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The effect of the rearing system, genotype and laying hens age on the egg weight and share of main parts of eggs

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Abstract: The aim of this study was to evaluate the effect of rearing system, genotype and hens age on egg weight and eggs components share. The tested rearing systems were the floor and organic, and tested genotypes were Isa Brown hybrid and New Hampshire breed. Eggs were collected for analyses three times in production cycle (32 weeks hens age, 48 weeks hens age, and 72 weeks hens age). In these samples (fifteen eggs per group, eggs were one day old) were investigated: egg weight, albumen share, yolk share and shell share. Egg weight was increased with hens age. Also, the interaction between the genotype and hens age was found, so the New Hampshire eggs in 32 weeks had less weight then Isa Brown eggs ($p \leq 0.05$), while in the 48 and 72 weeks this difference was lost ($p \geq 0.05$). The share of egg albumen and yolk was significantly affected by the rearing system, genotype and hens age ($p \leq 0.05$). Floor produced eggs had a lower proportion of albumen and a higher proportion of yolk compared to organic eggs. New Hampshire eggs had a higher content of yolk and the smaller content of albumen compared to Isa Brown eggs ($p \leq 0.05$). With hens age, the share of yolk was increased and albumen share was decreased. Interaction of all three studied factors - rearing system x genotype x hens age had the most important effect on the shell share.

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Keywords: Rearing system, genotype, hens age, eggs quality.

Introduction

Cage rearing system is the dominant way of rearing of laying hens in most countries in the world, and this situation probably will continue for a long time. The reason for this is because the rearing of hens in the cage is a most economical way of production, and it provides that the price of eggs is low and that product be accessible to all segments of the population. Statistics for 2013 did not record that in the big world egg producers such as Brazil, India, Iran, Mexico, Russia and Turkey laying hens were reared outside the cage (Windhorst, 2015). The exception of this trend is Europe, especially the EU countries wherein the cage system is reared only about 56% (with a decreasing trend) in the floor about 26%, in the so-called "free range" about 14% and about 4% of the birds are organic hens (Committee for the Common Organization of Agricultural Markets, 2016). Some European countries have even banned the keeping of hens in cages (Switzerland, Norway, Luxembourg). There are two reasons for this situation in the European egg production: concern for the welfare of farmed animals and the awareness that the products produced in a natural way are better and healthier for the human consumption.

Various genotypes can be used for rearing in some of the non-cadged rearing systems. Commercial hybrids have excellent production performance,but and some problems typically associated with the use of commercial hybrids for production under strictly controlled conditions in a free-range system - weak legs, excessive rates of heart attacks, a high incidence of congestive heart failure (ascites), poor foraging ability, poor heat tolerance, and other liabilities; therefore, producers are often discouraged from rearing these hybrids in alternative production systems (Fanatico *et al*., 2005).

On the other hand, the breeds have poorer production performances, but they are much more resistant for disease and parasites, they are better adapted to free range and unfavorable climatic factors and also capable of producing on a less protein-rich diet.

A number of studies have been conducted significant effect of hens age on egg quality (Zita *et al*. 2009; Chung and Lee, 2014), but the interaction of hens age, rearing system and hens genotype is not fully known. Therefore, the aim of this study was to evaluate the effect of rearing system, genotype and hens age on egg weight and eggs components share.

Material and methods

The effect of rearing system, genotype and age and of hens on egg weight and eggs components share was observed on 120 laying hens which were divided into four groups (two genotypes and two rearing systems), each of 30 birds.

The tested rearing systems were the floor and organic, and tested genotypes were Isa Brown hybrid and New Hampshire breed.

Hens from floor system had 4000 cm^2 per bird spaces availability. Wood shavings were used as litter cover. In facility was set perches and nests. As the floor hens, the organic layers also had 4000 cm^2 per bird spaces availability, but and about 5 m^2 per birds available outdoor area. Outlet in most of their part was covered with grass and bushes, and birds were able to supplement their diets using grass and insects living on free range.

Floor laying hens were fed *ad libitum* with standard commercial 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 most of 80% organically grown components. Its chemical composition is also shown in Table 1. In all of four experimental groups water was available *ad libitum.*

Table 1. 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

Eggs were collected for analyses three times in production cycle (32 weeks hens age, 48 weeks hens age, and 72 weeks hens age). In these samples (fifteen eggs per group, eggs were one day old) were investigated: egg weight, albumen share, yolk share and shell share.

