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QUALITY OF TABLE EGGS FROM DIFFERENT PRODUCTION SYSTEMS

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SUMMARY

The production system is one of the most significant factors influencing internal and external egg quality. Due to concerns for the welfare of laying hens, and on the basis of Council Directive 1999/74/EC, EU countries banned conventional cages, so it is necessary to determine the influence of alternative systems on the external and internal quality traits of table eggs. Consumers believe that organic eggs are healthier than eggs from the conventional production systems. In addition, consumer awareness of the welfare of laying hens has been raised in the last few decades. This research aimed to determine the quality of table eggs from the cage, free-range and organic systems that are present on the Serbian market. External and internal quality traits were examined for 30 eggs taken from the market from the cage, organic and free-range systems. The value of Haugh units was 77.16 for organic eggs, 66.01 for conventional cages, and 62.01 for free-range system. The results showed that eggs from the organic system had significantly higher egg weight, shape index, albumen height, and Haugh units ($p \leq 0.05$) compared to cage and free-range eggs. Eggs from the free-range system had the highest number of meat and blood spots (2.25), while it was the lowest in eggs from the cage system (0.40). Eggs from organic production and conventional cages showed better results in internal and external egg quality. Shell quality traits, yolk color, and yolk pH were not affected by the production system.

Key words:
egg quality, housing system, organic eggs

INTRODUCTION

Internal and external egg quality traits are affected by a significant number of genetic and environmental factors. Production systems affect productivity, health, and welfare of laying hens, as well as the quality traits of table eggs. In addition, these systems significantly affect the environment, welfare, health, and productivity (Guyonnet, 2012). The importance of alternative housing systems in recent years is growing, so it is important to determine the impact of these systems on quality traits of table eggs, as well as economic and environmental factors (Molnár & Szollosi, 2020). A large number of authors state that the housing system can significantly affect egg quality, including egg weight, shape index, shell color, shell weight, shell thickness, shell breaking force, and yolk and albumen height (Lewko & Gornowicz, 2011; Dalle Zotte et al., 2013; Batkowska & Brodacki, 2017; Dedousi et al., 2020).
Molnár & Szollosi (2020) state that consumption of eggs is the easiest way to meet human needs for animal proteins, because eggs are the cheapest and have the least impact on the environment.
According to Council Directive 1999/74/EC, EU countries banned conventional cages. In Serbia, the ban will take effect in 2023, and producers must find the best alternative housing system for laying hens in terms of egg

production and quality. In addition, consumer awareness of the welfare of laying hens has been raised in recent years. It is generally accepted that eggs from organic production have more health benefits and higher quality (Sokołowicz et al., 2019). According to European Commission for year 2020, 48% of laying hens were housed in enriched cages, 33.9% in barn and aviary systems, 11.9% in free-range systems, and only 6.2% in organic housing.
This research aimed to determine the external and internal quality of eggs from the conventional cages, organic and free-range systems that are present on the Serbian market, as well as to determine the impact of the production system on the quality traits of table eggs.

MATERIAL AND METHODS

The research was conducted on table eggs from the cage, organic and free-range systems. Eggs used in this study were stored for 7 days at temperature of 8°C. External and internal quality of eggs was determined on samples of 30 L class eggs per housing system. Egg samples were taken from the market and the examination of external and internal quality of eggs from all three systems was performed on the same day. The following traits of the external quality of eggs were examined: egg weight, shell color, shell cleanness, shape index, shell breaking force, shell thickness, and shell weight. The examined traits of the internal quality of eggs included: albumen height, Haugh units (HU), yolk height, yolk index, yolk color, yolk and albumen pH, and meat and blood spots. Egg weight and shell weight were measured for each egg using precision scales. Shell weight was measured after 48 hours of drying at room temperature. Shell color was evaluated by scoring from 1 (white) to 5 (dark brown). Shell cleanness was assessed by scoring from 1 (clean) to 4 (very dirty). Egg Force Reader (Orka Food Technology Ltd, Israel) was used to measure shell breaking force. Shell thickness, albumen and yolk height were measured using a micrometer. The following formula was used to calculate Haugh units (HU): $HU=100\log (H+7.57-1.7M^{0.37})$. Albumen height (H) and egg weight (M) were used to calculate HU. Yolk index was calculated as the ratio of width and length of the yolk. Roche color fan was used to determine the color of the yolk. The pH of albumen and yolk was measured using a pH meter (HANNA Instruments). Meat and blood spots were determined by counting and are shown as the average value per egg.
Statistical analysis was performed using statistical software STATISTICA 13.5 (TIBCO Stat Soft). One-way ANOVA was used to analyze results obtained in this research. Post hoc analysis was done using Duncan's multi range test. Results of statistical analysis were considered significant when $p \leq 0.05$.

