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QUALITY OF EGGS LAID AT DIFFERENT TIMES OF THE DAY BY HENS WITH DIFFERENT EGG PRODUCTION LEVELS

Józefa Krawczyk ✉, Joanna Obrzut

Department of Poultry Breeding, National Research Institute of Animal Production, 32-083 Balice near Kraków

ABSTRACT

The aim of the study was to assess the development of the quality of eggs laid at different times of the day by hens with low egg production (Green-legged Partridge strain Z-11) and higher egg production rates (Rhode Island White strain A-33). The research material consisted of eggs collected from these two breeds/strains of laying hens included in the conservation programme in Poland. During the 24–56 weeks of age, all eggs at 7:00, 10:00 and 13:00 h were collected every 4 weeks from each breed of hens from the same compartment and analysed for internal egg quality and egg shell quality. In addition, at 40 weeks of age for 3 days, 10 eggs each were collected at the aforementioned times of the day and sent to the Institute's Central Laboratory for chemical analysis of their yolks. In the study conducted, statistically significant differences were found for most physical and chemical egg quality traits between eggs derived from Green-legged Partridge hens (strain Z-11), an old native breed with low egg production rates, and eggs obtained from Rhode Island White hens (strain A-33) with much higher egg production rates. For most egg quality traits, there was no clear relationship with oviposition time.

Key words: egg quality, oviposition time, laying rate, native breeds of hens, Green-legged Partridge, Rhode Island White

INTRODUCTION

In the poultry sector, the production of table eggs is based on high-laying commercial hybrids, mainly of foreign origin, which has led to the reduction and even elimination of native or locally adapted populations of laying hens. One way to stop this phenomenon is to look for quality characteristics of products obtained from indigenous breeds that are beneficial to consumers. The quality of eggs is shaped by many genetic and environmental factors. The hens under study are breeds included in Poland's conservation programme, listed in the Red List of Threatened Species [FAO 2007]. Numerous studies have confirmed their biodiversity evident not only in the assessment of phenotypic traits, but also in the level of productivity and egg quality [Lewko et al. 2021, Krawczyk et al. 2021, Obrzut et al. 2021].

Some studies conducted on commercial hybrid hens show that egg weight, which determines other egg quality traits, and shell quality vary with genotype and age of hens, but also with oviposition time and egg production rate [Tůmová et al. 2007, Tůmová et al. 2009]. The oviposition time of the commercial hybrids most influences their egg weight, yolk percentage and shell strength. According to our previous studies, the egg quality and laying performance of native breed hens not under selection for improved productivity changes slightly differently under the influence of environmental factors compared to commercial hybrids [Krawczyk 2009, Obrzut et al. 2021, Krawczyk et al. 2023]. A study by Calik [2016] shows that also the chemical composition of eggs from native breeds of hens differs significantly compared to eggs obtained from commercial hybrids. On the other hand, Ianni et al. [2021] found significant differences in all egg quality traits obtained from native breed hens compared to commercial hybrids. Thus, it seems interesting to evaluate the development of the quality of eggs laid at different times of the day by hens differing significantly in the egg production level, i.e. Green-legged Partridge (Z-11) and Rhode Island White (A-33).

MATERIAL AND METHODS

The research material consisted of eggs collected in the years 2022–2023 from 2 breeds/strains of laying hens

✉ jozefa.krawczyk@iz.edu.pl

included in the conservation programme in Poland, i.e.: Green-legged Partridge (Z-11) and Rhode Island White (A-33). The birds were kept on an experimental farm, each strain in 4 compartments of 30 birds. The hens were kept on litter, at a stocking rate of 5 hens per m^2, and fed a complete feed mixture recommended for laying hens, with free access to water and feed (*ad libitum*). Chemical analysis showed that the feed mixture contained 92.31% dry matter, 11.63% crude ash, 15.33% crude protein, 3.09% crude fat, 3.15% crude fibre.

