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# Heritability of some meat quality traits in ducks*

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**The aim of the study was to estimate the heritability coefficients of fourteen meat quality traits in ducks. The study was conducted on 387 individuals of an F2 cross of Polish and French Pekin ducks. The following traits were examined in the breast (BM) and leg (LM) muscles: electrical conductivity at 15 minutes post-slaughter (BMEC15 and LMEC15), pH at 24 hours post-slaughter (BMpH24 and LMpH24), thermal drip (TDBM and TDLM) and lightness (L*) (LBM and LLM). Additionally, sensory traits were evaluated in the raw breast (BM) and leg (LM) muscles: colour (CRMB and CRLM), odour (ORBM and ORLM) and general appearance (GARBM and GARLM). Estimators of the variance components were obtained by the Restricted Maximum Likelihood method, using ASReml computer software. In general, varied heritability estimates were obtained: 0.01 (BMEC15), 0.16 (LMEC15), 0.01 (BMpH24), 0.06 (LMpH24), 0.07 (TDBM), 0.06 (TDLM), 0.08 (LBM), 0.07 (LLM), 0.08 (CRBM), 0.73 (CRLM), 0.11 (ORBM), 0.92 (ORLM), 0.24 (GARBM), and 0.40 (GARLM).**

**KEY WORDS: meat quality / heritability / sensory assessment / ducks**

With the diversification of the meat market, duck breeding takes on a greater importance. Duck meat has been popular in South-East Asia for many decades, and has recently become increasingly popular in European Union countries, including Poland. Duck meat has many valuable qualities [3, 10]. It should be noted that apart from objective and me-

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asurable meat quality traits, another important consideration is consumer impressions, and underlying these are the results of a sensory evaluation by a panel of experts [4, 9]. Unfortunately, knowledge of the genetic backgrounds of these traits is still limited.

This study is a continuation of research whose results were presented by Mucha et al. [16, 17], Gornowicz et al. [10] and Moliński et al. [15]. Findings have included identification of regions of the duck genome (using the polymorphism of 25 microsatellite markers) which explain a small portion of the genetic variation in some meat quality traits—from 2.7% (the odour of raw leg muscle) to 3.2% (electrical conductivity of the leg muscle).

Poultry production is based mainly on 'commercial sets', which in practice are individuals from crosses of pure lines [24]. The present study analysed a population of crosses which was established for an experiment focused on gene mapping, but can also be viewed as a potential offer for duck meat producers, especially in the context of the short interval between generations.

The aim of the study was to estimate the heritability of some meat quality traits in ducks.

## Material and methods

The experiment was carried out after obtaining the consent of the Local Ethics Commission for Animal Experiments in Poznan. The study was conducted on 387 individuals of an F2 cross of lines A-55 (Polish Pekin ducks) and GL-30 (French Pekin ducks) on a private duck farm in Nowa Wieś Wielka near Buk (Wielkopolska). The ducks were housed indoors without access to a paddock, fed ad libitum the same feed, whose nutritional value is specified in a declaration by its manufacturer (see: Gornowicz et al. [10]). For twelve hours before slaughter the birds received no feed, but had permanent access to water. Slaughter and post-slaughter processing were carried out under the same technological conditions.

The analysis covered the following breast (BM) and leg (LM) muscle traits, measured instrumentally:

- electrical conductivity 15 minutes post-slaughter (BMEC15, LMEC15)
- pH 24 hours post-slaughter (BMoH24, LMpH24)
- lightness L* 24 hours post-slaughter (LBM, LLM)

At 48 hours post-slaughter thermal drip was determined (TDBM, TDLM).

Additionally, 48 hours post-slaughter a sensory evaluation was performed on the raw breast (BM) and leg (LM) muscle, including the following traits:

- colour (CRBM, CRLM),
- odour (ORBM, ORLM),
- general appearance (GARBM, GARLM).

The concentration of hydrogen ions was measured with a portable pH meter manufactured by Mettler-Toledo (Switzerland) with the symbol MP 125 DE and an Inlab 427 calomel electrode. Electrical conductivity was measured with a Matthäus LF-STAR apparatus (Germany). Lightness L* was evaluated [5] using a Minolta Chroma Meter C580 electronic trichromatic colorimeter (light source D65, observer 10°, 8 mm measuring cell, white calibration standard: L* - 99.18). Thermal drip was estimated using a method introduced by Pikul [19].

A sensory evaluation (according to PN-ISO 6658 [20]) was conducted for the raw breast and leg muscle. The evaluation was performed on chilled elements, according to the methodology developed by Ziołecki [26] and modified by Baryłko-Pikielna and Matuszewska [4]. A four-point scale from 2 to 5 was used, with 2 indicating the lowest quality and 5 very good (desirable) quality. For each characteristic tested, scores were assigned with accuracy to 0.5 points. The final score was calculated as the average of the individual scores, with accuracy to 0.1 point. The evaluation was performed by a panel of five experts, properly trained in accordance with Polish Standards [21] and with many years of experience. Basic statistics for each trait (mean, standard deviation and median) are given in Table 1.

