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Original Paper

Differences in the eggshell quality and tibia strength in Lohmann White and Czech Hen housed in cages and on litter

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This study investigated the differences in the eggshell quality and the tibia measurements between Lohmann White and Czech Hens housed in conventional cages and on litter system. The significant interactions between genotype and housing system were detected for the egg weight; the significantly heaviest eggs ($P \leq 0.001$) were in Lohmann White from cages and the lightest weight in Czech Hen in both housing systems. There was also significant interaction of genotype and housing system in the shell thickness, with the significantly thickest eggshells ($P \leq 0.003$) in Lohmann White from litter system (0.357 mm) and the thinnest in Czech hen housed in cages (0.310 mm). From tibia strength characteristics only the tibia strength was affected by interactions ($P \leq 0.004$), the tibia strength was higher in Czech Hen on litter system (498 N) than in conventional cages (318 N). Serum calcium concentration and pore density were not significantly influenced by the interaction of genotype and housing system. The results indicated that genotypes can have a different reaction in the eggshell quality depending on housing system, and these interactions can be more important than individual factors.

Keywords: eggshell quality, genotype, housing system, serum Ca, tibia strength

1. Introduction

Eggshell quality is one of the most important problems facing poultry industry; it economically influences egg production and hatchability. The eggshell quality is often expressed through its weight, percentage, thickness and strength. Composition of the eggshell and its characteristics are affected by many factors from which housing system and genotype are very important. Several studies were done in order to evaluate the effect of housing systems on eggshell quality including cages and litter systems, and to indicate which housing system is more effective for better eggshell quality. Pištěková et al. (2006), Zemková et al. (2007) and Singh et al. (2009) detected heavier eggs on litter, whereas Moorthy et al. (2000), Leyendecker et al. (2001a); Lichovníková and Zeman (2008) and Tůmová et al. (2011) found heavier eggs in cages. Hidalgo et al. (2008) showed the effect of housing on the eggshell thickness and the strength, they stated that the shell thickness was the lowest in eggs produced in cages, while barn eggs presented the highest values. On the other hand, Pištěková et al. (2006) suggested that difference in the shell strength in eggs from deep litter system and in eggs from cage system was not found statistically significant. Pores density was higher in cage system than on litter (Tůmová et al., 2011). Eggshell parameters can be related to serum calcium concentration, because it is the major structural element in the eggshell and large amounts of Ca are required to synthesize the shell. Řezáč et al. (2000) reported that the highest serum Ca levels in laying hens producing eggs with damaged shells, similar results were found by Pavlík et al. (2009) who reported that increased serum Ca level was associated with decreasing the eggshell strength and the thickness.

Tibia breaking strength is an important welfare problem for laying hens. Leyendecker et al. (2001a) suggested that the eggshell stability and the thickness seem to be negatively correlated with the bone strength. Several studies have shown a higher incidence of bone fragility in caged laying hens compared to hens kept in alternative housing system. Leyendecker et al. (2005) reported that, the weakness of the bones of hens kept in conventional cages is estimated to be mainly due to the limited opportunity to exercise.

Not only housing system affects eggshell quality but also genotype has a great effect on eggshell characteristics (Tůmová et al., 2007; Zita et al., 2009; Ledvinka et al., 2011). Tůmová et al., (2007) confirmed the effect of genotype on the eggshell weight which were higher in eggs of Plymouth Rock strain than Blue strain.

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Ledvinka et al. (2011) observed the significant effect of genotype on the eggshell thickness and the eggshell strength. On the other hand, Leyendecker et al. (2001b) found a thinner eggshell in brown eggs compared to the white ones. Basmacioglu and Ergul (2005) did not report a significant effect of the genotype on the shell strength and the thickness. Moreover, non-significant differences in the shell strength were determined by Tůmová et al. (2007) in variable brown strains.

Eggshell quality is also influenced by interaction between housing and genotype. Leyendecker et al. (2001b) reported genotype and housing system interactions on eggshell parameters. Vits et al. (2005) pointed out that eggshell quality characteristics were lower in enriched cages than in conventional cages, and that Lohmann Brown hens showed better results compared to Lohmann LSL. Singh et al. (2009) suggested that strain should be considered when using alternative housing systems.

The present study was conducted to investigate the differences in the eggshell parameters and the tibia strength in Lohmann White and Czech Hen housed in cages and on litter.

2. Material and methods

In the experiment with 123 laying hens of Lohmann White and pure breed Czech Hen, birds were housed in conventional cages Eurovent (72 hens, 550 cm^2 hen, 3 hens in a cage, 12 cages for genotype) and in six littered pens (60 hens, 7 hens per m^2, 10 hens per pen and 3 pens for each genotype). The experiment was carried out in the second half of the laying cycle. Laying hens in both housing systems were fed commercial type of feed mixtures. The daily photoperiod consisted of 15 h light and 9 h darkness. Eggs for the egg shell quality assessment were collected in two weeks interval, two days in row, all eggs laid from each cage or litter pen and there were analyzed 300 eggs of Lohmann and 150 eggs of Czech Hen. Eggs were weighed, and the shell strength was determined by the shell-breaking method using a QC-SPA device (TSS York, UK). Egg shell weight was determined after drying. Egg shell thickness was evaluated by QCT shell thickness micrometer (TSS York, UK). Egg shell proportion was calculated from egg shell weight, which was determined after drying, and egg weight.

