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# COMPARISON OF BASIC INTERNAL AND EXTERNAL EGG QUALITY TRAITS OF BROWN AND WHITE EGG-LAYING HENS IN RELATIONSHIP TO THEIR AGE

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## Abstract

This study was focused on the comparison of the brown and white eggs from two laying hybrids. The objective was to assess basic quality traits of eggs from both groups of hens and compare them. The impact of how age influences the technological value of eggs was also observed. The most important correlations were calculated. Products of Czech original genetic programmes, Dominant Brown D 102 and Dominant Leghorn D 229 hens were included. A total of 1500 eggs were analysed. The egg collection was made for three consecutive days when the hens were at the 28, 35 and 59 weeks of age. The results showed that eggshell weight, yolk weight and yolk share increased with the age, while egg shape index, yolk index and albumen share decreased in both hybrids. Eggshell weight and share fluctuated with the age in both hybrids. Other traits differed within the hybrids. Interactions between age and hybrid were non-significant ($P > 0.05$) only in eggshell and yolk weight. The heaviest eggs were from 59-week-old Dominant Brown D 102 hens (68.89 g) and the lightest eggs were from 28-week-old Dominant Leghorn D 229 hens (57.76 g). Highly significant ($P \leq 0.001$) positive correlations were found between egg weight and all individual egg components weights and between eggshell weight and yolk and albumen weight and eggshell thickness in both laying hybrids.

Keywords: age, albumen, Dominant Brown D 102, Dominant Leghorn D 229, egg, egg quality, eggshell, genotype, yolk

## INTRODUCTION

The preferences and requirements of the consumers regarding food differ nowadays from country to country and eggs are not an exception (Aygun, 2014). Besides other important aspects such as egg weight or eggshell integrity, one of the main aspects that have an influence on the customers' choice is eggshell colour (Arthur and O'Sullivan, 2005). Nevertheless, eggshell colour does not determine internal quality of eggs (Odabaşi *et al.*, 2007; Samiullah *et al.*, 2015). The hens could be divided into two basic groups depending on the eggs they lay, first group lay eggs with brown eggshell and the other eggs with white eggshell (Arthur and O'Sullivan, 2005). Furthermore, some breeds lay eggs with different eggshell colour, which may vary from creamy, to green and blue to dark brown (Samiullah *et al.*, 2015). Generally, in Africa, Australia and Europe, the vast majority of eggs on the market are brown. However, in both, Latin and North America and in Asia the trend is the opposite. When considering worldwide production, ratio between eggs with brown eggshell colour and eggs with white eggshell colour is roughly balanced (Hooge, 2007; Windhorst *et al.*, 2013). Eggshell colour is substantially influenced by genotype (Arthur and O'Sullivan, 2005). According to Kraus and Zita (2019), genotype and age are among the most important factors that have an effect not only on the eggshell colour, but also on the other egg quality traits. Many other authors including Campo *et al.* (2007), Anderson (2013) or Zita *et al.* (2018) confirm significant effect of genotype on egg quality. There are notable genetic differences between brown and white egg-laying hens that mainly relate to body constitution, laying performance and some traits of egg quality. However, these differences constantly decrease thanks to intensive breeding programs (Ledvinka *et al.*, 2012). From the consumers' point of view, another important aspect is the occurrence of blood and meat spots in yolk and/or in albumen, which lower in eggs from white egg layers (Arthur and O'Sullivan, 2005). The effect of age on the basic quality traits is obvious from various studies including Zita *et al.* (2009), Hanusová *et al.* (2015) and Lee *et al.* (2016).

This study was focused on the comparison of the eggs from the two most used groups of layers in the world, brown and white egg-laying hens, specifically on products of Czech original genetic programmes, Dominant Brown D 102 and Dominant Leghorn D 229. The objective was to assess basic quality traits of eggs from both groups of hens and compare them. The impact of how age influences the technological value of eggs was also observed. Interactions between age and hybrid were determined. Last but not least, the most important correlations among the egg quality traits were calculated.