The hens started laying at 20 weeks of age. During the period from 24 to 56 weeks of age, all eggs were collected every 4 weeks from each breed of hen from the same compartment at 7:00, 10:00 and 13:00 h. The collected eggs were laid in a cold store, at a temperature of about 6–8°C, and their quality analysis was performed on the second day after collection. A total of 174 Z-11 eggs and 216 A-33 eggs were included in the study. The collected eggs were subjected to qualitative evaluation using an electronic EQM (Egg Quality Measurements) apparatus from TSS QCS-II. Egg shape index (%) was calculated by dividing egg length by egg width. Measurements were made to the nearest 0.5% with a Shape-Meter (B.V. Apparatenfabriek Van Doorn, De Bilt, The Netherlands), scaled 65–85%.

In addition, at 40 weeks of age for three days, 10 eggs each were collected at the above times of the day and sent to the National Research Institute of Animal Production's Central Laboratory for chemical analysis of their yolks. The eggs were taken to the Central Laboratory (a distance of about 150 m from the farm and egg storage area), 18 hours after the last collection, where they were placed in a refrigerator, at 4–5°C. Eggs were subjected to chemical analysis according to AOAC [1990] methodology 4 days after delivery.

Data were processed using Statistica 13.1 PL software. Mean values for all analysed parameters were calculated. A two-way model of ANOVA was used to analyse variability (variable 1: time of oviposition; variable 2: genotype). The significance of differences was verified using Duncan's test. Interactions between experimental variables were assessed. The significance of differences was set at $P \leq 0.05$ and $P \leq 0.01$.

RESULTS

In 2022, the average laying rate of Green-legged Partridge hens (Z-11) in the period 21–56 weeks was 152 eggs per hen and that of Rhode Island White hens (A-33) was 177 eggs per hen. The hens of the breeds studied start laying later than the high laying hens and at 20–23 weeks their laying rate is low (especially of the Z-11 breed). Therefore the study started at 24 weeks. Analysing the results of the chemical composition of egg yolks in the A-33 strain, statistically significantly lower levels of all analysed components were recorded compared to egg yolks from Z-11 hens (Table 1). In contrast, there were no significant differences in this respect between egg yolks laid at different times of the day with the exception of crude ash in eggs from Z-11 hens, which was found to be lower in egg yolks laid in the afternoon. A-33 hens laid eggs with a higher weight but lower Haugh units and lower yolk colour compared to eggs of Z-11 hens (Table 2). In the A-33 strain, yolks of eggs collected at

Table 1. Effect of hen genotype and oviposition time on the basic chemical composition (x ±SD) of egg yolk (%)

Genotype	n	Egg collection time (hour)	Dry matter,%	Crude ash, %	Crude protein, %	Crude fat, %	Total cholesterol content, mg · g^{-1}
Z-11	56	07:00	49.1 ±1.05	1.66 ±0.09 ^{a}	16.0 ±0.35	34.3 ±1.03	11.0 ±0.80
	39	10:00	49.5 ±0.54	1.59 ±0.09	16.0 ±0.33	34.6 ±0.35	11.5 ±0.42
	79	13:00	49.2 ±0.67	1.53 ±0.05 ^{b}	16.0 ±0.11	34.0 ±1.58	11.6 ±1.01
	174	Average	49.3 ±0.74**	1.59 ±0.09**	16.0 ±0.26**	34.3 ±1.04*	11.4 ±0.76**
A-33	53	07:00	48.2 ±0.45	1.49 ±0.03	15.4 ±0.43 ^{b}	33.2 ±1.34	9.9 ±0.31
	77	10:00	48.9 ±0.71	1.57 ±0.06	15.8 ±0.25 ^{a}	33.1 ±0.69	10.7 ±0.42
	86	13:00	48.0 ±0.43	1.48 ±0.08	15.6 ±0.27	33.4 ±0.59	10.4 ±0.53
	216	Average	48.6 ±0.67**	1.51 ±0.07**	15.6 ±0.36**	33.3 ±0.86*	10.4 ±0.53**
			Significance of differences (P value)				
Genotype			0.004	0.009	0.002	0.021	0.000
Collection time			0.108	0.070	0.304	0.949	0.105
Genotype × collection time			0.677	0.122	0.309	0.668	0.747

Explanations: Strains of hens: Green-legged Partridge (Z-11), Rhode Island White (A-33);
* differences significant at P < 0.05; ** – highly significant differences at P < 0.01;
Differences significant (a, b...) or highly significant (A, B...) between egg collection times, separately for each hen strain.