Tibia characteristics were determined in 48 hens, 12 birds per a group, at 50 weeks of age. After slaughtering, both tibias were completely removed from the carcass. Weight, strength were measured in the right tibia. Tibia strength was measured by QC-SPA device (TSS York, UK) and thickness by micrometer QCT (TSS York, UK). Tibia Ca content was analysed in the left tibia after ashing at 550 °C overnight using a method AOAC 965.17 based on vanad-molybden reagent and spectrophotometry analysis on Solaar M6 apparatus (TJA Solutions, Cambridge, UK).

Egg shell quality data and tibia measurements were evaluated by two-way (housing, genotype) analysis of variance using the GLM procedure of SAS (SAS Institute Inc., Cary, Nc, 2003).

3. Results and discussion

In our study, significant interaction between housing system and genotype were detected. The significant interaction of housing system and genotype revealed that egg weight (Table 1) was higher in Lohmann White than Czech Hen, which is in accordance with results of Tůmová et al. (2009), Singh et al. (2009) and Ledvinka et al. (2012) who found interaction between housing system and genotype for the egg weight. Lohmann White hens produced significantly heavier eggs in cages than on litter; however, in Czech Hen the egg weight was not affected by housing system. Results of Lohmann White in the egg weight are in agreement with Moorthy et al. (2000), Leyendecker et al. (2001a), and Jenderal et al. (2004), who found heavier eggs in cages. On the other hand, Tůmová and Ebeid (2005), Pištěková et al. (2006), Zemková et al. (2007), and Singh et al. (2009) that detected heavier eggs on litter.

The eggshell percentage was not affected by evaluated factors. The eggshell thickness was the significantly highest (P ≤0.003) in Lohmann White on litter; Lohmann White produced thicker shells than Czech

Table 1 Mean of eggshell parameters from Lohmann White and Czech Hen housed in cages and litter

	Lohmann White		Czech Hen		RMSE	Significance Genotype × Housing
	cages	litter	cages	litter		
Egg weight in g	61.18^{a}	60.05^{b}	49.04^{c}	49.19^{c}	6.134	0.001
Eggshell percentage in %	12.23	12.20	11.33	11.55	0.903	0.101
Eggshell thickness in mm	0.352^{b}	0.357^{a}	0.310^{d}	0.322^{c}	0.028	0.003
Eggshell strength in g / kg	4358	4384	4157	4186	903.6	0.696

$^{a, b, c, d}$ statistically significant differences (P ≤0.05) within columns are indicated by different superscripts
RMSE-root mean square error

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Table 2 Mean of pore numbers from Lohmann White and Czech Hen housed in cages and litter

	Lohmann White		Czech Hen		Significance Genotype × Housing
	cages	litter	cages	litter	
Blunt end	112.4	110.0	105.4	103.5	NS
Sharp end	41.8	19.6	44.3	24.4	NS
Equatorial	102.9	99.8	96.6	98.6	NS

Table 3 Mean of tibia parameters and serum Ca concentration from Lohmann White and Czech Hen housed in cages and litter

	Lohmann White		Czech Hen		Significance Genotype × Housing
	cages	litter	cages	litter	
Tibia weight in g	4.68	5.18	5.18	5.58	NS
Tibia strength in N	318d	460c	477b	498a	0.004
Serum Ca in mm / l	9.56	10.12	2.53	4.96	NS

a, b, c, d statistically significant differences ($P \leq 0.05$) within columns are indicated by different superscripts

Hen. The eggshell thickness was higher on litter system than in cages; however, Hidalgo et al. (2008) showed that shell thickness was the lowest in eggs produced in cages, while free-range and barn eggs presented the highest values. Non-significant interactions were detected for the eggshell strength. On the other hand, Tůmová et al. (2011) found significant interactions of housing and genotype in brown-egg hybrid kept in conventional cages and on litter.

The eggshell quality can be also characterized by pore density. There were no significant interactions between genotype and housing system on eggshell pore density (Table 2). On the other hand, we found numerically higher pore density in cages than on litter, especially in the shell sharp end. Similar results were reported by Tůmová et al. (2011), who detected a higher pore density on the sharp end and in the equatorial area in eggs from hens from litter.

The significant interactions ($P \leq 0.004$) in the tibia strength were observed between housing system and genotype (Table 3) which is in agreement with results of Vits et al. (2005). Tibia strength in Czech Hens was stronger in both housing systems than those of Lohmann White.

