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THE EFFECT OF THE REARING SYSTEM AND THE GENOTYPE OF LAYING HENS ON THE EGGSHELL QUALITY AT DIFFERENT PHASES OF THE LAYING PERIOD

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Abstract: Eggshell quality can be crucial for success in poultry production. This applies particularly to the alternative rearing systems of laying hens. For this reason, experimental research was conducted with the aim to evaluate the effect of rearing system, genotype and hen's age on the eggshell quality. Isa Brown and New Hampshire were genotypes used in this study. These two genotypes were housed in floor and organic rearing systems. Eggs were collected for analyses in three different phases of the productive activity (at the beginning of the laying period - 24 weeks hen's age, in the middle of the laying period - 48 weeks hen's age, and at the end of the laying period - 72 weeks hen's age). In these samples (fifteen eggs per group) were investigated eggshell quality parameters: weight, proportion, thickness, deformation and breaking strength.

There was no significant effect of the rearing system on the observed parameters ($p \geq 0.05$) in the 24 week hen's age, while Isa Brown had higher weight, thickness and breaking strength but less eggshell deformation compared to New Hampshire ($p \leq 0.05$). Floor reared Isa Brown layers had a higher weight and proportion compared to the other three experimental groups ($p \leq 0.05$), as well as higher thickness but lower eggshell deformation compared to floor New Hampshire and organic Isa Brown hens in the 48 week hen's age. Organic New Hampshire hens had a lower weight, proportion and eggshell breaking strength but a higher deformation compared to the other experimental groups ($p \leq 0.05$) in the 72 weeks hen's age.

Keywords: laying hens, rearing systems, genotype, hen's age, eggshell

Introduction

The number of laying hens that are rearing in some of non-cage production systems is constantly increasing in Europe, so that in the United Kingdom this percentage is already about 50%, while in some countries even forbidden to keep hens in cages (Switzerland,

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Norway) (Rakonjac et al., 2018). In the report of Committee for the Common Organisation of the Agricultural Markets (2018), it is stated that in the EU countries 18.4% of the hens have access to an outlet (free range and organic together). One of the main reasons for the spread of new rearing systems is the production of better and healthier products for human consumption. For this reason, great attention is paid to the internal and external characteristics of the quality of the eggs and their chemical composition, while the quality of the eggshell does not pay much attention. However, Roberts (2004) think that eggshell quality can be crucial for success in eggs production. Thus Coucke et al. (1999) state that 6-8% of eggs produced in conventional system break up before it comes to use, which makes financial losses of millions of dollars. A large percentage of this damage was caused by inadequate shell quality. This problem may become more pronounced in alternative rearing systems because hens have direct contact with the produced eggs in the nest. Second and perhaps even more important reason is that for rearing in these production systems uses breeds, which usually have a weaker eggshell then hybrids. From all the above, the aim of this study was to evaluate the effect of rearing system, genotype and hen's age on the eggshell quality.

Material and Methods

The experiment was arranged in 2 x 2 factorial design with two layer genotypes and two rearing systems (30 birds per group). Isa Brown hybrid and New Hampshire dual-purpose breed were genotypes used in this study. These two genotypes were housed in floor and organic rearing systems when hens were 18 weeks of age. In both rearing systems, the stocking density was 2.5 birds/m^2. The organic layers also had about 5 m^2 per birds available outdoor area which was covered with grass and bushes.

Table 1. The chemical composition of diet from laying hens

	Floor system	Organic system
Chemical composition	%	%
Dry matter	88.38	89.82
Crude proteins	16.79	16.82
Crude fats	5.15	4.31
Cellulose	4.82	4.29
Ash	12.52	12.68
Ca	3.72	3.43
Total P	0.71	0.81
Na	0.17	0.18
Lysine	0.79	0.80
Methionine+cystine	0.68	0.48
Metabolisable energy MJ	11.5 MJ	11.3 MJ

Laying hens were fed with diets whose average chemical composition is shown in Table 1. In organic system, except in the facility, the feeders and drinkers were located in the outlet.

It is important to note that the diet from organic hens was complete without additions of synthetic amino acids, vitamins and minerals, with the use of more 80% organically grown components. In all experimental groups feed and water was available *ad libitum.*

Eggs were collected for analyses in three different phases of the productive activity (at the beginning of the laying period - 24 weeks hen's age, in the middle of the laying period - 48 weeks hen's age, and at the end of the laying period - 72 weeks hen's age). In these samples (fifteen eggs per group, eggs were one day old) were investigated eggshell quality parameters: weight, proportion, thickness, deformation and breaking strength).

