Comparison of two Different Breeding Systems of Laying Hens in Relation to Egg Shell Quality

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Abstract

The aim of work was to follow up and statistically evaluate the selected quality indicators of egg shell according to two different breeding systems and different age of laying hens. An object of investigation were shell weight, share of the shell, strength and thickness of the shell for table eggs. There were used the laying hens of final hybrid ISA Brown reared in enriched cage system, and free range system. In both breeding systems were ensured the conditions with application of the welfare principles. There was used to feed a complete feed mixture HYD 10 in the both breeding systems. The feeders were supplemented with feed by hand, daily and the same day was supplemented water to drinking troughs. Egg collection was hand in both breeding systems. This paper is a contribution to the solution of optimal breeding laying hens and production of high quality and safe production of table eggs. From the evaluation of the results was formulated conclusion, which shows that statistically significant ($p \leq 0.05$) higher egg shell thickness was observed in the breeding free range system compared to the thickness of the egg shell in the breeding cage system, and in age 40 weeks of laying hens in both breeding systems compared to the thickness of the egg shell in age 30 weeks of laying hens. No statistically significant difference ($p \geq 0.05$) was observed in egg shell weight between breeding cage system and free range system. Statistically significant ($p \leq 0.05$) higher egg shell weight was observed in the age 40 weeks of laying hens in both breeding systems compared to age 30 weeks of laying hens. There no statistically significant difference ($p \geq 0.05$) was observed in the share of egg shell and egg shell strength between breeding cage system and free range system, nor between age 30 and 40 weeks of laying hens.

Keywords: egg shell quality, table egg, laying hen, breeding system, age, comparison.

1. Introduction

Direct comparison of different breeding systems of laying hens (cages, halls with deep litter, free-range) on the egg shell quality is difficult to perform because there is the lack of experimental data and knowledge. Much knowledge to formulation of conclusions was taken on the basis of experience which is not scientifically substantiated. Prevailing problems remain in monitoring of the breeding system of laying hens in the free range system [1]. Strength egg shell, dynamic stiffness, deformation and thickness parameters are for the assessment of its quality [2]. If is the reduced quality of the egg shell, there is reduced the quality of eggs, and following the economic losses. The research results of breeding system effect on quality egg shell are contradictory and do not provide a clear indication where the breeding system ensures the production of egg shell quality [3].

The aim of this paper is to contribute to the solution of safe production of table eggs, and with research quality shells depending on the various systems of rearing and age of laying hens.

2. Materials and methods

Object of investigation were the table eggs, their damage and dirty, and egg weight in laying hens of final hybrid ISA Brown reared in enriched cage

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system in an experimental device of Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Food Hygiene and Safety, no. SK P 1001, and in the free range system in smally-breeder. We progressed according to the methodology of Angelovičová et al. (2014) [4]. Egg shell weight was determined on the instrument type KERN 440-35N, with an accuracy of 0.01 g and a maximum weight of 400 g. The share of egg shell was calculated on the basis of egg shell weight and egg weight. Egg shell strength was measured on a test apparatus Instron 1112 with luteum of diameter 4.48 mm for exerting pressure on the shell by the method Angelovičová et al. (1994) [5] and Rataj (1994) [6]. The egg shell thickness was measured on the test device micrometer Somet type 60/0, 01 mm with a range of 0-10 mm. Sample preparation: the egg shell was dried at 55 °C, were then cut 3 pcs of samples in the equator, 1 pc of sample at an blunt and 1 pc of sample at the sharp end. Data from measurements of the samples were evaluated on the basis of the basic statistical characteristics (arithmetic mean, standard deviation, coefficient of variation). For statistical comparison of the differences between groups was used Scheffe's test ANOVA in SAS software system, version 8.2 at significance level $P_{0.05.}$

3. Results and discussion

Egg shell weight

The values of the average egg shell weight were different in the breeding cage system and in the free range system. The average egg shell weight was in the breeding cage system 6.42 g and in the free range system 6.49 g but no difference statistically significant ($p \geq 0.05$).

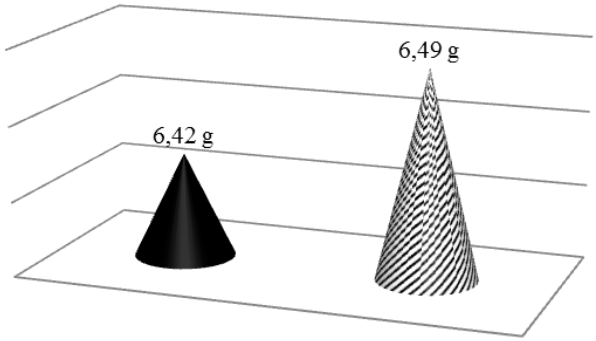

Figure 1. Average egg shell weight in the breeding cage system and breeding free range system (g) 6.42 = cage system, 6.49 =free range system.

