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# EFFECT OF CHICKEN BREED AND STORAGE CONDITIONS OF EGGS ON THEIR QUALITY

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**Abstract.** The aim of the study was to assess the quality of eggs stored in different conditions for 28 days after oviposition. The eggs were produced by two breeds of hens covered by the gene-pool protection programme, and by commercial hybrids. The experiment used eggs from Greenleg Partridge (line Z-11) and Rhode Island White hens (line A-33) and Hy-Line commercial hybrids. Sixty class M eggs were collected from each breed and divided into three groups. Group I contained fresh eggs which were weighed and evaluated for quality on the first day after oviposition. In group II, eggs were stored in a cool room for 28 days at an average temperature of 14°C and humidity of 39–46%. Group III were eggs refrigerated for 28 days at an average temperature of 5.5°C and humidity of 29–36%. Regardless of bird's genotype, egg weight was found to decrease and egg yolk percentage to increase as a result of storing the eggs for 28 days. Storage of eggs contributed to decreasing the height of thick albumen and Haugh units (HU). Egg storage caused no significant changes in shell breaking strength. The effect of storage on reducing egg quality characteristics was much lower for Hy-Line hens compared to hens from the protected populations: Greenleg Partridge (Z-11) and Rhode Island White (A-33).

**Key words:** chicken, egg, quality, genotype, keeping quality

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## INTRODUCTION

Eggs are a staple human food due to their high nutritive quality and low price [Biesiada-Drzazga and Janocha 2009, Kijowski et al. 2013]. European Union regulations ensure that eggs are labelled with information concerning their quality and safety [Council Regulation (EC) No. 1028/2006]. One of the essential features of eggs is freshness, which in addition to price was the main criterion consumers used when purchasing eggs in the 1990s [Sokołowicz et al. 2008, Babicz-Zielińska and Zabrocki 2007]. Egg quality deteriorates with storage time and storage temperature [Kokoszyński et al. 2008, Batkowska and Brodacki 2014]. In other studies, this characteristic was also found to be influenced by the housing system and hen's genotype [Biesiada-Drzazga and Janocha 2009, Batkowska et al. 2014]. Eggs should stay fresh if marketed for not longer than 28 days after laying [Council Regulation (EC) No 589/2008], and this period is shown on a package of eggs as the date of minimum durability. It is also recommended to store eggs in a refrigerator. A questionnaire survey conducted by Trziszka et al. [2006] suggests that the main criteria consumers look at when buying eggs are their weight, freshness, and price. Analysis of the results of other studies [Babicz-Zielińska and Zabrocki 2007, Sokołowicz et al. 2008] demonstrates that this order of priority has not changed much over the years.

Egg quality traits are influenced by several factors that have been thoroughly tested under intensive production conditions and are generally well known [Biesiada-Drzazga and Janocha 2009, Kijowski et al. 2013]. Over recent years, consumers have shown an increasing interest in buying eggs from backyard systems [Sokołowicz et al. 2008], in which the use of native chicken breeds resistant to harsh and varying environmental conditions is recommended. These include Greenleg Partridge, the oldest native Polish breed, as well as those imported from abroad, which constitute a gene pool and recently have not been selected to improve productive traits (such as Rhode Island White, line A-33). Greenleg Partridge hens were recognized as a breed in the late 19th century, and due to their occurrence mainly in south-eastern Poland, they were called "Galician hens" [www.bioroznorodnosc.izoo.krakow.pl/drob]. They are characterized by low body weight (around 1700-1800 g), green legs, and grey, partridge-like plumage. Greenleg Partridge hens are very well adapted to extensive free-range conditions, but their egg production is low (56–60%). They produce tasty eggs with cream-coloured shells. The small weight of the eggs (around 56 g) is not uniform throughout the egg production period but they contain a high percentage of yolk. Under free-range conditions, the yolk of eggs from Greenleg Partridge hens acquires a yellow colour desired by the consumers [Krawczyk et al. 2011]. Greenleg Partridge hens are increasingly used in free-range and organic production systems, and their eggs are marketed at high prices. Rhode Island White A-33 hens are a maternal line that has been developed at the Layer Farm in Duszniki to create commercial hybrids of laying hens. In 2009, the line was covered by the gene-pool protection programme and moved to the Experimental Station of the National Research Institute of Animal Production in Chorzelów. Since then, the improvement of productive traits in this line has been discontinued. Line A-33 hens are white-feathered and weigh around 1700 g. Up to the 66th week of age, an average hen produces around 220 brown-shelled eggs weighing around 58 g [www.bioroznorodnosc.izoo.krakow.pl/drob].

