Praca oryginalna *Original paper*

Influence of genotype on duck meat colour

JANINA WOŁOSZYN, GABRIELA HARAF, JULIUSZ KSIĄŻKIEWICZ*, ANDRZEJ OKRUSZEK

Department of Animal Food Technology, Faculty of Engineering and Economics, University of Economics, Komandorska 118/120, 53-345 Wrocław, Poland
*Department of Animal Genetic Resources Conservation, National Research Institute of Animal Production, 32-083 Balice, Poland; Branch Campus of the Biotechnology of University of Rzeszów, 36-100 Kolbuszowa, Werynia 505, Poland

Wołoszyn J., Haraf G., Książkiewicz J., Okruszek A.

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Summary

The aim of the study was to determine the influence of different genotypes on the meat colour of ducks from conservative and breeding strains. Seventy male duck carcasses from seven flocks (Pekin population – type A3, Miniduck – K2, Polish Pekin – P33, Orpinghton fauve – O1, synthetic strain – SB, the meat type breeding: P66 – maternal strain, the meat type breeding: A55 – sire strain) were used for comparison (10 ducks from each flock). Birds were slaughtered at the 8th week of age. The investigation of breast muscles included the following aspects: the determination of the colour parameters L* (lightness), a* (redness), b* (yellowness), and ΔE (colour difference); total haem pigment content (THP), including myoglobin (Mb), oxymyoglobin (MbO_2) and metmyoglobin (MMb); sensory evaluation (SE) of the colour intensity of raw muscles on a 10-point scale. The duck muscles from the P66 and P33 flocks were significantly higher in L* ($P \leq 0.01$) and lower in a* ($P \leq 0.01$) than the others. The lowest value of L* was observed in the muscles from the K2 flock. A significant diversity of colour parameters between breast muscles from different flocks was observed. The pairs of duck muscles from the SB, A55 (ΔE = 0.22) and the P66, P33 (ΔE = 0.61) flocks were the most similar in terms of colour parameters. As regards the total haem pigment content (THP), the examined breast muscles can be divided into two groups. The muscles from the P66, P33 and O1 flocks belong to the group with a lower THP content (3.77, 3.82, and 3.95 mg/g respectively), whereas the muscles from the A55, A3, SB, and K2 flocks had a higher THP content (4.46, 4.63, 4.65 and 4.97 mg/g respectively). The muscles from the A3 and K2 flocks showed a significantly higher Mb content than P66, P33 and O1. The muscles from the P33, P66 and SB flocks had a significantly lower MbO_2 content than the rest ($P \leq 0.01$). MbO_2 was predominant in duck muscles. The MMb content was highly diversified and depended on the genotype, ranging from 0.38 mg/g to 1.09 mg/g. The highest MMb content was observed in the muscles from the K2 ($P \leq 0.01$) flock but this value did not exceed the level that would render the colour undesirable. The sensory panel defined the colour of breast muscles as pink-red and the surface colour intensity scores ranged from 5.90 to 6.99 CU. The breast muscles from the K2 flock were characterized by the highest intensity of red-pink (6.99 CU). Generally, the duck muscles from the K2, A55, A3 and SB flocks were evaluated as darker (6.99, 6.83, 6.71, 6.51 CU respectively) than the duck muscles from the P66, P33 and O1 flocks (5.90, 5.93, 6.08 CU respectively). The results obtained in our research indicate a large total colour variation of samples within breeds. Colour differences (ΔE) between flocks were within the range of 0.22-5.77. With only a few exceptions, flocks with the ΔE value higher than 2, differed significantly in heam pigment content, L* a*, b* parameters, and sensory panel scores. The conducted research suggests that the genotype has a significant effect on the duck meat colour.

Keywords: ducks, meat, colour, genotype

Among many quality traits of meat, colour has always been considered a very important feature. Colour is regarded as an indicator of meat freshness by many consumers, and therefore can be the main factor which influences their purchasing behaviour. The impression of colour is caused by the diffusion and absorption of light falling on a surface. However, the shade of colour depends on the kind and concentration of pigments. The relative proportions of myoglobin forms, such as purple deoxymioglobin (Mb), red oxymyoglobin (MbO_2) and brown metmyoglobin (MMb), determine the colour of fresh meat. In fact, all factors affecting meat colour influence directly or indirectly the concentration and chemical state of myoglobin as well as the physical structure of meat (12, 14, 19). Colour depends on the breed, age, genotype, and sex of the animal (8, 23), as well as the type of muscle (21), feeding, pre-slaughter treatment and stress (6, 20),

method of slaughter (5), electrical stimulation (23), and storage conditions (22). Colour can be affected by a combination of these and many other factors (19).