## MATERIALS AND METHODS

### Animals and Housing Conditions

Dominant Brown D 102 and Dominant Leghorn D 229 hens were included in this experiment. Both hybrids came from the company Dominant CZ. Dominant Brown D 102 hens are the result of crossing Rhode Island White at maternal stock and Rhode Island Red at paternal stock. Dominant Leghorn D 229 hens are the result of crossing White Leghorns in maternal and paternal stock (Tyller, 2015). According to the data from the International Poultry Testing, Ústrašice, Czech Republic hen-day egg production of Dominant Brown D 102 hens is 320 pcs and the average weight of eggs is 64.3 g (Klejnová and Koželuhová, 2014). Hen-day egg production of Dominant Leghorn D 229 hens is 333 pcs and the average weight of eggs is 60.5 g (Klejnová and Koželuhová, 2012). Laying period in both hybrids lasted until the 74 weeks of age.

All hens were randomly placed in enriched cages that meet the requirements specified by Directive 1999/74/EC, which sets minimum standards for protection of layers. The cages were equipped with nipple drinkers and trough feeders. Hens were fed by a commercial type of feed mixture containing 11.50 MJ of metabolizable energy and 16.64% of crude protein from the age of 20 weeks. In the following period, from the age of 41 weeks, there was used feed mixture that contained 11.09 MJ of metabolizable energy and 15.02% of crude protein. Both feed and water were supplied ad libitum. The lighting regime was set to 16 h of light and 8 h of darkness. The lighting intensity values acquired from 5 to 10 lx. The conditions of microclimate were kept on the same level during the whole observation that took place at the Demonstration and Experimental Center of the Faculty of Agrobiology, Food and Natural Resources.

### Laboratory Evaluation

A total of 1500 eggs were analysed during the laboratory evaluation and all basic measurements were performed on each one of them. The egg collection was made for three consecutive days when the hens were at the 28, 35 and 59 weeks of age. The storage of eggs was realized under controlled conditions, where the constant temperature of 6 °C was preserved. The laboratory analysis took place 24 hours after the collection. The evaluation of technological value of eggs was realized according to Kraus and Zita (2019).

### Statistical Evaluation of the Results

All data of egg quality traits were processed by the computer program SAS (SAS Inst. Inc., 2011). The results of the particular traits of egg quality were assessed by the mixed model by PROC MIXED:

$$y_{ijk} = \mu + A_i + H_j + AH_{ij} + e_{ijk}, \quad (1)$$

where $y_{ijk}$ was the value of the sign, $A_i$ was the effect of age (28, 35 and 59 weeks of age), $H_j$ was the effect of hybrid (Dominant Brown D 102 or Dominant Leghorn D 229), $AH_{ij}$ was the effect of interaction between age and hybrid, $e_{ijk}$ was the random residual error. Scheffe's multiple range test was performed when the P-values were significant ($P \leq 0.05$). All the data are showed as means with standard errors. Pearson's correlation coefficients were calculated among some egg quality traits in PROC CORR (SAS Inst. Inc., 2011). Correlations were considered significant when the associated P-value was less than 0.05.

## RESULTS

The findings of this study are described in Tabs. I–III and Fig. 1. Basic quality traits of the whole egg and its external part are shown in the Tab. I, while traits of internal parts in Tab. II. The most important correlations among the chosen traits are shown in Tab. III. The share of individual egg parts is described in Fig. 1.

