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## Egg characteristics of New Hampshire laying hens from floor and organic rearing systems

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**Abstract:** The aim of this study was to compare the effect of two alternative rearing systems (floor and organic) on egg quality traits of New Hampshire laying hens in three different phases of the productive cycle (32, 48 and 72 weeks of age). Egg samples (15 eggs per group) were analysed for quality (egg weight, egg shape index, albumen height, Haugh unit, yolk colour) and chemical composition (dry matter, minerals, proteins and lipids). Egg weight, dry matter and protein content increased, while albumen height, Haugh unit and lipid content decreased with hen age ( $p \leq 0.05$ ). Eggs from the floor rearing system had a higher shape index and lipid content compared to organic eggs ( $p \leq 0.05$ ). Both factors and their interactions had a significant effect on yolk colour ( $p \leq 0.05$ ).

**Keywords:** New Hampshire, rearing systems, egg quality, chemical composition, laying hen age.

### Introduction

The number of laying hens reared in non-cage production systems is constantly increasing in Europe, already reaching about 50% in the United Kingdom while keeping hens in cages is even forbidden in some countries

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(Switzerland, Norway) (Rakonjac *et al.*, 2018a). There are two main reasons for the introduction of these alternative rearing systems: the production of better and healthier products for human consumption and the provision of a higher level of well-being for hens.

The introduction of new rearing systems has inevitably raised the question regarding the choice of genotypes to be used in this production. Namely, modern hybrids have been selected for the cage production system, which implies a fully controlled environment (temperature, light, humidity) and no risk of exposure to potential disease agents, parasites or predators. Feed for these layers must contain a high level of energy, vitamins, proteins and, in particular, some limiting amino acids, which in alternative rearing systems (especially organic) is not easy to provide. There are health and welfare risks associated with keeping high yielding hens in outdoor systems (Van de Weerd *et al.*, 2009).

For this reason, pure breed hens can be used in free-range production systems as they are better adapted to free-range, are capable of producing on a less protein-rich diet, and have a satisfactory behaviour and reasonable productivity (Sørensen *et al.*, 2004). The use of these breeds, which still have natural behaviours, could also be a valuable alternative, particularly if they are in danger of extinction (Mugnai *et al.*, 2009).

There are a few studies on the effect of alternative rearing systems on egg quality traits of pure breed hens (Rizzi and Chiericato, 2005; Mugnai *et al.*, 2009,) and on the effect of hen age on these parameters (Zita *et al.*, 2009; Chung and Lee, 2014), but the joint effect of rearing system and hen age for pure breeds is not fully known. Therefore, the aim of this study was to compare the effect of two alternative rearing systems (floor and organic) in three different phases of the productive cycle on egg quality traits of New Hampshire layers.

### Material and method

The study involved a total of 60 New Hampshire laying hens reared under floor and organic systems (30 birds per group). New Hampshire is a dual-purpose breed (for eggs and meat) and is suitable for non-intensive rearing conditions.

In both rearing systems, stocking density was 2.5 birds/m<sup>2</sup>. Organic layers were provided with 5 m<sup>2</sup> of outdoor natural grassland area per bird, and these hens were able to supplement their diets using vegetation and small creatures living on free range.

Laying hens were fed diets whose average chemical compositions are shown in Table 1. In the organic system, except in the facility, feeders and drinkers were located outdoors. It is important to note that the diet for organic hens contained no synthetic amino acids, vitamins and minerals, and had more than 80% organically grown components. In all experimental groups, feed and water were available *ad libitum*.

Table 1. The chemical composition of diet for laying hens

Chemical composition	Floor system	Organic system
	%	%
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 in three phases of the productive activity (at the beginning of the laying period – 24 weeks of hen age, in the middle of the laying period – 48 weeks of hen age, and at the end of the laying period – 72 weeks of hen age). These samples (eggs were one-day old) were analysed for external and internal quality parameters and chemical composition of eggs.

- Egg weight was measured on an electronic scale with an accuracy of  $10^{-2}$  g.
- Egg shape index, or short-axis to long-axis length ratio (%), was determined using a special device (B.V. Apparatenfabriek van Doorn, Holland).
- Albumen height was determined by a tripod micrometer (AMES, USA)
- Haugh units were calculated according to the following formula:  

$$HU=100\log(H+7.57-1.7M^{0.37})$$
 where H = albumen height, mm. M = egg weight, g.
- Egg yolk colour was determined according to the Roche yolk colour fan.

The chemical composition of eggs was determined according to AOAC procedures (AOAC, 1990).