Table 2. Effect of hen genotype and oviposition time on egg content quality (x ±SD)

Genotype	n	Egg collection time (hour)	Egg weight, g	Albumen height, mm	Haugh units	Yolk weight, g	Yolk colour (points)
Z-11	56	07:00	56.3 ±6.27 [b]	8.10 ±1.35 [a]	90.4 ±7.50 [a]	16.8 ±1.94 [a]	9.23 ±1.35
	39	10:00	53.1 ±5.77 [a]	8.84 ±1.68 [b]	94.7 ±8.95 [b]	15.2 ±2.36 [b]	9.61 ±1.23
	79	13:00	55.6 ±6.54 [c]	8.53 ±1.38	92.7 ±7.68	16.3 ±2.31 [a]	9.04 ±1.46
Sum or average	174		55.3 ±6.37**	8.46 ±1.46	92.4 ±8.04*	16.2 ±2.28	9.23 ±1.39**
A-33	53	07:00	57.4 ±7.13	8.03 ±1.68	89.3 ±9.80	15.6 ±2.04	8.43 ±1.82 [a]
	77	10:00	59.4 ±6.66	8.32 ±1.50	90.6 ±8.30	16.3 ±2.34	9.06 ±1.70 [b]
	86	13:00	58.0 ±6.63	8.52 ±1.44	92.0 ±8.14	15.6 ±2.25	8.66 ±1.68
Sum or average	216		58.3 ±6.78**	8.33 ±1.52	90.8 ±7.50*	15.9 ±2.25	8.75 ±1.59**
			Significance of differences (P value)				
Genotype			0.000	0.205	0.025	0.314	0.000
Collection time			0.725	0.018	0.021	0.283	0.025
Genotype × collection time			0.010	0.371	0.240	0.000	0.556

For explanations, see Table 1.
Objaśnienia patrz tabela 1.

10:00 a.m. were characterized by better colour than those laid in the morning and afternoon. A greater influence of the time of oviposition on egg quality was observed among eggs from Z-11 layers. Eggs from these hens laid in the morning were characterized by higher total weight and yolk weight, but worse freshness parameters (albumen height and Haugh units) compared to those laid later (Table 2).

The shells of Z-11 eggs compared to A-33 were lighter, thinner, less dense and lighter in colour compared to A-33 eggs (Table 3). No statistically significant differences in crushing strength were confirmed between the eggs of the two breeds tested. Eggs from Z-11 hens from the morning collection were characterized by significantly greater shell weight and thickness compared to those collected later. Among eggs from A-33 hens, a significant effect of the time of laying on the quality of their shells was noted in terms of thickness, crushing strength and colour. Eggs from these hens laid in the morning were characterized by the greatest shell thickness and greater crushing strength and lighter colour compared to those collected later (Table 3).

Table 3. Effect of hen genotype and oviposition time on eggshell quality (x ±SD)

Genotype	n	Egg collection time (hour)	Shell weight, g	Shell thickness, mm	Shell density, mg · cm^{-2}	Crushing strength, N	Shell colour (points)
Z-11	56	07:00	5.77 ±0.61 [b]	0.314 ±0.03 [a]	78.1 ±8.32	45.6 ±11.8	67.1 ±7.98
	39	10:00	5.49 ±0.65 [a]	0.303 ±0.03 [b]	77.4 ±8.96	42.8 ±9.62	65.6 ±8.79
	79	13:00	5.79 ±0.63 [b]	0.305 ±0.02	78.6 ±6.73	42.7 ±11.4	67.0 ±9.94
Sum or aveage	174		5.72 ±0.63**	0.307 ±0.03**	78.2 ±7.77**	43.6 ±11.0	66.7 ±9.04**
A-33	53	07:00	6.01 ±0.77	0.324 ±0.03 [A]	80.5 ±8.60	45.8 ±12.3 [b]	47.1 ±18.6 [a]
	77	10:00	6.20 ±0.67	0.313 ±0.02 [B]	81.3 ±5.90	39.6 ±10.4 [a]	40.5 ±12.1 [b]
	86	13:00	6.12 ±0.70	0.313 ±0.02 [B]	82.4 ±7.63	42.1 ±11.9 [b]	42.8 ±15.5
Sum or aveage	216		6.12 ±0.71**	0.316 ±0.03**	81.5 ±7.33**	42.1 ±11.7	43.0 ±15.4**
			Significance of differences (P value)				
Genotype			0.000	0.000	0.000	0.325	0.000
Collection time			0.425	0.001	0.308	0.009	0.068
Genotype × collection time			0.029	0.904	0.721	0.493	0.280