Eggshell weight was measured on an electronic scale with an accuracy of 10^{-2} g and then expressed its percentage in relation to the weight of the whole egg. Shell thickness was measured on shell fragments sampled from equatorial circumference (SOMET, USA). Shell deformation was measured using a special device (Marius, Holland). Shell breaking strength was tested with an Egg Crusher made by Pavlovski and Vitorović (1996). Eggshell quality data were analyzed by ANOVA and LSD test (Stat Soft Inc Statistica For Windows. Version 7.0., 2006).

Results and Discussion

At the beginning of the production cycle (24 weeks hen's age), there was no significant effect of the rearing system on the weight and shell proportion ($p \geq 0.05$). On the other hand, Isa Brown layers had higher shell weight compared to New Hampshire in both rearing systems ($p \leq 0.05$). Also, organic Isa Brown hens had a higher shell proportion then organic New Hampshire ($p \leq 0.05$), while only in the floor system there was no significant difference ($p \geq 0.05$) in the shell proportion between the examined genotypes. With the ageing of the hens, there was a significant interaction of the examined factors on the observed properties. In the 48 weeks hen's age, the floor reared Isa Brown hens had a significantly higher weight and a proportion of the eggshell compared to other three experimental groups ($p \leq 0.05$), which did not differ significantly from each other ($p \geq 0.05$). In the 72 weeks hen's age, the interaction of the investigated factors influenced that organic New Hampshire hens had a significantly lower weight and proportion of the eggshell compared to other experimental groups ($p \leq 0.05$). Krawczyk (2009) did not determine the significant effect of the rearing system on the proportion of eggshell between hens reared in the organic, "backyard" and conventional-cage system of production, as well as Rakonjac et al. (2018) between cage, floor and organic laying hens.

The results similar to ours in the 48 and 72 weeks hen's age, that the eggshell weight significantly influence the interaction ($p \leq 0.05$) between the rearing system and the genotype were also established by Svobodova et al. (2014) on Lohmann white and Czech hen genotypes, in the cage and floor rearing systems.

From this data, it can't be clearly defined how the weight and the proportion of the eggshell changed with the ageing of the laying hens, which is in accordance with the results published by Rizzi and Chiericato (2005). Apart from the significant differences in the weight and proportion of eggshell between four genotypes, these authors found that value of these parameters not changed in all genotypes in the same way with the ageing of hens - Hy Line Brown and Ermellinata of Rovigo with ageing decreased eggshell proportion, Hy Line White eggshell was at a constant level, and Robusta Maculata breed even increased this parameter with hens ageing.

Table 2. Effect of the rearing systems, genotype and age of laying hens on eggshell quality parameters

Rearing system	Genotype	Shell weight (g)	Shell proportion (%)	Shell thickness (0.01 mm)	Shell deformation (μm)	Shell breaking strength (N)
24 weeks hen's age						
Floor	Isa Brown	$7.41^{a}\pm0.48$	$12.76^{ab}\pm0.82$	$32.27^{a}\pm2.31$	$20.47^{b}\pm2.97$	$45.80^{a}\pm9.19$
	New Hampshire	$6.41^{b}\pm0.79$	$12.43^{ab}\pm1.29$	$29.73^{b}\pm2.49$	$25.13^{a}\pm3.64$	$36.97^{b}\pm9.47$
Organic	Isa Brown	$7.02^{a}\pm0.62$	$13.11^{a}\pm1.08$	$33.27^{a}\pm2.91$	$19.47^{b}\pm3.48$	$49.23^{a}\pm8.16$
	New Hampshire	$6.10^{b}\pm0.75$	$11.96^{b}\pm1.15$	$29.67^{b}\pm3.66$	$27.13^{a}\pm8.38$	$36.81^{b}\pm8.93$
48 weeks hen's age						
Floor	Isa Brown	$8.61^{a}\pm0.69$	$12.93^{a}\pm1.13$	$33.47^{a}\pm2.10$	$21.13^{b}\pm3.11$	40.07 ± 6.66
	New Hampshire	$7.65^{b}\pm0.69$	$11.61^{b}\pm0.79$	$30.60^{b}\pm2.44$	$23.87^{a}\pm3.00$	37.62 ± 6.99
Organic	Isa Brown	$7.81^{b}\pm0.54$	$11.96^{b}\pm0.92$	$31.00^{b}\pm2.88$	$24.87^{a}\pm4.96$	38.61 ± 6.80
	New Hampshire	$7.91^{b}\pm0.31$	$11.86^{b}\pm0.67$	$31.73^{ab}\pm2.40$	$23.40^{ab}\pm2.97$	38.94 ± 7.14
72 weeks hen's age						
Floor	Isa Brown	$8.18^{a}\pm0.69$	$12.23^{a}\pm0.81$	$31.00^{a}\pm3.14$	$21.40^{b}\pm2.56$	$38.43^{ab}\pm7.66$
	New Hampshire	$8.21^{a}\pm0.74$	$12.51^{a}\pm1.02$	$29.67^{b}\pm3.96$	$23.47^{b}\pm5.45$	$43.02^{a}\pm5.47$
Organic	Isa Brown	$8.17^{a}\pm0.56$	$12.48^{a}\pm0.81$	$31.33^{a}\pm2.19$	$22.67^{b}\pm2.58$	$37.14^{b}\pm7.49$
	New Hampshire	$7.59^{b}\pm0.57$	$11.41^{b}\pm1.03$	$29.00^{b}\pm3.63$	$28.00^{a}\pm5.28$	$33.54^{c}\pm7.00$