RESULTS AND DISCUSSION

External quality traits of table eggs originating from the cage, free-range and organic production systems are shown in Table 1. As expected, significant differences between housing systems have been identified.

Table 1. External egg quality traits from cage, free-range and organic systems ($\bar{x} \pm SD$)

Traits	Production system		
	Cages	**Free range**	**Organic**
Egg weight (g)	64.75 ± 2.38^{b}	63.05 ± 0.69^{c}	66.15 ± 1.89^{a}
Shell color (points)	4.35 ± 0.67^{a}	3.65 ± 1.09^{b}	4.05 ± 0.89^{ab}
Shell cleanness (points)	1.50±0.76	1.55±0.68	1.35±0.58
Shape index (%)	74.80 ± 3.04^{ab}	73.85 ± 1.98^{b}	76.60 ± 2.62^{a}
Shell breaking force (kg)	4.39±1.43	4.27±1.48	3.91±0.87
Shell thickness (mm)	0.38±0.03	0.39±1.04	0.39±0.03
Shell weight (g)	6.52±0.49	6.32±0.59	6.50±0.61

Legend: ^{a,b,c} Values without common superscript in the same row are significantly different ($p \leq 0.05$)

Table 1 shows statistically significant differences between all three housing systems. The lowest egg weight was found in eggs from the free-range system, while organic eggs had the highest weight. However, differences in egg weight can be primarily attributed to the age of hens, which a factor that is not known in market research. Đukić Stojčić et al. (2015) found in their research that free-range eggs had higher weight compared to eggs from the organic system, which is in contrast to the results from this research. Similarly, Perić et al. (2015) found that organic eggs had the lowest weight, while free-range eggs had the highest weight. On the other hand, Terčić et al. (2012) reported no difference in egg weight between the organic system and conventional cages. Higher egg weight in the free-range system compared to conventional cages was reported by Dalle Zotte et al. (2013).

Shell color is a significant trait for consumers, although it does not affect the quality of eggs. Consumers in Serbia prefer eggs with a darker shell, and this is why the shell color is an important quality trait of table eggs. Darker shell color was found in cage eggs, and was significantly higher compared to free-range and organic eggs. Some researchers indicate that shell color depends on the housing system (Tůmová et al., 2011; Sokołowicz et al., 2018). Perić et al. (2015) found that eggs from the free-range system had a darker shell (3.15) compared to eggs from conventional cages (2.85) and organic eggs (2.55). Dedousi et al. (2020) detected no differences between different production systems in regard to shell color.

No significant differences were found between the housing systems regarding shell cleanness, although organic eggs had the best score. Perić et al. (2015) found in their research that laying hens from the organic system had the dirtiest shell compared to conventional cages and free-range systems. They attributed these differences to the fact that hens from the organic system spend more time on the pasture compared to the laying hens from conventional cages and free-range.

Eggs from the organic system had the highest shape index and eggs from the free-range system had the lowest shape index and the difference was statistically significant ($p \leq 0.05$). Đukić Stojčić et al. (2015) reported that eggs from conventional cages were more rounded, i.e. they had a higher shape index compared to the organic and free-range systems. Perić et al. (2015) had similar findings. Batkowska & Brodacki (2017) reported that the housing system does not affect the egg shape index. Englmaierová et al. (2014) report that the production system affects the shape index. It should be noted that internal or external egg quality are not affected by the shape index.