In backyard farming it often happens that eggs are collected and stored in pantries for 1–2 weeks, after which they are distributed by direct sales. Marketed eggs are stored under different conditions, and due to their high price, Greenleg Partridge or organic eggs are bought in small quantities, which extends their shelf storage time. It is therefore interesting to examine the quality of eggs stored for 28 days not only in a refrigerator but also in cool room conditions. Furthermore, earlier findings suggest that fresh eggs from native breeds of chickens are significantly different in terms of many characteristics compared to eggs from commercial hybrids [Krawczyk 2009].

The aim of the study was to assess the quality of eggs, stored in different conditions for 28 days after oviposition, which were laid by two breeds of hens covered by the gene-pool protection programme and by commercial hybrids.

## MATERIAL AND METHODS

The experiment used eggs from hens covered by the gene-pool protection programme: Greenleg Partridge (line Z-11) and Rhode Island White hens (line A-33), and from Hy-Line Brown commercial hybrids. Hens were kept on litter under standard environmental conditions for laying hens and fed ad libitum complete diet with energy content of 11.4 MJ, which contained: CP 17%; Lys 0.80%; Met 0.38%. At 36 weeks of age, 60 class M eggs (53–63 g) were collected from each layer population and divided into three groups of 20. In group I, eggs were weighed and assessed for quality on the first day after oviposition. In group II, eggs were stored in a cool room for 28 days at an average temperature of 14°C and humidity of 3–46%. Group III were eggs refrigerated (as recommended on packages sold in shops) at an average temperature of 5.5°C and humidity of 29–36%. Interior egg and shell quality in groups II and III was evaluated after 28 days of storage using EQM system (Egg Quality Measurements by TSS, Technical Services and Supplies Limited, York, UK) and TA XT Plus Texture Analyser (Stable Micro System). The evaluated egg traits were: weight of eggs, yolks, albumens and shells; percentage egg yolk and albumen; albumen height and Haugh units (HU); shell thickness, density and breaking strength.

The results were statistically analysed with Statgraphics 5.0 using one-factorial analysis and Duncan's test to calculate arithmetic means, standard deviations, and significant differences.

## RESULTS AND DISCUSSION

Due to evaporative water loss resulting from the increasing egg storage period and ambient temperature, egg weight decreases and its class may have to be changed and price reduced. The effect of storage on total egg weight and yolk weight was smallest for A-33 hens and greatest, with a significant difference ($P \leq 0.01$), for Z-11 hens (Table 1).

A characteristic feature of eggs from Greenleg Partridge hens (Z-11) is their low weight, which in the present study decreased the most during storage compared to eggs from Rhode Island White hens (A-33) and Hy-Line commercial hybrids. In group II, 28 days after oviposition egg weight loss in Greenleg Partridge hens was 5.6%, as a result of which the eggs hardly fell within class M. The considerable weight loss in Greenleg Partridge eggs may be attributed to the least favourable ratio of shell area to egg weight, because the eggs from this breed were the lightest. For Yellowleg Partridge hens (a breed originating from Greenleg Partridges), Calik [2013] reported the identical weight loss for eggs stored for 21 days at around 16°C as in group II. In turn, weight loss in Z-11 eggs refrigerated for 28 days was 2.6 g, i.e. 1.7 g more than the result obtained by Calik [2013] for eggs stored in similar conditions but for a shorter period of 21 days. In the case of eggs from A-33 hens and Hy-Line commercial hybrids, egg weight loss during storage was small in both groups (around 1 g), i.e. 2.2 g lower than the value reported by Batkowska and Brodacki [2014], who stored eggs in rooms at slightly higher temperature and humidity. Jin et al. [2011] confirmed a highly significant relationship between an increase in storage temperature of eggs and a decrease in their total weight. Decreases in egg weight during storage were also reported by Silversides and Scott [2001], Silversides and Budgell [2004], Yilmaz and Bozkurt [2009]. As reported by Caner [2005], egg weight loss during storage is caused by the loss of water and carbon dioxide through eggshell pores. The same author indicates that the rate at which egg weight decreases is influenced by storage temperature, number of pores per shell, and the rate at which eggshell mucin disappears. In turn, Yilmaz and Bozkurt [2009] showed a correlation between egg size and rate of egg weight loss during storage.