Moreover the effect of housing system on the tibia breaking strength was found. The tibia strength was higher on litter system than in conventional cages which is in agreement with Newman and Leeson (1998), Leyendecker et al. (2001c), on the other hand Vits et al. (2005) did not detect difference in tibia strength among the housing systems. Leyendecker et al. (2005) reported that, the weakness of the bones of hens kept in conventional cages is estimated to be mainly due to the limited opportunity to exercise. Serum Ca concentration also did not significantly affected by interaction between housing system and genotype; however, numerically higher concentration was in Lohmann White.

4. Conclusions

The results of the present investigation showed significant interactions between genotype and housing systems on the egg weight, the eggshell thickness and the tibia strength. The results indicated that genotypes can have a different reaction in the eggshell quality depending on housing system, and these interactions can be more important than individual factors.

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6. References

BASMACIOGLU, H. and ERGUL, M. (2005) Research on the factors affecting cholesterol content and some other characteristics of eggs in laying hens. The effect of genotype and rearing system. In *Turk J Vet Anim Sci*, vol. 29, pp. 157–164.

HIDALGO, A. et al. (2008) A market study on the quality characteristics of eggs from different housing systems. In *Food Chemistry*, vol. 106, no. 3, pp. 1031–1038. DOI: http://dx.doi.org/10.1016/j.foodchem.2007.07.019.

JENDERAL, M. et al. (2004) Assessing the welfare of layers hens housed in conventional, modified and commercially-available furnished battery cages. [CD-ROM]. In *Proc. 22nd World Poultry Congress*, Istanbul, Turkey.

LEDVINKA, Z. et al. (2011) Effect of genotype, age of hens and K/k allele on eggshell quality. In *Czech Journal of Animal Science*, vol. 56, no. 5, pp. 242–249.

LEYENDECKER, M. et al. (2001a) Analysis of genotype-environment interactions between layer lines and hen housing systems for performance traits, egg quality and bone breaking strength. 1*st* communication: Egg quality traits. In *Züchtungskunde*, vol. 73, pp. 290–307 (in German).

LEYENDECKER, M. et al. (2001b) Analysis of genotype-environment interactions between layer lines and housing systems for performance trails, egg quality and bone strength. 2nd communication: Egg quality traits. In *Zűchtungskunde*, vol. 73, pp. 308–323 (in German).

LEYENDECKER, M. et al. (2005) Keeping laying hens in furnished cages and an aviary housing system enhances their bone stability. In *British Poultry Science*, vol. 46, no. 5, pp. 536–544. DOI: http://dx.doi.org/10.1080/00071660500273094.

LICHOVNÍKOVÁ, M. and ZEMAN, L. (2008) Effect of housing system on the calcium requirements of laying hens and eggshell quality. In *Czech Journal of Animal Science*, vol. 53, no. 4, pp. 162–168.

MOORTHY, M. et al. (2000) Effect of feed and system management on egg quality parameters of commercial White Leghorn Layers. In *Indian Veterinary Journal*, vol. 77, pp. 233–236.

PAVLÍK, A. et al. (2009) Blood Plasma Mineral Profile and Qualitative Indicators of the Eggshell in Laying Hens in Different Housing Systems. In *Acta Veterinaria Brno*, vol.78, pp. 419–429.

PIŠTĚKOVÁ, V. et al. (2006) The quality comparison of eggs laid by laying hens kept in battery cages and in a deep litter system. In *Czech Journal of Animal Science*, vol. 51, no. 7, pp. 318–325.

ŘEZÁČ, P. et al. (2000) Relationship between the levels of oestradiol-17β and cholesterol in plasma and eggshell strength in egg-laying hens. In *Czech Journal of Animal Science*, vol. 45, no. 7, pp. 313–317.

SAS (2003): The SAS System for Windows. Release 9.1.3. SAS Institute Inc., Cary, USA.

SINGH, R. et al. (2009) Production performance and egg quality of four strains of laying hens kept in conventional cages and floor pens. In *Poultry Science*, vol. 88, no. 2, pp. 256–264. DOI: http://dx.doi.org/10.3382/ps.2008-00237.

TŮMOVÁ, E. et al. (2007) The effect of oviposition time and genotype on egg quality characteristics in egg type hens. In *Czech Journal of Animal Science*, vol. 52, no. 1, pp. 26–30.

TŮMOVA, E. et al. (2011) Interaction between housing system and genotype in relation to internal and external egg quality parameters. In *Czech Journal of Animal Science*, vol. 56, no. 11, pp. 490–498.

VITS, A. et al. (2005) Production, egg quality, bone strength, claw length, and keel bone deformities of laying hens housed in furnished cages with different group sizes. In *Poultry Science,* vol. 84, no. 10, pp. 1511–1519.
DOI: http://dx.doi.org/10.1093/ps/84.10.1511.

ZEMKOVÁ, L. et al. (2007) The effects of housing systems and age of hens on the weight and cholesterol concentration of the egg. In *Czech Journal of Animal Science*, vol. 52, no. 4, pp. 110–115.

ZITA, L. et al. (2009) Effects of genotype, age and their interaction on egg quality in brown-egg laying hens. In *Acta Veterinaria Brno*, vol. 78, pp. 85–91.
DOI: http://dx.doi.org/10.2754/avb200978010085.