Shell breaking force was not significantly affected by the housing systems. Perić et al. (2015) found a significantly higher shell breaking force of 4.46 in organic eggs compared to 3.67 and 4.24 in conventional cages and free-range systems, respectively.

Very small differences were found between the three housing systems in shell thickness and shell weight. Dedousi et al. (2020) found that eggs from the free-range system had higher shell thickness compared to eggs from cages, although they did not find significant differences between two systems.

This study showed that there are significant differences in the internal quality of eggs between the cage, organic and free-range production systems (Tab. 2).

Table 2. Internal egg quality traits from cage, free-range and organic systems ($\bar{x} \pm SD$)

Traits	Production system		
	Cages	Free-range	Organic
Albumen height, mm	5.26 ± 1.41^{b}	4.59 ± 0.99^{b}	6.52 ± 1.41^{a}
Haugh units	66.62 ± 15.37^{b}	62.01 ± 10.43^{b}	77.16 ± 10.98^{a}
Yolk height, mm	18.45 ± 1.31^{a}	16.30 ± 0.81^{b}	16.69 ± 1.45^{b}
Yolk index, %	48.76 ± 4.78^{a}	42.48 ± 2.77^{b}	43.13 ± 5.38^{b}
Yolk color (Roche)	11.8±0.89	11.85±1.31	11.25±3.02
Yolk pH	6.33±0.14	6.51±0.18	6.30±0.16
Albumen pH	9.35 ± 0.03^{a}	9.29 ± 0.03^{ab}	9.13 ± 0.12^{b}
Meat and blood spots	0.40 ± 0.88^{b}	2.25 ± 2.82^{a}	0.55 ± 1.39^{b}

Legend: ^{a,b} Values without common superscripts in the same row are significantly different ($p \leq 0.05$)

Albumen height is an important quality trait of table eggs, and it is used to determine egg freshness. Significant differences were found between the organic and free-range systems, and the organic and conventional cages.

Haugh units were significantly higher ($p \leq 0.05$) in organic eggs compared to eggs from the free-range and conventional cages. Other authors also report that Haugh units are higher in eggs from conventional cages compared to eggs from other alternative production systems, i.e. organic and free range systems (Đukić Stojčić et al., 2015; Perić et al., 2015). Sekeroglu (2002) found that the housing system affects Haugh units, which is in accordance with the result obtained in this research.

Free-range and organic eggs had significantly lower yolk height and yolk index compared to eggs from conventional cages. No significant differences were found between the organic and free-range eggs.

Cage and organic eggs had slightly darker yolks compared to free-range eggs, but the difference was not statistically significant. Perić et al. (2015) found that yolk from cages and free-range system were darker compared to the organic system. Their conclusion is that synthetic pigments are banned in organic production. Consumers believe that yolk color is an important egg quality trait, and they prefer darker egg yolk color. It is important to point out that yolk color does not affect the quality and nutritional composition of eggs.

The highest yolk pH was found in free-range eggs while the lowest yolk pH was in organic eggs. Kralik et al. (2013) found no differences between the housing systems regarding albumen pH, which is in agreement with the results of this research.

Eggs from conventional cages had statistically higher albumen pH compared to the organic system.

Eggs from the free-range system had the highest content of meat and blood spots. Free-range eggs had a significantly higher average count of meat and blood spots than eggs from cages and organic systems. According to Sokołowicz et al. (2018) production systems had no significant effect on the meat and blood spots content. They concluded that the layer breed is the most important factor determining these traits.

CONCLUSION

The results obtained in this research showed that the production system significantly affects some internal and external quality traits of table eggs. Although eggs from all three production systems had good internal and external quality, eggs from organic production and conventional cages showed better results in regard to egg quality. Cage and organic eggs had significantly higher egg weight, albumen height, HU, and yolk height compared to free-range eggs. The production system did not affect shell quality traits, yolk color, and yolk pH. In general, all three production systems had good external and internal egg quality traits.

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Conflict of interest: The authors declare that they have no conflict of interest.

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