The decrease in egg weight occurred as a result of evaporative loss of water, which constitutes 88% of egg content. This relationship is confirmed by other authors for hens [Jin et al. 2011, Calik 2013, Batkowska et al. 2014] and guinea fowl [Banaszewska et al. 2015]. Albumen weight in fresh eggs from Hy-Line hens was

Table 1. Interior egg quality of Greenleg Partridge (Z-11), Rhode Island White (A-33) and Hy-Line Brown hens (x ±SD) depending on storage conditions

Tabela 1. Jakość treści jaj kur zielononóżka kuropatwiana (Z-11), rhode island white (A-33) i Hy-Line Brown (x ±SD) w zależności od warunków przechowywania

| Item<br>Wyszczególnienie | Hen genotype (line) or name of commercial hybrid<br>Genotyp kur (symbol rodu) lub nazwa mieszańców towarowych | Storage time, days<br>Czas przechowywania, dni | | |
|---|---|---|---|---|
| | | 0<br>(x ±SD) | 28<br>cold room<br>chłodny pokój<br>(14–16°C)<br>(x ±SD) | 28<br>refrigerator<br>chłodziarka<br>(4–5°C)<br>(x ±SD) |
| Weight of egg, g<br>Masa jaja, g | Z-11 | 56.79 ±2.21 B | 53.52 ±1.86 A | 54.08 ±1.26 A |
| | A-33 | 57.77 ±2.56 | 55.99 ±2.87 | 56.85 ±238 |
| | Hy-Line Brown | 60.47 ±1.11 b | 59.04 ±1.59 a | 59.79 ±0.96 ab |
| Weight of yolk, g<br>Masa żółtka, g | Z-11 | 16.27 ±0.83 a | 18.11 ±2.26 b | 16.44 ±1.63 a |
| | A-33 | 16.18 ±1.12 | 16.21 ±1.11 | 16.61 ±1.19 |
| | Hy-Line Brown | 16.15 ±0.68 | 16.49 ±1.58 | 16.39 ±1.28 |
| Weight of albumen, g<br>Masa białka, g | Z-11 | 34.48 ±1.91 c | 29.29 ±2.64 b | 31.43 ±2.11 a |
| | A-33 | 34.94 ±1.99 b | 32.93 ±2.22 a | 33.23 ±1.89 a |
| | Hy-Line Brown | 37.90 ±1.12 b | 36.29 ±1.37 a | 37.04 ±1.25 ab |
| Egg albumen content, %<br>Zawartość białka w jaju, % | Z-11 | 61.15 ±1.65 aD | 54.71 ±4.46 bE | 58.09 ±3.23 c |
| | A-33 | 62.26 ±1.82A | 58.79 ±1.83B | 58.52 ±1.76 B |
| | Hy-Line Brown | 62.67 ±1.08 | 61.05 ±2.49 | 61.96 ±2.06 |
| Zawartość żółtka w jaju, %<br>Egg yolk content, % | Z-11 | 28.69 ±1.34 A | 33.83 ±4.11 B | 30.40 ± 3.20 A |
| | A-33 | 27.28 ±1.87 b | 28.96 ±1.85 a | 29.14 ±1.76 a |
| | Hy-Line Brown | 26.74 ±1.20 | 27.91 ±2.23 | 27.40 ±2.02 |
| Wysokość białka, mm<br>Albumen height, mm | Z-11 | 7.65 ±0.94 B | 4.43 ±0.95 A | 4.78 ±0.67 A |
| | A-33 | 8.10 ±1.26 C | 4.26 ±0.68 B | 6.19 ±0.96 A |
| | Hy-Line Brown | 10.50 ±0.95 cB | 7.87 ±0.71 bA | 8.70 ±0.75 aA |
| Jednostki Haugha<br>Haugh units | Z-11 | 87.99 ±5.45 B | 65.09 ±10.39A | 68.67 ±6.07 A |
| | A-33 | 90.08 ±6.30 C | 62.72 ±7.00 B | 78.45 ±7.03 A |
| | Hy-Line Brown | 101.1 ±4.11 cB | 88.72 ±4.19bA | 93.0 ±3.83 aA |

a, b, c – significant differences at $P \leq 0.05$; A, B, C – highly significant differences at $P \leq 0.01$; Z-11 – native breed, developed in Poland; A-33 – Rhode Island White, imported from abroad, currently covered by the gene-pool protection programme; Hy-Line Brown – interstrain hybrid.
a, b, c – różnice istotne przy $P \leq 0,05$; A, B, C – różnice wysokoistotne przy $P \leq 0,01$; Z-11 – rasa rodzima, wytworzona w kraju; A-33 – ród rhode island white, pochodzący z hodowli zagranicznej, aktualnie objęty programem ochrony zasobów genetycznych kur; Hy-Line Brown – mieszaniec międzyrodowy.