Egg quality data were analysed by ANOVA and LSD test (Stat Soft Inc Statistica for Windows. Version 7.0., 2006).

## Results and discussion

At 48 and 72 weeks of hen age, eggs had greater weights ( $p \leq 0.05$ ) than at the beginning of the production cycle (24 weeks), which is consistent with the results published by Rakonjac *et al.* (2017 and 2018b). Padhi *et al.* (2013) found that egg weight increased only at the beginning of egg production while it remained unchanged in later phases. Calik (2011) determined that the weight of eggs from New Hampshire layers ranged from 59.3 to 60.9 g at 30 weeks of hen age, which is in line with the tendency of egg weight to increase with ageing, as determined

in our research. On the other hand, there was no significant difference in egg weight between floor and organic eggs ( $p \geq 0.05$ ), similarly to the results reported by Mugnai *et al.* (2009) and Rakonjac *et al.* (2017).

Table 2. Effects of rearing system and hen age on egg quality characteristics

Rearing system (RS)	Hen age (HA) (weeks)	Egg weight (g)	Egg shape index	Albumen height (mm)	Haugh unit	Yolk colour (Roche)
Floor	24	51.81 <sup>b</sup>	76.07 <sup>a</sup>	86.47 <sup>a</sup>	93.40 <sup>a</sup>	10.73 <sup>c</sup>
	48	66.07 <sup>a</sup>	75.53 <sup>ab</sup>	76.13 <sup>b</sup>	84.47 <sup>b</sup>	11.47 <sup>b</sup>
	72	65.71 <sup>a</sup>	75.80 <sup>ab</sup>	61.80 <sup>c</sup>	73.93 <sup>c</sup>	13.73 <sup>a</sup>
Organic	24	51.39 <sup>b</sup>	74.40 <sup>ab</sup>	86.73 <sup>a</sup>	94.67 <sup>a</sup>	11.20 <sup>bc</sup>
	48	66.84 <sup>a</sup>	74.07 <sup>b</sup>	81.80 <sup>ab</sup>	87.47 <sup>ab</sup>	11.07 <sup>bc</sup>
	72	66.69 <sup>a</sup>	74.60 <sup>ab</sup>	62.93 <sup>c</sup>	74.87 <sup>c</sup>	11.60 <sup>b</sup>
p value						
RS		0.708	0.016	0.431	0.420	$\leq 0.001$
HA		$\leq 0.001$	0.798	$\leq 0.001$	$\leq 0.001$	$\leq 0.001$
RS x HA		0.875	0.948	0.730	0.915	$\leq 0.001$

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

Eggs from the floor rearing system had a higher shape index compared to organic eggs ( $p \leq 0.05$ ), which is in agreement with the results by Kralik *et al.* (2013), who reported that free range rearing increased egg elongation. There was no change in egg shape index with ageing ( $p \geq 0.05$ ), which is consistent with the results found by Sokolowitz *et al.* (2019) for Green-legged Partridge and Araucana genotypes. The results of the authors who found the opposite, i.e. a significant effect of hen age on this trait (Zita *et al.* (2009), Ledvinka *et al.* (2012), Rakonjac *et al.* (2018a and 2018b)), can be explained by the following fact: in these studies they used hybrids whose egg shape index increased with ageing, which is often not the case. In a study by Škrbić *et al.* (2011), the value of the egg shape index decreased with ageing ( $P = -0.15$ ) in Lohmann Brown hens in a conventional rearing system, while there was no change in the egg shape index with ageing in Banat Naked-Neck hens in a free-range system.

Haugh unit decreased throughout the experimental period, due to the decrease in albumen height with the ageing of hens (Rakonjac *et al.*, 2018a). Similar results were also obtained by Ojedapo (2013) and Padhi *et al.* (2013). These characteristics were not significantly affected by the rearing system, which is consistent with the results reported by Lewko and Gornowicz (2011) and Kralik *et al.* (2013).

Both factors and their interactions had a significant effect on yolk colour ( $p \leq 0.05$ ). Roche values increased with hen age in the floor system, but were

relatively constant in the organic system throughout the production cycle. Floor reared hens consumed the same amount of synthetic carotenoids in the diet throughout the experimental period, and the increasing intensity of yolk colour was the result of their greater synthesis in the body with ageing of hens (Rakonjac *et al.*, 2018a). In organic hens, there were no synthetic carotenoids in their diet and yolk colour was much more dependent on the availability of grass at the range, which is consistent with the results published by Mugnai *et al.* (2009), Kucukyilmaz *et al.* (2012) and Kralik *et al.* (2013).