For explanations, see Table 1.
Objaśnienia patrz tabela 1.

DISCUSSION

The present study investigated eggs from two hen breeds (Z-11 and A-33) that differed significantly in laying rate and egg weight. The Z-11 hens are an old native breed that has been under a conservation programme since the early 1970 s. The A-33 birds, on the other hand, are a maternal strain developed in the 1970s at the Duszniki pedigree farm, used there to produce commercial hybrids. In the A-33 strain, breeding work to improve productive traits only ceased in the late 1980s, after the birds were included in a conservation programme (www.bioroznorodnosc.izoo.krakow.pl/drob/kury). In this situation, the mean egg weight was significantly higher in the A-33 strain than in the Z-11, with a similar level of standard deviation. A similar difference was found between the hen strains studied in terms of the number of eggs collected every 4 weeks from a single compartment with equal numbers of birds, which was 42 eggs higher in the A-33 strain compared to Z-11. Calik and Obrzut [2023] note the greater stability of the mean egg weight of A-33 hens over five generations compared to other native hen breeds, which may be a result of longer breeding efforts in this bird population. Research suggests that modern commercial hybrid hens lay eggs with a higher and more even weight compared to the population of conservation breeds, which is undoubtedly the result of breeding work carried out on pedigree farms [Krawczyk 2009, Ianni et al. 2021, Nowaczewski et al. 2021]. Furthermore, in eggs from commercial hens, there is a high correlation between egg weight and albumen and yolk weight, which was not recorded among the eggs studied, but was confirmed, however, as in the study by Krawczyk and Calik [2018], by the high percentage of yolks in the eggs studied.

As shown in our previous studies, eggs from Green-legged Partridge hens are characterized by the lowest weight compared to the other breeds/strains of hens included in the conservation programme, which was also confirmed by the results of our data collected during the experiment [Krawczyk 2009, Krawczyk and Calik 2018, Kasperek et al. 2023]. Also Ianni et al. [2021] point out the lower egg and shell weight and the higher yolk percentage in hens of a native Italian breed compared to commercial hybrids. In our study, the lowest egg and yolk weights were found in eggs from Z-11 hens collected at 10:00 a.m., the opposite of the eggs from A-33 hens, which were heaviest at this time of collection. It is difficult to find an explanation for this situation in the literature, and the results of similar studies performed on different breeds of hens are inconclusive. The heaviest eggs from Z-11 hens were obtained from the morning collection at 7:00 a.m. and these results are consistent with those obtained by Tůmová et al. [2007] for eggs from laying hens, but opposite to those obtained by Tůmová et al. [2008] in a similar study on eggs from meat-type hens. In the presented study results, irrespective of the genotype of the hens, the thickest shell with the highest crushing strength was found in eggs collected at 7:00 a.m., and these results are consistent with those obtained by Tůmová et al. [2008]. In the study carried out, there was no clear relationship in the development of the other internal egg quality and shell quality characteristics depending on the time of oviposition. Also Tůmová et al. [2009] observed that the quality of eggs from hens of the indigenous Moravia breed differed significantly in most traits from eggs from commercial hybrids Hisex Brown and ISA Brown and did not show a significant dependence on the laying season, which is the case for commercial hybrids.