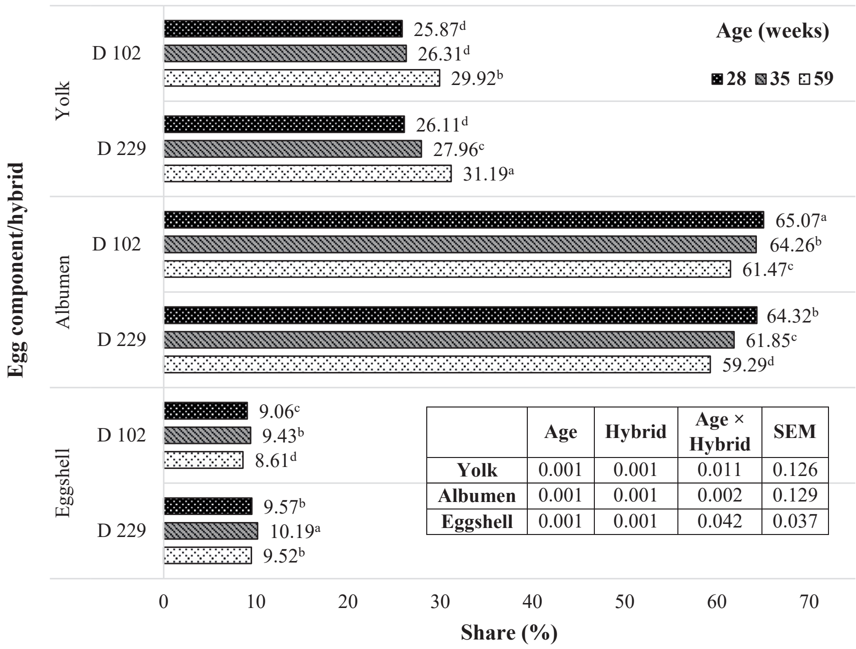
The egg weight (Tab. I) was significantly (P = 0.011) influenced by interaction between age and hybrid. The heaviest eggs were from 59-week-old Dominant Brown D 102 hens (68.89 g). Vice versa, the lightest eggs were from 28-week-old Dominant Leghorn D 229 hens (57.76 g). The eggs from 28-week-old Dominant Brown D 102 hens had significantly (P = 0.017) the highest value of egg shape index (77.98%) contrary to eggs of this genotype analysed at the age of 59 weeks (75.68%) and eggs from Dominant Leghorn D 229 hens (75.49, 75.27 and 75.09%).

There was not found the interaction (P = 0.956) between age and hybrid in eggshell weight (Tab. I). The heaviest eggshell was detected in eggs from 35-week-old Dominant Brown D 102 and Leghorn D 229 hens (6.07 g), whereas the lightest eggshell was observed in eggs from 28-week-old Dominant Brown D 102 hens (5.50 g) and Dominant Leghorn D 229 hens (5.51 g). The eggshell share (Fig. 1) was significantly (P = 0.042) influenced by interaction between age and hybrid. The highest eggshell share was found in eggs from 35-week-old Dominant Leghorn D 229 hens (10.19%), while the lowest eggshell share was found in eggs from 59-week-old Dominant Brown D 102 hens (8.61%). There was detected significant interaction (P = 0.032) between age and hybrid in eggshell thickness (Tab. I). The thickest eggshell had eggs from Dominant Leghorn D 229 hens (0.354, 0.349 and 0.346 mm) contrary to eggs from 28-week-old (0.324 mm) and 59-week-old (0.326 mm) Dominant Brown D 102 hens. Eggshell strength was significantly (P = 0.001) influenced by interaction between age and hybrid. The eggs with the highest eggshell strength came from 28-week-old Dominant Leghorn D 229 hens (44.13 N/cm$^2$), while eggs with the lowest eggshell strength came from 28 and 59-week-old Dominant Brown D 102 hens (34.73 and 35.04 N/cm$^2$). The eggshell colour was observed for determination of correlations. Statistically significant (P = 0.001) effect of interaction between age and hybrid was detected in eggshell colour. The eggs with the lightest colour were from 59-week-old Dominant Leghorn D 229 hens (83.63%) contrary to eggs from 28 and 35-week-old Dominant Brown D 102 hens (39.92 and 38.67%).

I: *Basic quality traits of the whole egg and its external part in relationship to hybrid and age (mean ± SE)*