The National Research Institute of Animal Production in Kraków has carried out a breeding program for the preservation of duck genetic resources. Genetic reserve flocks include, among others, native Pekin population – type A3, Miniduck – K2, Polish Pekin – P33, Orpington faouve – O1, cross-breeds of Pekin-type ducks of English origin, SB – belonging to the conservative flocks and two Pekin-type breeding strains: A55, P66. The populations of O1, P33, K2, A3, SB, A55 and P66 ducks have been tested for reproductive and meatiness traits so far (10, 13). These populations of birds, unique on an international scale, are maintained *in situ* at the Department of Waterfowl Breeding in Dworzyska. The birds are characterized by very good health, resistance to variable, often adverse climatic conditions of their region of origin and good conversion of farm-produced feeds (9). Previous studies concerned mainly carcass traits such as body weight, percentage yield of muscles, skin with subcutaneous fat and abdominal fat in the carcass.

However, data on the functional traits of meat of specific duck populations are scarce, and that is why an investigation into the quality of muscles is needed. The aim of the study was to determine the influence of different genotypes on the meat colour of ducks.

Material and methods

The following ducks (male), maintained *in situ* at the Department of Poultry Breeding in Dworzyska, were used for the research: Pekin population – type A3 (progeny of a commercial stock imported from England in 1977); Miniduck (K2) – bred from wild mallards (*Anas platyrhynchos L.*) and Pekin-type ducks; Polish Pekin (P33) – native of an old indigenous breeding strain subjected to selection and taken from the farm at Borowy Młyn; Orpinghton fauve (O1 – yellow variety) – progeny of a breeding stock bought in France in 1971; synthetic strain (SB) – obtained by crossing A1, A2 and A3 (progeny of a stock imported from Cherry Valley Farm) with each other for ten years (they have the same share of each group A1, A2, A3); the meat type P66 – maternal strain – bred from Pekins of American and English-German origin; the meat type A55 sire strain – obtained by crossing A44 (bred from Pekins and Aylesbury and selected over 22 years) with P8 (Pekins of Danish origin) over 17 consecutive years of selection (9, 10, 13, 25).

During the testing period, ducks were reared up to the 4th week of age in a poultry house with a controlled air temperature, and afterwards they were kept on fenced yards, partially shaded and covered with straw. All birds were fed *ad libitum* on the same complete feeds. This diet contained 20% of crude protein and 12.13 MJ metabolizable energy until the 3rd week of age and later 16.5% of crude protein and 12.34 MJ metabolizable energy per 1 kg of feed. At the 8th week of age, from each flock (comprising 60 birds) ten males with body weights close to the arithmetic mean in particular flocks were selected for analysis (K2 –1789 g, v% = 8.0; P33 – 2589 g, v% = 6.3; A3 – 2723 g, v%, = 5.6; SB – 2476 g, v% = 5.5; A55 – 2925 g, v% = 7.5; P66 – 2678 g, v% = 6.4; O1 – 1925 g, v% = 6.7).

The slaughter of birds and the dissection of breast muscles were carried out in a local slaughterhouse. The breast muscles were stored at 2-4°C for 24 h after slaughter and then examined.

The analysis included the determination of haem pigment content (concentration of total haem pigments and its derivatives: myoglobin [Mb], oxymyoglobin [MbO_2] and metmyoglobin [MMb]). Pigments were extracted according to the procedure described by Pikul (16). The absorbency was measured at 525, 545, 565 and 572 nm using the Hewlett-Packard Diode Array UV/VIS Spectrophotometer. The concentration of total haem pigments (THP) and relative concentrations of Mb, MbO_2 and MMb were calculated by the equations provided by Krzywicki (11).

The colour parameters of the surface of muscles i.e. lightness (L*), redness (a*) and yellowness (b*) were determined with the Minolta CR – 310 ChromaMeter. Colour differences (ΔE) were calculated by the formula $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$, where ΔL*, Δa* and Δb* were differences between the mean values of L*, a* and b*, respectively, for individual flocks (ΔE).

The sensory evaluation of the colour of raw muscles and its intensity was conducted by a sensory panel, using the Analsens NT programme with a 10-point scale (1 – very light colour; 10 – very dark colour). The intensity was expressed in conventional units (CU) (3). The sensory panel consisted of 7 trained testers.

All tests for each muscle were performed three times.

Statistical analysis was based on arithmetic mean ($\overline{x}$) and standard deviation (sd). The results for each flock were analysed by one-way analysis of variance (Anova) in a non-orthogonal scheme. Significant differences between average values were determined by Duncan's multiple range test. The statistical analysis was conducted with the Software System Statistica, version 7.1.

