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Original Paper

Comparative analysis of the external and internal egg quality in different pure chicken breeds

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The present study was conducted to evaluate some parameters of external and internal egg quality of some dual purpose chicken breeds. A total of 500 eggs (100 eggs from each breed) were collected to study for egg (weight, shape index), albumen (weight, percentage), yolk (weight, percentage) and shell (weight, percentage, thickness, strength) quality. The results showed that the egg weight and egg length of New Hampshire were significantly higher ($P < 0.05$) than that of Oravka whereas difference in egg shape index between these breeds was no significant ($P > 0.05$). Differences in albumen weight, albumen percentage, yolk weight and yolk percentage of tested dual purpose chicken breeds were statistically no significant ($P > 0.05$). Albumen height was significantly higher ($P < 0.05$) in New Hampshire compared with Plymouth Rock Buff and Sussex Light and Haugh unit score were significantly higher ($P < 0.05$) in New Hampshire compared with Oravka (Slovakian breed), Plymouth Rock Buff, Rhode Island and Sussex Light. The significantly ($P < 0.05$) higher values of yolk height and yolk index were detected in Oravka than New Hampshire, Plymouth Rock Buff, Rhode Island Red and Sussex Light. The shell weight and proportion were affected by the breed of hens ($P < 0.05$) but there were no significant differences ($P > 0.05$) in egg shell thickness and strength.

Keywords: breeds, laying chicken, shell eggs, egg quality

1 Introduction

Gardini and Villa (2003) recorded that local breed are an evidence of great achievement of many generations of breeding. For centuries farmers have been adapting chickens to local conditions, cultural needs and preferences.

Because of centuries of domestication and breeding, a wide range of chicken breeds exists today. However, an increasing number of local chicken breeds are under threat of extinction, and valuable genotypes and traits are at risk of being lost (Blackburn, 2006; Dávila et al., 2009).

In European countries, various governmental, nongovernmental, and private organizations try to preserve genetic diversity of livestock *in situ* (e.g., by stimulating the use of indigenous, rare breeds by farmers; in nature reserves; or in non-commercial farms). In the case of poultry, maintaining *in situ* populations of the non-commercial (fancy) breeds largely relies on hobby farmers. In addition to *in situ* conservation, gene banks are being established for *ex situ* conservation (Woelders et al., 2006; Anderle et al. 2014).

Egg quality is factor which contributes for better economy price of fertile and table eggs. Egg quality is factor which contributes for better economy price of fertile and table eggs (Kocevski et al., 2011). The egg quality parameters are under the influence of a number of factors and major one of which is the

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breed or variety of the observed chicken. From the point of view of consumers, egg weight is the most important quality trait. Among many quality characteristics, external factors including cleanliness, freshness, egg weight and shell weight are important in consumer's acceptability of shell eggs (Song et al., 2000; Adeogun and Amole, 2004; Dudusola, 2010). Shell strength is important for producers but also for consumers. Beside egg shell quality, maybe the most important marketing parameter is egg weight or egg size (Nikolova et al. 2014).

The internal quality of egg is very important from the consumers' point of view but it cannot be assessed without breaking the egg. The interior of hen´s egg consists of the yolk and white or albumen. Interior characteristics such as yolk index, Haugh unit and chemical composition are also important in egg product industry as the demand for liquid egg, frozen egg, egg powder and yolk oil increases (Scott and Silversides, 2001).

The present study was conducted to evaluate of external and internal egg quality of New Hampshire, Oravka (Slovakian breed), Plymouth Rock, Rhode Island Red and Sussex Light chicken breeds.

2 Material and methods

The study was performed in the laboratory of the Department of Poultry Science and Small Animal Husbandry at the Faculty of Agrobiology and Food Resources of Slovak University of Agriculture in Nitra.

The birds were kept in deep litter system with density 7 hens per m^2. During the egg production period, hens were fed *ad libitum* by a diet containing 158.06 g crude protein/kg and 11.32 MJ ME per kg feed.

The eggs were obtained at 40 weeks of age and data recorded on the same day of collection. A lighting schedule of 16 hours per day was applied during laying period. Standard procedure with respect to preventive vaccination and medication were followed during the study period.

Egg weight was individually determined to 0.01g accuracy using a laboratory scale Owa Labor (VEB Wägetechnik Rapido, Germany). Egg length (along the longitudinal axis) and egg width (along the equatorial axis) were measured with a micrometer. Egg shape index was calculated as the ratio of egg width to length (%) by the method of Anderson et al. (2004).

After the eggs were broken, egg shells were washed with water and dried in order to clean the remaining albumen. Following this procedure, shell weight (with membrane) was measured using a laboratory scale Owa Labor (VEB Wägetechnik Rapido, Germany) and the percentage proportion of the shell in the egg was determined.

Shell thickness (with membrane) was measured at the sharp poles, blunt poles and equatorial parts of each egg. Shell thickness was obtained from the average values of these three parts. The egg shell strength was determined manually using an Egg Crusher device (VEIT Electronics, Czech Republic).