The pedigree data covered 454 individuals, including 28 founders and 39 individuals constituting the F1 generation—parents of the ducks whose traits were observed. Since on the day of slaughter (at 11 weeks of age) the birds could not always be identified as male or female, molecular methods were used, according to the methodology described by Clinton et al. [6].

The mean, standard deviation and median were estimated for each trait. Normality of distribution of random residuals was tested by the Shapiro-Wilk test. Next, preliminary modelling was used to assess the impact of gender on the recorded traits, for inclusion of this effect in the model to evaluate variance components. Statistical inference was based on the Wilcoxon rank sum test. These computations were performed using the R package [22]. The variance components were estimated using the REML method, based on the following single trait animal model:

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{Za} + \boldsymbol{e}$$

where:

$\boldsymbol{y}$ – 378×1 vector of observations

$\boldsymbol{\beta}$ – 2×1 vector of fixed effects for sex

$\boldsymbol{a}$ – 454×1 vector of random additive genetic effects

$\boldsymbol{e}$ – 387×1 vector of random residual effects

$\boldsymbol{X}, \boldsymbol{Z}$ – known incidence matrixes corresponding to the fixed and random effects, with dimensions of 387×2 and 387×454, respectively. The heritability estimates ($h^2$) and their standard errors were estimated (SE($h^2$)). The heritability was estimated as the ratio of the additive genetic variance to the phenotypic variance, according to the following formula [11]:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

where:

$\sigma_a^2$ – additive genetic variance,

$\sigma_e^2$ – random residual variance, interpreted as the environmental variance.

This part of the calculations was carried out using the ASReml package [8].

## Results and discussion

A good indicator of water-binding by muscle tissue is measurement of its initial electrical conductivity. In the case of poultry, it is most often measured 15 minutes after slaughter. The results obtained, BMEC15 = 6.23 mS/cm and LMEC15 = 4.60 mS/cm (Table 1), indicated that the meat was of good quality [23]. This was confirmed by the results for the thermal drip, which did not exceed 16.75%. In a study by Larzul et al. [13], the average thermal drip of the breast muscles was 20.63% in Pekin-type ducks and up to 24.57% in Muscovy ducks.

**Table 1**
Means, standard deviations and medians of the analysed traits (n=387)

| Trait | Units | Mean | Median | Standard deviation |
|---|---|---|---|---|
| BMEC15 | mS/cm | 6.23 | 6.20 | 0.08 |
| LMEC15 | mS/cm | 4.60 | 4.50 | 0.06 |
| BMpH24 | | 5.96 | 5.95 | 0.00 |
| LMpH24 | | 6.26 | 6.24 | 0.01 |
| TDBM | % | 16.70 | 16.33 | 0.14 |
| TDLM | % | 16.19 | 16.40 | 0.16 |
| LBM | | 44.49 | 44.04 | 0.20 |
| LLM | | 51.23 | 51.26 | 0.15 |
| CRBM | points | 4.61 | 4.60 | 0.01 |
| CRLM | points | 4.28 | 4.30 | 0.02 |
| ORBM | points | 4.63 | 4.60 | 0.00 |
| ORLM | points | 4.47 | 4.50 | 0.01 |
| GARBM | points | 4.29 | 4.50 | 0.03 |
| GARLM | points | 4.26 | 4.30 | 0.02 |

BMEC15 – electrical conductivity of breast muscle at 15 minutes post-slaughter, LMEC15 – electrical conductivity of leg muscle at 15 minutes post-slaughter, BMpH24 – breast muscle pH after 24 hours, LMpH24 – leg muscle pH after 24 hours, TDBM – thermal drip of breast muscle, TDLM – thermal drip of leg muscle, LBM – lightness (L*) of breast muscle, LLM – lightness (L*) of leg muscle, CRBM – colour of raw breast muscle, CRLM – colour of raw leg muscle, ORBM – odour of raw breast muscle, ORLM – odour of raw leg muscle, GARBM – general appearance of raw breast muscle, GARLM – general appearance of raw leg muscle

The average pH values in the breast and leg muscle measured after 24 hours were very similar to the mean values reported by Witak [25] in ducks at 7, 8, and 9 weeks of age. These were 5.74 for breast muscle and 6.26 for leg muscle. The pH obtained in the present study (BMpH24 = 5.96 and LMpH24 = 6.26) is indicative of normal post-mortem glycolytic changes in the muscle; according to the literature this allows it to be classified as poultry meat of good technological quality [12, 23]. This is particularly evidenced by the fact that the level of this parameter was uniform between individuals, as the standard deviation was 0.00 for BMpH24 and 0.01 for LMpH24.

The average colour of the muscle as defined by the L* parameter in the individuals analysed in our study was 44.9 LBM and LLM 51.23, which was much lighter than in A-44 Pekin ducks imported from the UK. For these birds the value of the L* parameter was 30.56 for breast muscle and 32.23 for leg muscle [25]. It should be noted that in the analysed literature the meat colour parameters measured with a colorimeter were much different. Similar lightness L* of breast muscle was observed [13] in Pekin ducks (44.9) and mulards (44.2).