Quality of eggs data were analyzed by ANOVA and LSD test (Stat Soft Inc Statistica For Windows, Version 7.0., 2006).

Results and discussion

In table 2 was presented effect of the rearing system, genotype and hens age on investigate parameters of egg quality

Table 2. Effect of the rearing system, genotype and hens age on eggs weight and share of the main component of eggs

Rearing system	Genotype	Hens age (week)	Egg weight (g)	Albumen share (%)	Yolk share (%)	Shell share (%)
Floor	Isa Brown	32	61.18 b	60.62 ab	27.02 ef	12.36 abc
		48	66.86 a	58.77 c	28.30 cde	12.93 a
		72	67.03 a	59.14 bc	28.63 cd	12.23 bc
	New Hampshire	32	57.43 cd	59.10 bc	28.82 cd	12.59 ab
		48	66.07 a	56.06 ef	32.21 a	11.61 d
		72	65.71 a	55.69 f	31.80 a	12.51 abc
Organic	Isa Brown	32	60.03 bc	61.87 a	25.56 f	12.57 ab
		48	65.54 a	60.04 bc	28.00 cde	11.96 bcd
		72	65.63 a	58.70 c	27.89 de	12.48 abc
	New Hampshire	32	56.23 d	58.74 c	28.71 cd	12.56 abc
		48	66.84 a	58.61cd	29.53 bc	11.86 cd
		72	66.69 a	57.55 de	31.04 ab	11.41 d
Significance						
Rearing system			0.417	**0.007**	**0.002**	0.111
Genotype			0.076	**≤0.001**	**≤0.001**	**0.023**
Hens age			**≤0.001**	**≤0.001**	**≤0.001**	**0.035**
Rearing system x Genotype			0.282	0.379	0.595	0.671
Rearing system x Hens age			0.808	0.230	0.585	0.290
Genotype x Hens age			**0.031**	0.955	0.686	0.069
Rearing system x Genotype x Hens age			0.731	0.086	0.065	**0.002**

a-f: Values within columns with different superscripts are significantly different ($p \leq 0.05$)

Table 2 shows that the egg weight was significantly influenced by hens age and interaction hens age x genotype. Housing system had not significant ($p \geq 0.05$) effect on egg weight, which is consistent with the results reported by Rizzi *et al*. (2006), Zemkova *et al*. (2007) and Mugnai *et al*. (2009). Generally, egg weight was increased with hens age, so that the eggs from hens 32 weeks age had significantly lower weight ($p \leq 0.05$) compared to the eggs of hens 48 and 72 weeks age. These results are in agreement with findings Curtis *et al*. (2005), Rizzi and Cassandro (2009) and Škrbić *et al*. (2011) who showed that egg weight increases with the age of hens. Also, the interaction between the genotype and hens age was found, so the New Hampshire eggs in 32 weeks had less weight then Isa Brown eggs ($p \leq 0.05$), while in the 48 and 72 weeks this difference was lost ($p \geq 0.05$). Similar results were reported and Zita *et al*. (2009), who found that ISA Brown had a significantly ($p \leq 0.001$) higher egg weight than the Moravia BSL genotype at the beginning of the production cycle (20-26 week), but at the end of the production (56-60 week) Moravia BSL produced the heaviest eggs.

The share of egg albumen and yolk was significantly affected by the rearing system, genotype and hens age ($p \leq 0.05$). On the other hand, rearing system did not significantly effect on the egg shell share ($p \geq 0.05$), while the effect of genotype and age of hens on this trait was significant ($p \leq 0.05$).

Floor produced eggs had a lower proportion of albumen and a higher proportion of yolk compared to organic eggs ($p \leq 0.05$. The lower yolk proportion in organic eggs may be due to a deficiency of some nutrients, primarily methionine (Shafer *et al*., 1996), given the fact that methionine is the first limiting amino acid in organic diets for laying hens (Hancock *et al*., 2003; Zollitsch *et al*., 2004). Elwinger *et al*. (2002) also found the same effects due to dietary deficiencies when feeding low methionine organic diets.