Table 1. Statistical characteristics and statistical significance of difference in weight of egg shell between breeding cage system and breeding free range system

Breeding system	n	SD	CV	$P_{0.05}$
Cage	120	0.36	5.61	
Free range	120	0.40	6.16	$p \geq 0.05$

SD = standard deviation, CV = coefficient of variation, ≥ 0.05 = no statistically significant difference.

Average egg shell weight in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

Statistical evaluation of the egg shell weight between breeding cage system and breeding free range system in the age 30 weeks showed no difference statistically significant ($p \geq 0.05$) but difference statistically significant ($p \geq 0.05$) was observed in the age 40 weeks.

Table 2. Average egg shell weight in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

		Breeding system					
		Cage			Free range		
Age of hens, weeks	n	$\bar{x}$	SD	CV	$\bar{x}$	SD	CV
30	60	6.31	0.29	4.60	6.26	0.35	5.59
40	60	6.53	0.40	6.13	6.66	0.42	6.31

$\bar{x}$ = mean, SD = standard deviation, CV = coefficient of variation.

Table 3. Statistical significance of difference in weight of egg shell between breeding cage system and free range system depending on age 30 and 40 weeks of laying hens

Breeding system, age of hens	Free range, week 30	Cage, week 40	Free range, week 40
Cage, week 30	$p \geq 0.05$	$p \leq 0.05$	$p \leq 0.05$
Free range, week 30		$p \leq 0.05$	$p \leq 0.05$
Cage, week 40			$p \leq 0.05$

$p \leq 0.05$ = statistically significant difference, $p \geq 0.05$ = no statistically significant difference

Statistically significant differences ($p \leq 0.05$) were observed in the weight of egg shell between different ages of laying hens and different breeding systems. There difference significant was observed in weight egg shell between age 30 weeks of laying hens in breeding cage system and age 40 weeks of laying hens in free range system, and between age 30 weeks of laying hens in free range system and age 40 weeks of laying hens in the breeding cage system. The increase in shell weight as hens' age was not sufficient to compensate for the increment of egg weight, so that the ratio of shell weight to egg weight decreased. Increasing egg shell with advancing age of laying hens reported by [7] on the basis significantly increase of egg shell area.

Share of the egg shell of the egg weight

The difference in share of egg shell between breeding cage system and free range system during our experiment was negligible and statistically non-significant ($p \geq 0.05$). Another conclusion reported by [8] in their study, according to which the highest share of egg shell was for eggs of produced in the breeding system of conventional cages compared to eggs produced in all other production systems (free range, hall with deep litter and organic breeding).

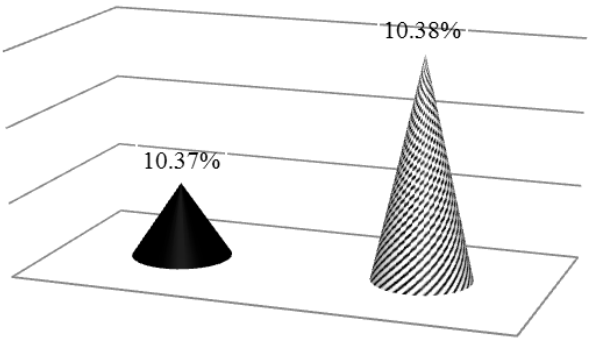

Figure 2. Average share of egg shell in the breeding cage system and breeding free range system (%) 10.37 = cage system, 10.38 = free range system.

Table 4. Statistical characteristic and statistical significance of difference in share of egg shell between breeding cage system and breeding free range system

Breeding system	n	SD	CV	$P_{0.05}$
Cage	120	0.5	5.59	
Free range	120	0.64	6.17	$p \geq 0.05$

SD = standard deviation, CV = coefficient of variation, $p \geq 0.05$ = no statistically significant difference.

Average share of egg shell in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

No difference statistically significant ($p \geq 0.05$) was confirmed also in the share of the egg shell between different ages of laying hens and between different breeding systems.