| Trait | Age (weeks) | Hybrid | | Significance | | | SEM |
|---|---|---|---|---|---|---|---|
| | | Dominant D 102 | Dominant D 229 | Age | Hybrid | Age × Hybrid | |
| Egg weight (g) | 28 | 60.81$^d$ ± 0.42 | 57.76$^e$ ± 0.59 | 0.001 | 0.001 | 0.011 | 0.249 |
| | 35 | 64.47$^b$ ± 0.42 | 59.60$^d$ ± 0.52 | | | | |
| | 59 | 68.89$^a$ ± 0.44 | 62.75$^c$ ± 0.60 | | | | |
| Egg shape index (%) | 28 | 77.98$^a$ ± 0.27 | 75.49$^c$ ± 0.39 | 0.001 | 0.001 | 0.017 | 0.137 |
| | 35 | 77.18$^b$ ± 0.27 | 75.27$^c$ ± 0.34 | | | | |
| | 59 | 75.68$^c$ ± 0.29 | 75.09$^c$ ± 0.39 | | | | |
| Eggshell weight (g) | 28 | 5.50 ± 0.05 | 5.51 ± 0.07 | 0.001 | 0.726 | 0.956 | 0.025 |
| | 35 | 6.07 ± 0.05 | 6.07 ± 0.06 | | | | |
| | 59 | 5.93 ± 0.05 | 5.97 ± 0.07 | | | | |
| Eggshell thickness (mm) | 28 | 0.324$^c$ ± 0.002 | 0.354$^a$ ± 0.003 | 0.117 | 0.001 | 0.032 | 0.001 |
| | 35 | 0.334$^b$ ± 0.002 | 0.349$^a$ ± 0.003 | | | | |
| | 59 | 0.326$^c$ ± 0.003 | 0.346$^a$ ± 0.003 | | | | |
| Eggshell strength (N/cm$^2$) | 28 | 34.73$^d$ ± 0.70 | 44.13$^a$ ± 0.99 | 0.002 | 0.001 | 0.001 | 0.356 |
| | 35 | 38.54$^c$ ± 0.70 | 41.86$^{ab}$ ± 0.87 | | | | |
| | 59 | 35.04$^d$ ± 0.74 | 39.53$^{bc}$ ± 1.00 | | | | |
| Eggshell colour (%) | 28 | 39.92$^d$ ± 0.46 | 71.79$^b$ ± 0.65 | 0.001 | 0.001 | 0.001 | 0.762 |
| | 35 | 38.67$^d$ ± 0.46 | 71.80$^b$ ± 0.57 | | | | |
| | 59 | 44.04$^c$ ± 0.49 | 83.63$^a$ ± 0.66 | | | | |

Data labelled with same superscript letters in concrete trait do not differ significantly ($^{abcde}$P ≤ 0.05); SE – Standard Error; Dominant D 102 – brown egg-layers; Dominant D 229 – white egg-layers; SEM – Standard Error of the Mean




1: *Share of individual egg components in relationship to hybrid and age of hens*
Data labelled with same superscript letters in concrete trait do not differ significantly ($^{abcd}P \le 0.05$); D 102 – brown egg-layers Dominant; D 229 – white egg-layers Dominant

II: *Basic quality traits of internal parts of egg in relationship to hybrid and age (mean ± SE)*

| Trait | Age (weeks) | Hybrid | | Significance | | | SEM |
|---|---|---|---|---|---|---|---|
| | | Dominant D 102 | Dominant D 229 | Age | Hybrid | Age × Hybrid | |
| Yolk weight (g) | 28 | 15.70 ± 0.16 | 15.16 ± 0.23 | 0.001 | 0.001 | 0.142 | 0.112 |
| | 35 | 16.94 ± 0.16 | 16.65 ± 0.20 | | | | |
| | 59 | 20.57 ± 0.17 | 19.53 ± 0.23 | | | | |
| Yolk index (%) | 28 | 56.21$^{a}$ ± 0.25 | 53.72$^{b}$ ± 0.35 | 0.001 | 0.001 | 0.001 | 0.325 |
| | 35 | 42.38$^{c}$ ± 0.25 | 41.22$^{d}$ ± 0.31 | | | | |
| | 59 | 40.52$^{d}$ ± 0.26 | 37.08$^{e}$ ± 0.35 | | | | |
| Albumen weight (g) | 28 | 39.61$^{b}$ ± 0.32 | 37.10$^{c}$ ± 0.46 | 0.001 | 0.001 | 0.003 | 0.177 |
| | 35 | 41.47$^{a}$ ± 0.32 | 36.88$^{c}$ ± 0.40 | | | | |
| | 59 | 42.38$^{a}$ ± 0.34 | 37.25$^{c}$ ± 0.46 | | | | |
| Albumen index (%) | 28 | 7.18$^{a}$ ± 0.16 | 6.06$^{c}$ ± 0.22 | 0.001 | 0.885 | 0.001 | 0.083 |
| | 35 | 6.62$^{b}$ ± 0.16 | 7.64$^{a}$ ± 0.20 | | | | |
| | 59 | 5.21$^{d}$ ± 0.17 | 5.24$^{d}$ ± 0.23 | | | | |
| Haugh units | 28 | 76.27$^{a}$ ± 0.86 | 69.62$^{b}$ ± 1.24 | 0.001 | 0.104 | 0.001 | 0.484 |
| | 35 | 70.74$^{b}$ ± 0.86 | 78.74$^{a}$ ± 1.09 | | | | |
| | 59 | 61.73$^{c}$ ± 0.93 | 64.58$^{c}$ ± 1.25 | | | | |