Results and discussion

Physicochemical parameters and results of the sensory evaluation of the colour of raw muscles are shown in tab. 1. While comparing the colour parameters of breast muscles of male ducks, significant differences were found. The muscles of P66 and P33 were significantly higher in L* ($P \leq 0.01$) and lower in a* ($P \leq 0.01$) than the others. These muscles were also characterized by a higher b* value ($P \leq 0.01$) than the rest. The lowest L* value was observed for K2 muscles. The colour differences (tab. 2) indicate that pairs SB, A55 (ΔE = 0.22) and P66, P33 (ΔE = 0.61) were the most similar in terms of colour parameters. However, P33 and P66 were the most distinct from the other flocks (ΔE_{P33} = 3.24 – 5.77; ΔE_{P66} = 2.78 – 4.93). The colour of P33 muscles differed the most in comparison with A3 (ΔE = 5.77), and P66 differed the most from K2 (ΔE = 4.93).

Tab. 1. Characteristics of duck breast colour (n = 60; $\bar{x} \pm sd$)

Parameter	Flock						
	A3	K2	P33	O1	SB	P66	A55
L*	40.30 ± 0.53^{Da}	39.40 ± 0.54^{Ab}	43.60 ± 0.75^{B}	41.00 ± 0.78^{Ca}	40.70 ± 0.21^{Da}	43.40 ± 1.15^{B}	40.50 ± 0.55^{Da}
a*	20.34 ± 1.01^{A}	20.91 ± 1.72^{A}	17.90 ± 0.85^{B}	18.12 ± 0.63^{B}	19.32 ± 1.95^{A}	18.42 ± 0.65^{B}	19.40 ± 1.60^{A}
b*	3.01 ± 0.47^{A}	3.74 ± 0.84^{A}	5.71 ± 1.14^{B}	3.78 ± 0.92^{A}	3.19 ± 0.54^{A}	5.22 ± 1.26^{B}	3.24 ± 0.84^{A}
THP (mg/g)	4.63 ± 0.09^{Ba}	4.97 ± 0.10^{Cb}	3.82 ± 0.11^{A}	3.95 ± 0.21^{A}	4.65 ± 0.20^{Ba}	3.77 ± 0.09^{A}	4.46 ± 0.29^{B}
Mb (mg/g)	1.67 ± 0.07^{Ba}	1.64 ± 0.07^{Ba}	1.30 ± 0.08^{A}	1.30 ± 0.07^{A}	1.53 ± 0.09^{bD}	1.13 ± 0.07^{C}	1.43 ± 0.06^{D}
MbO_2 (mg/g)	2.50 ± 0.10^{A}	2.43 ± 0.10^{A}	2.14 ± 0.09^{B}	2.49 ± 0.11^{A}	2.32 ± 0.09^{B}	2.26 ± 0.12^{B}	2.59 ± 0.14^{A}
MMb (mg/g)	0.51 ± 0.02^{Ba}	1.09 ± 0.07^{A}	0.38 ± 0.02^{C}	0.16 ± 0.02^{D}	0.79 ± 0.04^{E}	0.38 ± 0.03^{C}	0.45 ± 0.03^{Ca}
SE (CU) – red-pink intensity	6.71 ± 0.11^{A}	6.99 ± 0.28^{A}	5.93 ± 0.12^{B}	6.08 ± 0.30^{Ba}	6.51 ± 0.42^{Ab}	5.90 ± 0.11^{B}	6.83 ± 0.23^{A}

Explanations: means carrying different superscripts in the same line differ significantly ($P \leq 0.05$ a – b); ($P \leq 0.01$ A – E); Mb – myoglobin content; MbO_2 – oxymyoglobin content; Mb – metmyoglobin content; THP – total haem pigment content; SE – sensory evaluation (expressed in CU – conventional unit)

Tab. 2. Colour differences (ΔE) between individual flocks

Flock	A3	K2	P33	A55	P66	SB	O1
A3	–	1.24	5.77	0.96	4.19	1.25	2.41
K2	1.24	–	5.53	1.93	4.93	2.18	3.21
P33	5.77	5.53	–	4.24	0.61	4.09	3.24
A55	0.96	1.93	4.24	–	2.78	0.22	1.48
P66	4.19	4.93	0.61	2.78	–	3.39	2.85
SB	1.25	2.18	4.09	0.22	3.39	–	1.19
O1	2.41	3.21	3.24	1.48	2.85	1.19	–