The albumen weight was calculated from the difference between the egg weight, and the yolk and shell weight and the percentage proportion of the albumen in the egg was determined. Albumen index (%) was determined by the method of Alkan et al. (2010) on the basis of the ratio of the thick albumen height (mm) measurement taken with a micrometer to the average of width (mm) and length (mm) of this albumen with 0.01mm accuracy. Haugh unit score was calculated according to the procedure of Haugh (1937).

Yolk weight with 0.01 g accuracy was determined using the laboratory scale Owa Labor (VEB Wägetechnik Rapido, Germany) and its percentage proportion was calculated. Yolk index (%) was measured on the basis of the ratio of the yolk height (mm) to the yolk width (mm) by the method of Funk (1948) using micrometer with 0.01mm accuracy. Yolk colour was determined with the scale of Hoffman La Roche.

The evaluated variables were submitted to analysis of variance using Statistical Analysis System software package (SAS, 2003). The significance of differences ($P < 0.05$) among the chicken breeds was tested by the Duncan Multiple Range Test (Duncan, 1955) at the levels of significance.

3 Results and discussion

Present study showed significantly ($P < 0.05$) lower egg weight of Oravka in comparison with New Hampshire, followed by Sussex Light, Rhode Island Red, Plymouth Rock and New Hamsphire (Table 1). Zanon et al. (2006) published egg weight for local light Italian breeds Modenese and

Romagnolo (53.7 g and 54.0 g). For light breed Czech Golden Spotted Hen egg weight was balanced from 57.0 to 58.0 g (Anderle et al., 2014). For example, Turkish breeds Benizli and Gerze lay eggs with weight 53.94 and 54.30 g (Sarica et al., 2006). Hrnčár et al. (2015) found egg weight in heavy breeds Brahma (51.89 g), Cochin (51.56 g) and Orpington (52.24 g). In comparison, for game breed Aseel, Singh (2000) and Mohan et al. (2008) reported an average egg weight from 41 to 52 g.

Table 1 Effect of breed on egg parameters

Parameter/Breed	New Hampshire	Oravka	Plymouth Rock Buff	Rhode Island Red	Sussex Light
Egg weight (g)	58.69 ±3.64[a]	56.74 ±3.58	57.96 ±3.59	57.78 ±3.67	57.46 ±3.76
Egg length (cm)	5.83 ±1.14[a]	5.71 ±1.13	5.79 ±1.14	5.78 ±1.13	5.74 ±1.13
Egg width (cm)	4.34 ±1.08	4.27 ±1.07	4.31 ±1.10	4.32 ±1.09	4.29 ±1.07
Egg shape index (%)	74.44 ±0.44	74.78 ±0.35	74.43 ±0.31	74.74 ±0.36	74.73 ±0.38

Values shown are mean ± SD (standard deviation); [a] – indicates statistical significant difference among breeds ($P < 0.05$) for the same characteristics

We recorded a similar average egg shape index from 74.43 % for Plymouth Rock Buff to 74.78 % for Oravka (Table 1). A higher egg shape index (75.46 %) was reported by Singh (2000) for Aseel and Hanusová et al. (2015) for Oravka (75.71 %). Egg shape is influenced by genetic factors and individual traits, and is determined in the oviduct. The egg shape index ranges between 57 % and 92 %, but it is believed that values under and below 74 % are a cause for higher incidence of cracked and broken eggs (Narushin, 2005; Popova-Ralcheva et al., 2009).

Table 2 Effect of breed on egg albumen parameters

Parameter/Breed	New Hampshire	Oravka	Plymouth Rock Buff	Rhode Island Red	Sussex Light
Albumen weight (g)	34.87 ±3.85	33.07 ±3.68	34.23 ±3.88	34.12 ±3.79	33.86 ±3.71
Albumen percentage (%)	59.41 ±3.96	58.29 ±3.88	59.05 ±3.95	58.75 ±3.94	58.92 ±3.89
Albumen height (mm)	55.86 ±2.42[a]	55.07 ±2.46	54.72 ±2.39	55.11 ±2.44	54.96 ±2.36
Albumen width (mm)	78.25 ±0.78	78.63 ±0.65	78.06 ±0.68	78.48 ±0.72	78.19 ±0.74
Albumen index (%)	71.39 ±2.14[a]	70,04 ±2.08	70,09 ±2.13	70,22 ±2,09	70,29 ±2,11
Haugh units score	74.26 ±1.58[a]	73.69 ±1.63	73.54 ±1.49	73.80 ±1.54	73.82 ±1.59

Values shown are mean ± SD (standard deviation); [a] – indicates statistical significant difference among breeds ($P < 0.05$) for the same characteristics