According to studies by Calik [2016] and Kasperek et al. [2023], the chemical composition of egg yolks is significantly influenced by the genotype of the hens. In the study by Calik [2016], similarly to the presented results, lower levels of all tested components except crude fat and cholesterol were found in eggs of A-33 hens compared to Z-11. The study also shows that the cholesterol levels in egg yolks of commercial crosses are similar to those of native breeds with the exception of Z-11 hens. Adequate levels of cholesterol in egg yolk are an essential component for proper development of the hen embryo and the correct course of many metabolic processes, although it is an undesirable component of the human diet, it is difficult to effectively reduce its content in egg yolks. In our study, lower levels of cholesterol were found in egg yolks from A-33 hens compared to Z-11, contradicting the opinion put forward by Calik [2016] that eggs from Z-11 hens have genetically determined lower cholesterol levels. Some authors have suggested that the lower levels of cholesterol in eggs are the result of dilution of cholesterol in eggs from higher laying hens [Ryś et al., 1996]. These studies suggest that the use of different nutritional additives in feed mixtures for laying hens has a significant effect on egg laying rates with a variable effect on yolk cholesterol, which varies with laying rate and increases with the age of the hens. In the work of Ryś et al. [1996], a decrease in cholesterol levels in egg yolks of Green-legged Partridge hens at 32–36 weeks of age was reported, and then an increase to higher levels compared to eggs from Hisex commercial hybrids. Kasperek et al. [2023] note significantly lower levels of cholesterol in the yolks of Green-legged Partridge eggs than in eggs from native Polbar hens. Also, Calik [2016] reported the lowest cholesterol levels in the egg yolks of Green-legged Partridge hens compared to 3 native hen breeds and a Hy-Line commercial hybrid. Ianni et al. [2021] reported lower but statistically insignificant cholesterol levels in eggs of native Italian breed hens compared with those of the commercial hybrid. The variable cholesterol levels in eggs of native breed hens is an interesting phenomenon and the study of this important egg quality trait for the human diet should continue to be investigated.

SUMMARY

The present study found statistically significant differences in most physical and chemical traits of egg quality between eggs from the old native breed of Green-legged Partridge hens (strain Z-11) with a low laying rate, and eggs obtained from Rhode Island White (strain A-33) hens with a much higher laying rate. A-33 hens laid eggs with a higher weight but lower Haugh units and lower yolk colour com-pared to eggs of Z-11 hens. There was no clear effect of time of oviposition over a 24-hour period on most egg quality traits.

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JAKOŚĆ JAJ ZNOSZONYCH O RÓŻNEJ PORZE DNIA PRZEZ KURY O ZRÓŻNICOWANYM POZIOMIE NIEŚNOŚCI

STRESZCZENIE

Celem badań była ocena kształtowania się jakości jaj znoszonych o różnych porach dnia przez kury o niskim poziomie nieśności (zielononóżka kuropatwiana ród Z-11) i większym poziomie nieśności (rhode island white ród A-33). Materiałem badawczym były jaja pobrane od tych dwóch ras/rodów kur nieśnych objętych w Polsce programem ochrony. W okresie 24–56. tygodniu życia co 4 tygodnie od każdego rodu kur z tego samego przedziału zbierano wszystkie jaja o godz. 7,00, 10,00 i.13,00, które następnie poddawano analizie oceny jakości treści i skorup. Ponadto w 40 tygodniu życia przez 3 dni zebrano po 10 jaj w ww. porach dnia i przekazano do Centralnego Laboratorium Instytutu do wykonania analizy chemicznej ich żółtek. W przeprowadzonych badaniach stwierdzono statystycznie istotne różnice w zakresie większości cech fizycznych i chemicznych jakości jaj między jajami pochodzącymi od starej rodzimej rasy kur, o niskiej nieśności, zielononóżka kuropatwiana (ród Z-11) a jajami uzyskanymi od kur o znacznie większej nieśności rhode island white (ród A-33). Dla większości cech jakości jaj nie odnotowano wyraźnej zależności od pory zniesienia jaj.

Słowa kluczowe: jakość jaj, pora znoszenia jaj, nieśność, rodzime rasy kur, zielononożka kuropatwiana, rhode island white

Józefa Krawczyk https://orcid.org/0000-0001-6494-3807
Joanna Obrzut https://orcid.org/0000-0002-8170-2105