Explanations: ΔE – the differences in L*, a*, b* between individual flocks

The values of L*, a* and b* reported by Kisiel and Książkiewicz (8) for K2 and P33 were somewhat different than the results obtained by the authors of this paper, but the nature of the revealed differences was the same: P33 had significantly higher values of L*, and b* colour parameters than K2. In the breast muscles of Mullards, values similar to our results for L* (41.14) but considerably lower for a* (11.72) and higher for b* (12.61) were found by Baeza et al. (2). Skrabka-Błotnicka et al. (21) obtained the following values for breast muscles of Muscovy ducks: L* = 42.27, a* = 20.99, and b* = 4.83. However, Romboli et al. (20), studying breast muscles of Muscovy ducks, observed L* = 40.43, a* = 17.44, and b* = 5.71. The results obtained by these authors were similar to the results presented in this paper. Wołoszyn (24) carried out research on breast muscles of force-fattened male Mullards. The results for a* (24.55) and b* (6.58) were higher than the present findings but L*(40.88) was very close to SB, A55, A3, and O1. Mullard breast muscles were also characterized by a higher differentiation in colour parameters between sexes. Haraf et al. (7), studying breast muscles of seven-week-old female Kh1, O1, P8, K2, P33, SB, observed a higher L* (above 44.0) and lower a* (below 17.0) compared with the muscles examined in the present research. The muscles of females were more homogenous than the examined here; only the female muscles of K2 differed distinctly in pigment content and colour from the others.

As regards the total haem pigment content, breast muscles can be divided into two groups: P66, P33 and O1 belong to the group with a lower THP content (3.77, 3.82, and 3.95 mg/g respectively), whereas A55, A3, SB, and K2 had a higher THP content (4.46, 4.63, 4.65 and 4.97 mg/g respectively). Differences between these two groups are statistically significant at $P \leq 0.01$ and $P \leq 0.05$. The Mb content in breast muscles ranged from 1.13 mg/g (for P66) to 1.67 mg/g (for A3). A3 and K2 showed significantly higher Mb content than P66, P33 and O1 (tab. 1). The MbO_2 content varied from 2.14 mg/g (for P33) to 2.59 mg/g (for A55). The MbO_2 content in P33, P66 and SB was significantly lower than in the other flocks ($P \leq 0.01$). The MMb content was more differentiated and dependant on the genotype: it ranged from 0.38 mg/g to 1.09 mg/g. The highest MMb content was observed in K2 ($P \leq 0.01$) but it did not exceed the level that would render the colour undesirable. Considering the obtained results, oxymyoglobin was predominant in duck muscles.

Breast muscles of force-fattened male Mullards were characterized by a similar THP content (4.69 mg/g) to A55, A3 and SB, but a lower than K2. It was observed that Mullard muscles included more Mb (1.97 mg/g), the same amount of MMb but significantly less MbO_2 (1.66 mg/g) than all other examined flocks (24). Pikul et al. (17, 18) and Niewiarowicz et al. (15) found a similar range of THP values (from 3.68 to 4.54 mg/g) in Pekin breast muscles. A considerably lower pigment content in the muscles of 8-week-old White Pekin (2.75 mg/g) was found by Alexieva et al. (1).

The sensory panel defined the colour of breast muscles as pink-red and the surface colour intensity scores ranged from 5.90 to 6.99 CU. The breast muscles of K2 were characterized by the highest intensity of red-pink (6.99 CU) but the differences between K2 and A55, A3, and SB were not significant. Generally, the muscles of K2, A55, A3 and SB were evaluated as darker (6.99, 6.83, 6.71, 6.51 CU respectively) than P66, P33 and O1 (5.90, 5.93, 6.08 CU respectively). These results were somewhat different than colour parameters. This can be explained by the fact that the measurement of sensory traits (L*, a*, b* parameters) by human senses and by instruments cannot be substituted: the results of instrumental methods are related to physical stimuli creating sensations, while sensory evaluation informs about the sensations caused by the stimuli. Therefore, the two methods of measuring sensory characteristics of foods are complementary but cannot be substituted (4).

Conclusion

On the basis of the obtained results, it can be concluded that the muscles of P66 and P33 are significantly lighter in colour than the others. These muscles were characterized by lower pigment contents, and were evaluated as lighter than the rest by the sensory panel. Considering the total haem content and sensory evaluation, breast muscles can be divided into two groups. Flocks P66, P33 and O1 belong to the group with a lower THP content and the intensity of red-pink colour, while A55, A3, SB, and K2 had a higher THP and the intensity of red-pink colour. The muscles of P33 and P66 contained less Mb, MbO_2, whereas those of K2 were characterized by a higher MMb content in comparison with the others. A relation was established between the ΔE values and statistically significant differences in colour parameters, pigment content and the sensory evaluation of colour. If ΔE equalled more than 2, there was a high probability that the traits analysed in the paper would differ significantly between these groups. Only few exceptions to this rule can be found (A3 and O1 – parameter L*, K2 and SB – parameter SE, P33 and O1 – parameter THP, O1 and P66 – parameters THP and SE). The conducted research suggests that the genotype has a significant influence on the duck meat colour.

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Author's address: dr hab. inż. Janina Wołoszyn prof. UE, Uniwersytet Ekonomiczny, ul. Komandorska 118/120, 53-345 Wrocław; e-mail: janina.woloszyn@ue.wroc.pl