Table 3. Effects of rearing system and hen age on the chemical composition of eggs

Rearing system (RS)	Hen Age (HA) (weeks)	Dry matter (%)	Minerals (%)	Protein (%)	Lipids (%)
Floor	24	23.58 <sup>bc</sup>	0.89 <sup>ab</sup>	12.86 <sup>a</sup>	8.24 <sup>c</sup>
	48	23.96 <sup>bc</sup>	0.89 <sup>ab</sup>	12.27 <sup>bc</sup>	10.15 <sup>ab</sup>
	72	25.89 <sup>a</sup>	0.86 <sup>b</sup>	12.60 <sup>ab</sup>	10.87 <sup>a</sup>
Organic	24	22.29 <sup>c</sup>	0.86 <sup>b</sup>	12.94 <sup>a</sup>	7.69 <sup>c</sup>
	48	24.38 <sup>abc</sup>	0.86 <sup>b</sup>	12.12 <sup>c</sup>	9.69 <sup>b</sup>
	72	24.85 <sup>ab</sup>	0.90 <sup>a</sup>	12.44 <sup>bc</sup>	9.90 <sup>ab</sup>
p value					
RS		0.280	0.691	0.484	0.038
HA		0.008	0.751	≤0.001	≤0.001
RS x HA		0.421	0.040	0.634	0.744

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

Dry matter content in eggs increased with hen age ( $p \leq 0.05$ ), while this trait was not significantly affected by rearing system ( $p \geq 0.05$ ), which is in agreement with the results reported by Hidalgo *et al.* (2008) and Pavlovski *et al.* (2011).

Mineral content in eggs was relatively constant throughout the experimental period and was not significantly affected by rearing system, which is in agreement with the results published by Bologa *et al.* (2013) and Nistor *et al.* (2014). Only at week 72, organic eggs had a higher mineral content compared to eggs from hens aged 24 and 48 weeks.

The protein content was not significantly affected by rearing system ( $p \geq 0.05$ ), as in the research by Krawczyk and Gornowicz (2010) and Radu-Rusu *et al.* (2014). On the other hand, floor produced eggs had a higher fat content compared to organic eggs ( $p \leq 0.05$ ), which is in agreement with the results by Matt *et al.* (2009) and Radu-Rusu *et al.* (2014), who reported that free-range eggs had a lower fat content compared to eggs from the conventional system.

With the ageing of hens, the protein content generally decreased and the fat content of eggs increased. The results are similar to those reported by Rakonjac

*et al.* (2018b) for Isa Brown hens, showing not only a similar effect of rearing system on the tested traits, but also similar dynamics of age-related change in fat and protein contents in eggs under the cage, floor and organic rearing systems.

### Conclusion

Based on the results of these investigations, it can be concluded that:

- Egg weight, dry matter and protein content increased, while albumen height, Haugh unit and lipid content decreased with hen age ( $p \leq 0.05$ );
- Eggs from the floor rearing system had a higher shape index and lipid content compared to organic eggs ( $p \leq 0.05$ );
- Both factors and their interactions had a significant effect on yolk colour ( $p \leq 0.05$ ).

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## KARAKTERISTIKE JAJA NEW HAMPSHIRE KOKOŠI NOSILJA IZ PODNOG I ORGANSKOG SISTEMA GAJENJA

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### Rezime

Cilj ovog rada je bio da se ispita uticaj dva alternativna sistema gajenja (podnog i organskog) u tri različite faze proizvodnog ciklusa (32, 48. i 72. nedelja starosti kokoši nosilja) na kvalitet jaja New Hampshire rase kokoši. Na 15 jaja po grupi ispitivani su parametri kvaliteta jaja (masa, indeks oblika, visina belanca, Hogove jedinice, boja žumanca) i osnovni hemijski sastav (sadržaj suve materije, minerala, proteina i masti). Sa starenjem nosilja, smanjivala se masa jaja i sadržaj suve materije i proteina, a povećavala visina belanca, Hogove jedinice i sadržaj masti ( $p \leq 0.05$ ). Jaja iz podnog sistema gajenja imala su veći indeks oblika i sadržaj masti u poređenju sa organskim jajima ( $p \leq 0.05$ ). Oba ispitivana faktora i njihova interakcija značajno su uticali na boju žumanca ( $p \leq 0.05$ ).

**Ključne reči:** New Hampshire, sistem gajenja, kvalitet jaja, hemijski sastav, starost kokoši nosilja.