As shown Table 2, albumen percentage of tested chickens breed was in interval from 58.29% (Oravka) to 59.41 % (New Hampshire). The weight of albumen is about 56–60 % of egg weight. This is an inherited trait, determined by numerous genes (Popova-Ralcheva et al., 2009). Anderle et al. (2014) reported albumen proportion for Czech Golden Spotted hens from 58.4 to 60.1 %. In the present study it has been observed that New Hampshire has significantly ($P < 0.05$) higher albumen height than Plymouth Rock Buff and Sussex Light. Haugh unit score were significantly higher ($P < 0.05$) in New Hampshire compared with Oravka, Plymouth Rock Buff, Rhode Island and Sussex Light. The difference in Haugh unit scores might be attributed to the differences in albumen height of observed birds which is in agreement with the results of Monira et al. (2003) who reported different albumen heights for different breeds, but Haunshi et al. (2011) observed non significant differences in Haugh unit score among Vanaraja and White Leghorn breeds of chickens.

Table 3 Effect of breed on egg yolk parameters

Parameter/Breed	New Hampshire	Oravka	Plymouth Rock Buff	Rhode Island Red	Sussex Light
Yolk weight (g)	17.83±1.68	17.93±1.66	18.07±1.64	18.23±1.68	17.58±1.64
Yolk percentage (%)	30.38±0.85	31.60±0.87	31.17±0.89	31.39±0.82	31.11±1.81
Yolk height (mm)	17.25±1.12	17.97±1.09[a]	17.12±1.14	16.73±1.07	17.02±1.11
Yolk width (mm)	41.26±0.68	40.98±0.59	41.22±0.64	41.14±0.67	40,96±0.55
Yolk index (%)	41.81±0.69	43.85±0,79[a]	41.53±0,75	40.67±0,61	41,55±0,69
Yolk colour (°LR)	9.65±0.95	9.74±0.91	9.49±0.99	9.57±0.88	9.51±0.93

Values shown are mean ± SD (standard deviation); [a] indicates statistical significant difference among breeds ($P < 0.05$) for the same characteristics

The present results in Table 3 showed that we found no significant difference in yolk weight and yolk percentage among chicken breeds. Oravka showed significantly ($P < 0.05$) higher yolk height and yolk index than New Hampshire, Plymouth Rock Buff, Rhode Island Red and Sussex Light. The yolk weight of chickens breed was from 17.58 g (Sussex Light) to 18.23 g (Rhode Island Red). Stahishevskaya and Toritisna (2007) published similar weight of yolk in local breeds 18.2 g, in Rhode Island 18.3 g and in Leghorns 17.4 g. In our study, we found yolk percentage from 30.38 % in New Hampshire to 31.60 % in Oravka. Anderle et al. (2014) reported yolk proportion for Czech Golden Spotted hens from 31.2 to 32.9 % and Zanon et al. (2006) found yolk proportion 34.69 % in Modenese and 32.35 % in Romagnolo. Haunshi et al. (2011) observed significant differences in the yolk index of different breeds of chickens. The colour of yolk was almost uniform in all studied pure chicken breeds, as the birds received the same compound poultry feed.

The weight, percentage, thickness and strength of egg shell are presented in Table 4. In shell weight and percentage we recorded significantly ($P < 0.05$) lower value for Rhode Island Red compared with New Hampshire Red and Oravka. There were no significant differences ($P > 0.05$) in egg shell thickness and strength among hens of New Hamsphire, Oravka, Plymouth Rock Buff, Rhode Island Red and Sussex Light.

Table 4 Effect of breed on egg shell parameters

Parameter/Breed	New Hampshire	Oravka	Plymouth Rock Buff	Rhode Island Red	Sussex Light
Shell weight (g)	5.99 ±0.33[a]	5.74 ±0.33[b]	5.67 ±0.32	5.43 ±0.33	5.73 ±0.34
Shell percentage (%)	10.21 ±0.65[a]	10.11 ±0.61[b]	9.78 ±0.62	9.40 ±0.60	9.97 ±0.64
Shell thickness (μm)	371.45 ±24.29	368.82 ±24.42	364.39 ±24.27	361.58 ±24.22	366.83 ±24.36
Shell strength (N cm^{-2})	30.44 ±5.52	29.81 ±5.39	29.27 ±5.48	30.18 ±5.53	29.51 ±5.49

Values shown are mean ± SD (standard deviation); [a, b] – indicates statistical significant difference among breeds ($P < 0.05$) for the same characteristics

Zanon et al. (2006) reported higher eggshell proportion for both Italian breeds Modenese and Romagnolo (12.88 and 13.29 %) compared with our experiment. The proportion of eggshell from the egg weight in Czech Golden Spotted hens ranged from 9.0 to 9.5 % (Anderle et al., 2014). Shell percentage can be use to estimate the eggshell quality (Mertens et al. 2006).

4 Conclusions

Based on obtained results can be concluded that in this study the breed affected some parameters of exterior and interior quality in pure chicken breeds. This effect is most pronounced in egg weight, egg length, quality of albumen (height, Haugh unit score) and yolk (height, index) and egg shell weight and percentage.

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