Data labelled with same superscript letters in concrete trait do not differ significantly ($^{abcde}P \le 0.05$); SE – Standard Error; Dominant D 102 – brown egg-layers; Dominant D 229 – white egg-layers; SEM – Standard Error of the Mean

There was not found to be any interaction (P = 0.142) between age and hybrid in yolk weight (Tab. II). The heaviest yolk was found in eggs from 59-week-old Dominant Brown D 102 hens (20.57 g), while the lightest yolk was found in eggs from 28-week-old Dominant Leghorn D 229 (15.16 g) and Dominant Brown D 102 hens (15.70 g). The yolk share (Fig. 1) was significantly (P = 0.011) influenced by interaction between age and hybrid. The highest yolk share was found in eggs from 59-week-old

III: *Correlations between egg weight, eggshell weight, eggshell colour and selected egg quality characteristics in relation to hybrid*

| Trait | Hybrid/Trait | | | | | |
|---|---|---|---|---|---|---|
| | D 102 | D 229 | D 102 | D 229 | D 102 | D 229 |
| | Egg weight | | Eggshell weight | | Eggshell colour | |
| Yolk weight | 0.689*** | 0.772*** | 0.305*** | 0.474*** | | |
| Albumen weight | 0.873*** | 0.859*** | 0.404*** | 0.531*** | | |
| Eggshell weight | 0.538*** | 0.676*** | | | | |
| Yolk share | 0.151** | 0.277*** | | | | |
| Albumen share | -0.061NS | -0.206** | | | | |
| Eggshell share | -0.313*** | -0.310*** | | | -0.250*** | -0.270*** |
| Eggshell strength | -0.009NS | -0.211** | 0.398*** | 0.036NS | -0.115* | -0.197** |
| Eggshell thickness | 0.004NS | 0.038NS | 0.650*** | 0.451*** | -0.210*** | -0.103NS |

D 102 – brown egg-layers Dominant; D 229 – white egg-layers Dominant; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001; NS – non-significant (P > 0.05)

Dominant Leghorn D 229 hens (31.19%) contrary to eggs from this genotype analysed at age of 28 weeks (26.11%) and eggs from 28 and 35-week-old Dominant Brown D 102 hens (25.87 and 26.31%). The yolk index (Tab. II) was significantly (P = 0.001) influenced by interaction between age and hybrid. The highest value of the yolk index was found in eggs from 28-week-old Dominant Brown D 102 hens (56.21%) and the lowest value of the yolk index was found in eggs from 59-week-old Dominant Leghorn D 229 hens (37.08%).

The albumen weight (Tab. II) was significantly (P = 0.003) influenced by interaction between age and hybrid. The heaviest albumen weight was observed in eggs from 35 and 59-week-old Dominant Brown D 102 hens (41.47 and 42.38 g) contrary to eggs from Dominant Leghorn D 229 hens (37.10, 36.88 and 37.25 g). The albumen share (Fig. 1) was significantly (P = 0.002) influenced by interaction between age and hybrid. The highest albumen share was found in eggs from 28-week-old Dominant Brown D 102 hens (65.07%), whereas the lowest albumen share was found in eggs from 59-week-old Dominant Leghorn D 229 hens (59.29%). Albumen index (Tab. II) was significantly (P = 0.001) influenced by interaction between age and hybrid. The highest value of albumen index was found in eggs from 28-week-old Dominant Brown D 102 hens (7.18%) and 35-week-old Dominant Leghorn D 229 hens (7.64%) contrary to eggs from 59-week-old Dominant Brown D 102 (5.21%) and Dominant Leghorn D 229 (5.24%) hens. Statistically significant (P = 0.001) interaction between age and hybrid was determined in Haugh units. The highest value of Haugh units was found in eggs from 28-week-old Dominant Brown D 102 hens (76.27) and 35-week-old Dominant Leghorn D 229 hens (78.74) contrary to eggs from 59-week-old Dominant Brown D 102 (61.73) and Dominant Leghorn D 229 (64.58) hens.