New Hampshire eggs had a higher content of yolk and the smaller content of albumen compared to Isa Brown eggs ($p \leq 0.05$). Confirmation that hens eggs from races have a higher content of egg yolks compared to hybrid hens eggs we can find in the results of Suk and Park (2001) who determined the crucial effect of genotype on a share of yolk and albumen. They were found 6.07% more the egg yolk and 5.38% less egg albumen at KNC - Korean native breeds, compared to Isa Brown hybrid.

Also, Rizzi and Chiericato (2005) established that indigenous races, Robusta Maculata and Ermellinata of Rovigo had a higher content of egg yolks and smaller content of egg albumen compared to commercial hybrids Hy Line Brown and Hy Line White. These researchers are, according to our results, also found a significant effect of age on this traits - from 30 to 42 weeks of laying, the percentage of egg yolk significantly increased while albumen decreased. And Ledvinka *et al*. (2012) found a significant effect of genotype and age of the hens, as well as their interactions, on the yolk: albumen ratio.

Interaction of all three studied factors - rearing system x genotype x hens age had the most important effect on the shell share. According to our results, Rizzi and Chiericato (2005) also found a significant difference in the proportion of shell in four genotypes in organic production systems. Checks were carried out twice - in the 30th and 42nd week of age. In addition to the significant difference in the size of this parameter between genotypes, it must be noted that the value of this parameter did not change at all genotypes in the same way with hens aging. Thus, at Hy Line Brown and Ermellinata of Rovigo layers with age shell share decreased, with the Hy Line White was at a constant level, and in Robusta maculata race even increased.

Conclusion

Based on the results of these investigations, it can be concluded that rearing system, hens genotype, and hens age had a significant effect on the most of investigated egg quality parameters. Generally, egg weight was increased with hens age. Also, the interaction between the genotype and hens age was found, so the New Hampshire eggs in 32 weeks had less weight then Isa Brown eggs ($p \leq 0.05$), while in the 48 and 72 weeks this difference was lost ($p \geq 0.05$). The share of egg albumen and yolk was significantly affected by the rearing system, genotype and hens age ($p \leq 0.05$). Floor produced eggs had a lower proportion of albumen and a higher proportion of yolk compared to organic eggs. New Hampshire eggs had a higher content of yolk and the smaller content of albumen compared to Isa Brown eggs ($p \leq 0.05$). With hens age, the share of yolk was increased and albumen share was decreased. Interaction of all three studied factors - rearing system x genotype x hens age had the most important effect on the shell share.

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UTICAJ SISTEMA GAJENJA, GENOTIPA I STAROSTI KOKOŠI NOSILJA NA MASU JAJA I UDEO GLAVNIH DELOVA JAJA

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Rezime

Cilj ovog rada je bio da ispita uticaj sistema gajenja, genotipa i starosti kokoši nosilja na masu i udeo glavnih delova jaja. Ispitivani sistemi gajenja su bili podni i organski, a ispitivani genotipovi Isa Brown hibrid i New Hampshire rasa. Jaja su sakupljana za analizu tri puta za vreme proizvodnog ciklusa (kod 32-nedeljnih nosilja, 48-nedeljnih i 72-nedeljnih). Na ovim uzorcima (15 jaja po grupi, jaja stara jedan dan) su ispitivani: masa jaja, udeo belanca, udeo žumanca i udeo ljuske jaja. Masa jaja se povećavala sa starenjem nosilja. Takođe, interakcija genotip x starost nosilja je bila značajna, pa su New hampshire kokoši u 32. nedelji nosile jaja manje mase od Isa Brown hibrida ($p \leq 0.05$), dok tih razlika u 48. i 72. nedelji nije bilo ($p \geq 0.05$). Udeo belanca i žumanca je bio od značajnim uticajem sistema gajenja, genotipa i starosti nosilja ($p \leq 0.05$). Podno gajenje kokoši su nosile jaja koja su imala manji udeo belanca a veći udeo žumanca u poređenju sa organskim kokošima ($p \geq 0.05$). Jaja New Hampshire rase su imala manji udeo belanca a veći udeo žumanca u poređenju sa Isa Brown genotipom ($p \geq 0.05$). Sa starenjem kokoši, udeo žumanca se povećavao a udeo belanca smanjivao. Interakcija sva tri ispitivana faktora - sistema gajenja, genotipa i starosti nosilja je imala najznačajniji uticaj na udeo ljuske jaja.

Ključne reči: sistem gajenja, genotip, starost kokoši, kvalitet jaja.