Table 5. Average share of egg shell in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

		Breeding system					
		Cage			Free range		
Age of hens, weeks	n	$\bar{x}$	SD	CV	$\bar{x}$	SD	CV
30	60	10.36	0.65	6.27	10.23	0.73	7.14
40	60	10.39	0.49	4.72	10.42	0.53	5.09

$\bar{x}$ = mean, SD = standard deviation, CV = coefficient of variation

Table 6. Statistical significance of difference in the share of egg shell between breeding cage system and free range system depending on age 30 and 40 weeks of laying hens

Breeding system, age of hens	Free range, week 30	Cage, week 40	Free range, week 40
Cage, week 30	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$
Free range, week 30		$p \geq 0.05$	$p \geq 0.05$
Cage week 40			$p \geq 0.05$

$p \geq 0.05$ = no statistically significant difference

Egg shell strength

No statistically significant difference ($p \geq 0.05$) was observed in strength of egg shell during our experiment between breeding cage system and breeding free range system. These results confirm the conclusion of [9]. They showed no difference in

strength egg shell between the eggs produced in breeding system of conventional and enriched cages.

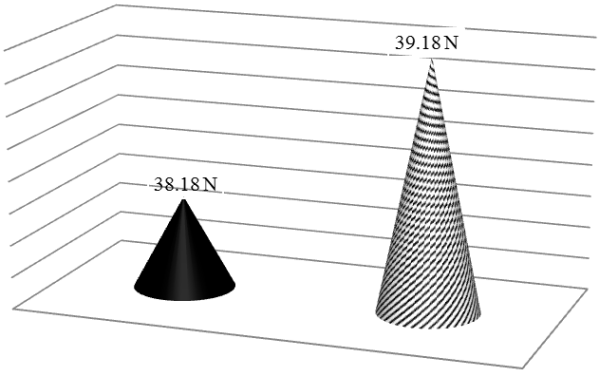

Figure 3. Average egg shell strength in the breeding cage system and breeding free range system (N) 38.18 = cage system, 39.18 =free range system.

Table 7. Statistical characteristic and statistical significance of difference in strength of egg shell between breeding cage system and breeding free range system

Breeding system	n	SD	CV	$P_{0.05}$
Cage	120	5.88	15.40	
Free range	120	5.62	14.34	$p \geq .05$

SD = standard deviation, CV = coefficient of variation, $p \geq 0.05$ = no statistically significant difference.

Table 8. Average egg shell strength in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

		Breeding system					
		Cage			Free range		
Age of hens, weeks	n	$\bar{x}$	SD	CV	$\bar{x}$	SD	CV
30	60	37.09	6.38	17.20	38.08	6.06	15.91
40	60	39.27	5.36	13.65	40.28	5.19	12.88

$\bar{x}$ = mean, SD = standard deviation, CV = coefficient of variation.

Table 9. Statistical significance of difference in the egg shell strength between breeding cage system and free range system depending on age 30 and 40 weeks of laying hens

Breeding system, age of hens	Free range, week 30	Cage, week 40	Free range, week 40
Cage, week 30	$p \geq 0.05$	$p \geq 0.05$	$p \geq 0.05$
Free range, week 30		$p \geq 0.05$	$p \geq 0.05$
Cage week 40			$p \geq 0.05$

$p \geq 0.05$ = no statistically significant difference.

Average egg shell strength in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

No statistically significant difference ($p \geq 0.05$) was observed in egg shell strength also between different ages of laying hens and the different breeding systems. Some authors justified the relation between egg shell quality indicators, such as between the thickness and strength. Egg shell strength is directly related to egg shell thickness [10] and the palisade layer of egg shell comprises approximately two-thirds of the egg shell [11]. Therefore, it is likely that alterations in the thickness of the palisade layer, independent of structural reorganization of the palisade columns, could affect shell strength. Egg shell strength ultimately affects the soundness of the shell, with weaker shelled eggs more prone to cracks and breakages and subsequently microbial contamination [12]. Shell strength can be affected by a wide range of factors.

Egg shell thickness

The difference statistically significant ($P \leq 0.05$) in thickness between the egg shell was observed between breeding cage system and free range system.

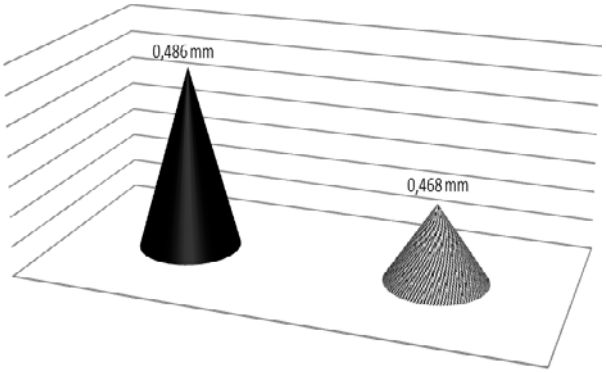

Figure 4. Average egg shell thickness in the breeding cage system and breeding free range system (mm) 0.486 = cage system, 0.468 = free range system.

