na straty podczas obróbki cieplnej, L*, kruchość, soczystość i ogólną akceptację konsumenta. Mięso samców w porównaniu z mięsem samic P-44 bez względu na system utrzymania charakteryzowały znacznie (P <0,05) większe wartości L* i mniejsze wartości a*. Statystyczna wielowymiarowa analiza składowych głównych (PCA) wykazała, że mięso kaczek P-44 utrzy-

mywanych w systemie wolno wybiegowym było lepiej postrzegane przez konsumentów w porównaniu z mięsem kaczek P-44 utrzymywanych w systemie intensywnym, głównie ze względu na większą kruchość i soczystość.

Słowa kluczowe: kaczki pekin, system utrzymania, jakość mięsa

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