The heritability estimates and their standard errors are presented in Table 2. In the case of the measurable meat quality traits, the heritability estimates were lower and did not exceed 0.1, except for electrical conductivity (0.16). It should be stressed that the standard errors of these parameters were high. From a practical point of view, such low heritability coefficients do not bode well for future selection. It is worth recalling that the analysed population comes from a crossbreeding experiment (see: Mucha et al. [17]), and that all the animals were kept in the same environmental conditions. The analyses were performed on a relatively small group of birds, in the context of estimation of genetic parameters, which is not without impact on the estimated standard errors for $h^2$. There are not many reports dealing with estimation of the heritability of meat quality traits in ducks. However, low heritability (0.02) of breast muscle pH has been reported in mulard ducks [14], which was confirmed in our research. The same values for heritability of this trait were obtained in a population of Barbary ducks [3]. In the case of breast muscle lightness L*, the estimates were lower in the population we studied (0.08) than in a study by Marie-Etancelin et al. [14], in which the heritability of this trait was 0.12. Higher estimates were presented by Alnahhas et al. [1] for broiler chickens; in this case the heritability of the L* parameter for the breast muscle was 0.58. Equally high estimates for $h^2$ were achieved for the breast and leg muscle: 0.57 and 0.41, respectively. In the case of Japanese quail, Narinc et al. [18] reported estimates of the heritability of breast muscle pH at a level of 0.73. In contrast, in a Brazilian broiler flock the heritability of breast muscle pH was low and did not exceed 0.30, and the same was true for the L* parameter of meat colour [7].

In the case of the sensory evaluation of meat traits, higher heritability estimates were obtained, with relatively high variation. Much higher heritability estimates were obtained for the leg muscle traits than for breast muscle traits. For example, for the odour and colour of the leg muscle, $h^2$ was 0.92 (SE($h^2$)=0.17) and 0.73 (SE($h^2$) = 0.17), respectively, while the heritability of the corresponding traits in the breast muscle was

**Table 2**
Heritability estimates ($h^2$) for meat quality traits and their standard errors (SE($h^2$))

| Trait | Heritability coefficient | Standard error of heritability coefficient |
|---|---|---|
| BMEC15 | 0.01 | 0.03 |
| LMEC15 | 0.16 | 0.11 |
| BMpH24 | 0.01 | 0.04 |
| LMpH24 | 0.06 | 0.06 |
| TDBM | 0.07 | 0.06 |
| TDLM | 0.06 | 0.05 |
| LBM | 0.08 | 0.07 |
| LLM | 0.07 | 0.06 |
| CRBM | 0.08 | 0.08 |
| CRLM | 0.73 | 0.17 |
| ORBM | 0.11 | 0.08 |
| ORLM | 0.92 | 0.17 |
| GARBM | 0.24 | 0.13 |
| GARLM | 0.40 | 0.16 |

BMEC15 – electrical conductivity of breast muscle at 15 minutes post-slaughter, LMEC15 – electrical conductivity of leg muscle at 15 minutes post-slaughter, BMpH24 – breast muscle pH after 24 hours, LMpH24 – leg muscle pH after 24 hours, TDBM – thermal drip of breast muscle, TDLM – thermal drip of leg muscle, LBM – lightness (L*) of breast muscle, LLM – lightness (L*) of leg muscle, CRBM – colour of raw breast muscle, CRLM – colour of raw leg muscle, ORBM – odour of raw breast muscle, ORLM – odour of raw leg muscle, GARBM – general appearance of raw breast muscle, GARLM – general appearance of raw leg muscle

0.11 (SE($h^2$)=0.08) and 0.08 (SE($h^2$)=0.08). It can be assumed that the differences in the values of these parameters for the breast and leg muscle were mainly linked to the significantly different proportion of intramuscular fat in the two types of muscle, which is characteristic of ducks [3, 10]. Intramuscular fat content and fatty acid profile have been shown to determine a number of physical and sensory meat traits [2, 25]. Interestingly, the heritability of the colour of broiler meat was higher, ranging from 0.50 to 0.57 [2]. Smaller disparities in heritability coefficients were found for the general appearance of the two muscle groups: 0.24 (breast muscle) and 0.40 (leg muscle).

Comparison of the mean values and medians of the traits shows that the low $h^2$ estimates do not result from overestimation of the residual variance. It is worth recalling that overestimation of the variance (and thus underestimation of the heritability coefficient) increases when the empirical distribution of the trait differs from the normal distribution. The arithmetic means and medians are very similar (Table 1). As mentioned above, all observed animals were reared at the same time and in the same environmental conditions. This may suggest the existence of other (unidentified) effects, or perhaps minor genetic variation in the traits.

Interpretation is much easier in the case of highly heritable traits, because while it does not necessarily indicate their high variation, it certainly it corresponds to low environmental variability.

The meat from the experimental crosses of Pekin ducks was characterized by good quality, expressed in physical parameters (EC15 electrical conductivity, pH24 and lightness L*) and sensory parameters (odour, colour and general appearance) desired by consumers. However, high heritability coefficients were obtained only for the odour (0.92) and colour (0.73) of the leg muscle.

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