Correlations between egg weight, eggshell weight and eggshell colour and some selected egg quality traits were determined in relationship to the hybrid of hens (Tab. III). Significant (P ≤ 0.001, P ≤ 0.01, P ≤ 0.05) correlations between the most important egg traits were determined with the exception of the correlations between egg weight and albumen share and eggshell strength in eggs from Dominant Brown D 102 hens and between egg weight and eggshell thickness in eggs from both hybrids. Other non-significant correlations were detected between eggshell weight and strength and between eggshell colour and thickness in eggs from Dominant Leghorn D 229 hens. Highly significant (P ≤ 0.001) positive correlations were determined between egg weight and yolk, albumen and eggshell weight and between eggshell weight and yolk and albumen weight and eggshell thickness in both hybrids. Significant negative correlations were found between egg weight and eggshell share and between eggshell colour and eggshell share and strength in both hybrids. The higher correlations between egg weight and yolk and eggshell weight, between eggshell weight and yolk and albumen weight and between eggshell colour and eggshell share and eggshell strength were observed in eggs from Dominant Leghorn D 229 hens in comparison with eggs from Dominant Brown D 102.

## DISCUSSION

The results show that hybrid and age had significant effect on the basic traits of egg quality. In addition, interaction between age and hybrid was found to be significant. Number of authors such as Roberts *et al.* (2013) or Hanusová *et al.* (2015) confirm the effect of age on egg quality, while Küçükyılmaz *et al.* (2012) and Samiullah *et al.* (2017) confirm the effect of genotype. Zita *et al.* (2009) and Kraus and Zita (2019) even found the significant effect of genotype, age and their interaction on the egg quality.

Sokołowicz *et al.* (2018) claim that genotype has statistically significant effect on egg weight, which is in accordance with our findings. Zita *et al.* (2009) and Ledvinka *et al.* (2014) describe effect of age as significant and similarly discovered increasing trend of egg weight with the age. Ledvinka *et al.* (2014) discovered the interaction between age and genotype in egg weight. Küçükyılmaz *et al.* (2012) found significant effect of genotype on egg shape index. Vice versa, Hanusová *et al.* (2015) claim that genotype does not have significant effect on egg shape index. Petričević *et al.* (2017) also state that age significantly influences egg shape index, which regularly decreases with the age. However, the results from Padhi *et al.* (2013) show the non-significant effect of age and irregular trend. Furthermore, Petričević *et al.* (2017) observed the interaction between age and genotype in egg shape index but did not determine it as significant. However, findings from Zita *et al.* (2009) or Kraus and Zita (2019) show the opposite.

Unlike our results, Tůmová *et al.* (2007) discovered significant effect of the genotype on eggshell weight. Padhi *et al.* (2013) similarly confirm that age significantly influences eggshell weight and that eggshell weight fluctuates with the age. Petričević *et al.* (2017) agree that the interaction between age and genotype in eggshell weight is significant. Küçükyılmaz *et al.* (2012) claim that genotype significantly influences eggshell share. Samiullah *et al.* (2017) discovered the significant effect of age on eggshell share, which regularly decreased with the age. Kraus and Zita (2019) found the interaction between age and genotype in eggshell share. Authors such as Tůmová *et al.* (2007) or Hanusová *et al.* (2015) confirm the significant effect of genotype on eggshell thickness. According to Lee *et al.* (2016) the effect of age on eggshell thickness is statistically significant, which contradicts our results. Furthermore, findings from Lee *et al.* (2016) show decreasing trend of eggshell thickness with the age. Zita *et al.* (2009) found the significant interaction between age and genotype in eggshell thickness, whereas Petričević *et al.* (2017) claim the opposite. Küçükyılmaz *et al.* (2012) state that genotype influences eggshell strength, while Roberts *et al.* (2013) found the significant effect of age on eggshell strength, which regularly decreased with the age. The interaction between age and genotype was found to be significant by Zita *et al.* (2009) but non-significant by Kraus and Zita (2019). Sokołowicz *et al.* (2018) observed that genotype significantly influences eggshell colour. Samiullah *et al.* (2017) confirm significant effect of age on this trait and simultaneously confirm increasing trend of eggshell colour with the age. Kraus and Zita (2019) confirmed significant interaction between age and genotype in eggshell colour.