Table 10. Statistical characteristic and statistical significance of difference in thickness of egg shell between breeding cage system and breeding free range system

Breeding system	n	SD	CV	$P_{0.05}$
Cage	120	0.028	5.76	
Free range	120	0.016	3.42	$p \leq 0.05$

SD = standard deviation, CV = coefficient of variation, $p \leq 0.05$ = statistically significant difference.

Table 11. Average egg shell thickness in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

		Breeding system					
		Cage			Free range		
Age of hens, weeks	n	$\bar{x}$	SD	CV	$\bar{x}$	SD	CV
30	60	0.481	0.009	1.87	0.463	0.047	10.15
40	60	0.492	0.014	2.84	0.473	0.031	6.55

$\bar{x}$ = mean, SD = standard deviation, CV = coefficient of variation.

Table 12. Statistical significance of difference in the egg shell thickness between breeding cage system and free range system depending on age 30 and 40 weeks of laying hens

Breeding system, age of hens	Free range, week 30	Cage, week 40	Free range, week 40
Cage, week 30	$p \geq 0.05$	$p \leq 0.05$	$p \leq 0.05$
Free range, week 30		$p \leq 0.05$	$p \leq 0.05$
Cage week 40			$p \leq 0.05$

$p \leq 0.05$ = statistically significant difference, $p \geq 0.05$ = no statistically significant difference.

Average egg shell thickness in the breeding cage system and breeding free range system in age 30 and 40 weeks of laying hens

No difference statistically significant ($p \geq 0.05$) was observed in the thickness of the egg shell in age 30 weeks of laying hens between breeding cage system and free range system but statistically significant difference ($p \leq 0.05$) was confirmed in the age 40 weeks of laying hens between breeding system. Statistically significant differences ($p \leq 0.05$) were observed in the thickness of the egg shell between different ages of laying hens and different breeding systems. There difference significant was observed in the thickness of the egg shell between age 30 weeks of laying hens in breeding cage system and age 40 weeks of laying hens in free range system, and between age 30 weeks of laying hens in free range system and age 40 weeks of laying hens in the breeding cage system. A similar conclusion stated by [13] in his study, where it is stated that there were significant differences in egg shell thickness with the differences of age of laying hens. Older birds tend to lay bigger eggs and have a higher egg output, which impacts on shell strength [14]. Very young birds with immature shell glands may produce shell-less eggs or eggs with very thin shells [15]. Interesting results were obtained these authors. In their study is reported the average egg shell thickness 0.401 mm. The shell was significantly ($p < 0.01$) thicker in the age 28 weeks of group compared to others. As age advanced the shell thickness gradually reduced with a significant lower shell thickness in the age 40 weeks. The higher egg shell thickness helps in preventing the damage during handling and also improves the keeping quality of the eggs.

4. Conclusions

The work is a contribution to the solution of optimal breeding system for laying hens and production of high quality and safe table eggs. Based on the results of investigation and statistical evaluation of selected quality the indicators egg shell in age 30 and 40 weeks of laying hens depending on the breeding system in enriched cages and free range system can be stated as follows:

a) Trend ($p \geq 0.05$) of increase of egg shell weight was observed in the breeding free range system compared to the egg shell in the breeding cage system. Statistically significant ($p \leq 0.05$) higher egg shell weight were observed in the age 40 weeks of laying hens in both breeding systems compared to the egg shell weight in the age 30 weeks of laying hens in both breeding systems. Statistically significant difference ($p \leq 0.05$) in weight of egg shell was observed between breeding systems in favour of free range system.

b) No statistically significant different ($p \geq 0.05$) in share of egg shell and in the egg shell strength were observed between breeding systems or between ages of laying hens.

c) Statistically significant difference ($p \leq 0.05$) in the egg shell thickness was observed between breeding cage system and breeding free range system. Trend ($p \geq 0.05$) of increase of egg shell thickness was observed in the breeding cage system in age 30 weeks of laying hens. Statistically significant ($p \leq 0.05$) higher egg shell thickness was observed in both breeding systems in the age 40 weeks of laying hens compared to egg shell thickness in the age 30 weeks of laying hens. Statistically significant difference ($p \leq 0.05$) in egg shell thickness was observed between breeding systems in favour of breeding cage system.

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