a-c: Values within columns with different superscripts are significantly different ($p\leq0.05$)

Isa Brown hens had a greater eggshell thickness compared to New Hampshire breed in the 24 and 72 weeks hen's age ($p\leq0.05$), while there was no significant effect of the rearing system on this trait ($p\geq0.05$). The smaller eggshell thickness of the New Hampshire breed compared to the Isa Brown hybrid in the present study is consistent with the results published by Mostert et al. (1995), which also found significantly less ($p\leq0.05$) eggshell thickness in the New Hampshire breed compared to three commercial hybrids reared in cage, floor and free-range systems. As in our experiment, in this case, the rearing system did not have a significant effect on this parameter (p≥0.05). According to our results, also Kucukyilmaz et al. (2012) confirmed that the genotype has a crucial effect on the of eggshell thickness. This researchers also did not find a significant difference in the eggshell thickness between layers reared in the conventional and organic production systems. On the other hand, this parameter significantly differed between the observed genotypes - Lohmann LSL had a thicker shell compared to ATAK-S of about 0.02 mm in both rearing systems. In the 48 week hen's age there was a significant interaction between the investigated factors, so the floor Isa Brown hens had a greater shell thickness (p≤0.05) than organic layers of the same genotype, while there was no the significant difference between the experimental groups of New Hampshire breed (p≥0.05). Ledvinka et al. (2012) also determined the significant interaction between the rearing system and the genotype on the eggshell thickness in the floor and cage production systems on Isa Brown, Hisex Brown and Moravia BSL genotypes. A deficiency of a clear tendency to change the eggshell thickness with aging in our research is in accordance with the results of Rizzi and Cassandro (2009), which found that only Hy Line Brown hybrid showed a constant shell thickness during the examined period from the 30 to the 42 week hen's age, while other genotypes (Hy Line White, Robusta Maculata and Ermellinata of Rovigo) did not show a clear tendency to change the thickness with ageing - eggshell thickness is without orderliness decreased and increased.

Isa Brown hens had significantly less eggshell deformation and greater breaking strength compared to the New Hampshire breed (p≤0.05) in the 24 week hen's age, while there was no significant effect of the rearing system (p≥0.05). The results which confirmed that the genotype has a greater effect on the shell deformation than the rearing system was published also by Svobodova et al. (2014). In the 48 week hen's age, there was no significant effect of the investigated factors on the breaking strength (p≥0.05), while in the 72 week hen's age the worst shell quality was recorded in the organic New Hampshire group (the greatest deformation and the smallest shell breaking strength). These results can be explained by the fact that, besides the genotype, a large number of factors influence the quality of the shell: hen's age, mating, nutrition, stress, some diseases, climatic factors, rearing system (Roberts, 2004), so the interaction of some of these factors influenced that the New Hampshire genotype in the organic rearing system reduced the eggshell quality.

The shell breaking strength in Isa Brown hybrids decreased by hens ageing, while this was not the case with the New Hampshire breed. The results in agreement with ours also published Škrbić et al. (2011), which found a reduction in the shell quality with the ageing of the Lohmann Brown hybrid, while in the Banat Naked-Neck this was not recorded. The value of shell breaking strength in Lohmann Brown hybrid in the controls carried out on the 24, 32 and 40 weeks hen's age was constantly decreasing, while the value of this parameter in the Banat Naked-Neck even increased during this period.

Conclusion

Based on these results, it can be concluded that in the 24 week hen's age, the most important effect on the investigated properties had a genotype, so Isa Brown layers had a better eggshell compared to New Hampshire breed. In the later phases of the production cycle there was a strong interaction of the investigated factors, and in the 48 week hen's age, the floor Isa Brown hens had better shell quality than the other three experimental groups. In the 72 week hen's age, a significant interaction of the rearing system x genotype for most of the investigated properties was contributed to the fact that the organic New Hampshire hens had a lower eggshell quality compared to other experimental groups.

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