Hanusová *et al.* (2015) confirm that genotype has significant effect on yolk weight. Padhi *et al.* (2013) state that yolk weight is significantly influenced by age and that yolk weight regularly increases with the age. In contrast, the findings from Zita *et al.* (2009) show the significant interaction between age and genotype in yolk weight. Kraus and Zita (2019) claim that genotype, age and their interaction significantly influence yolk share and add that it fluctuates with the age. Tůmová *et al.* (2007) determined the significant effect of genotype on yolk index. According to Padhi *et al.* (2013) yolk index is significantly influenced by age and the trend is irregular with the age. Ledvinka *et al.* (2014) found statistically significant interaction between age and genotype in yolk index.

Various authors such as Zita *et al.* (2009) or Hanusová *et al.* (2015) discovered the significant effect of genotype on albumen weight in their studies. Padhi *et al.* (2013) state that age significantly influences albumen weight, which has at first increasing and then decreasing trend with the age. Furthermore, findings from Zita *et al.* (2009) confirm the significant interaction between age and genotype in albumen weight. Ledvinka *et al.* (2014) state that genotype significantly influences albumen share, while Padhi *et al.* (2013) confirm the significant effect of age. Moreover, results from Padhi *et al.* (2013) show that albumen share fluctuates with the age. Kraus and Zita (2019) claim that there is the interaction between age and genotype in albumen share. Unlike our results, results from Zita *et al.* (2018) confirm the significant effect of genotype on albumen index, while the results from Kraus and Zita (2019) show the significant effect of age on this trait. Kraus and Zita (2019) claim that the trend of albumen index is irregular with the age. Ledvinka *et al.* (2014) state that there is the significant interaction between age and genotype in albumen index. Tůmová *et al.* (2007) did not find any significant effect of genotype on Haugh units, but Petričević *et al.* (2017) claim the exact opposite. According to Samiullah *et al.* (2017), Haugh units are significantly affected by age and constantly decrease with the age. Moreover, Petričević *et al.* (2017) found the significant interaction between age and genotype.

Large number of authors such as Zita *et al.* (2009), Mitrovic *et al.* (2010) or Padhi *et al.* (2013) calculated correlations among the traits of egg quality. All of the mentioned authors determined correlations primarily between egg weight and other egg quality traits. Furthermore, Zita *et al.* (2009) calculated correlations for eggshell share and eggshell colour.

All of the differences in the results of this study and other studies may be caused by several factors. The most important factors that affect the results are use of distinct genotypes and housing systems. Obviously, other factors may significantly influence the results such as dissimilar number of animals, samples or measurements. Nevertheless, majority of observed results is in accordance with the findings of previous studies from various authors.

## CONCLUSION

The significant effect of hybrid was determined in all observed traits, except for the eggshell weight, the albumen index and the Haugh units. The effect of age was found to be significant in all evaluated traits, with the only exception of the eggshell thickness. Interactions between age and hybrid were non-significant only in eggshell weight and yolk weight. Highly significant ($P \leq 0.001$) positive correlations were calculated between egg weight and yolk, albumen and eggshell weight and between eggshell weight and yolk and albumen weight and eggshell thickness in both hybrids. Significant ($P \leq 0.05$) negative correlations were determined between egg weight and eggshell share and between eggshell colour and eggshell share and strength in both hybrids. The variability between quality of eggs from brown and white egg-laying hens is reducing thanks to intensive breeding programmes. However, for better understanding of all differences in egg quality traits between brown and white egg-laying hens, further researches focused on the housing system are required. Understanding of the influence of the housing system is important because of the discussions about cage systems prohibition.

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