37.9 g, which accounted for 62.67% of egg weight (Table 1). A similar weight of albumen in eggs from intensively raised commercial hybrids was observed by Biesiada-Drzazga and Janocha [2009]. After 28 days of storage, albumen weight loss in eggs from Z-11 and A-33 hens was 2–3 g, similar to the study of Batkowska et al. [2014], and in Hy-Line commercial hybrids it was just 0.86 g for refrigerated eggs and 1.61 g for eggs stored in a cool room. For this reason, after 28 days of storing the eggs from Z-11 and A-33 hens, egg albumen percentage also decreased, whereas in Hy-Line hens these differences were small and statistically not significant. This pattern of albumen weight during storage of eggs from Hy-Line hens could have been influenced by their thicker shell compared to the eggs from Z-11 and A-33 hens (Table 2).

After 28 days of storage in different conditions (groups II and III), eggs from heritage breed hens (Z-11 and A-33) had a higher yolk percentage in total egg weight compared to Hy–Line commercial hybrids ($P \leq 0.01$ or $P \leq 0.05$). Yolk weight of eggs from A-33 and Hy-Line hens remained at a similar level regardless of storage conditions, and in Z-11 hens from group II it was even significantly higher than in fresh eggs and in refrigerated eggs ($P \leq 0.05$), which is consistent with the findings of Banaszewska et al. [2015] obtained for guinea fowl eggs. As observed by Roberts [2004], during storage membranes surrounding the yolk are weakened, which allows water to move from albumen to yolk, thus increasing its size. Likewise, Batkowska et al. [2014] found yolk weight to increase by 3.37 g in eggs stored for 28 days and produced by Hy-Line commercial layers. According to King'ori [2012], prolonged storage of eggs damages the vitelline layer, which causes water to move from albumen to yolk, thus increasing its weight and triggering the incidence of spots which vary in colour.

Egg quality is at risk of deterioration with increasing storage time and storage temperature, which is also supported by the present study. Freshness of eggs can be assessed by measuring air cell size, and after breaking out, albumen height and Haugh units are the main measurable indicators of this trait. The higher the albumen and HU value, the fresher the egg is, and this characteristic is mainly influenced by storage conditions. Regardless of bird's genotype, egg weight after 28 days of storage decreased by 2.12 mm in group III (refrigerator) and by 3.23 mm in group II (cool room). Silversides and Budgell [2004] maintain that a decrease in the height of thick albumen due to storage time is associated with proteolysis of ovomucin, cleavage of disulfide bonds, interactions with lysozyme, and changes in the interaction between $\alpha$- and $\beta$-ovomucin. The decrease in albumen height and HU was highest in eggs from hens of the native breed Z-11 and lowest in Hy-Line commercial hybrids. These results are in line with those of other authors. After storing eggs from hens of the native breed Yellowleg Partridge for only 21 days, Calik [2013] found albumen height to decrease by 1.82 mm for eggs stored at 6°C and by 3.95 mm for eggs stored in a warm room (21°C). In turn, Kokoszyński et al. [2008], who refrigerated eggs from Hy-Line commercial hybrids for 21 days, observed, similar to the present study, a small decrease in albumen height and HU (0.8 mm and 6.1, respectively). Also the findings of Jin et al. [2011] confirm the highly significant relationship between increasing egg storage temperature and decreasing HU. According to Caner [2005], Haugh units for good quality consumable eggs should exceed 70. This shows that in the present study, the quality of eggs from Greenleg Partridge hens considerably deteriorated during storage.

Table 2. Shell quality of class M eggs from Greenleg Partridge (Z-11), Rhode Island White (A-33) and Hy-Line Brown hens (x ±SD) depending on storage conditions

Tabela 2. Jakość skorup jaj klasy M kur zielononóżka kuropatwiana (Z-11), rhode island white (A-33) i Hy-Line Brown (x ±SD) w zależności od warunków przechowywania

| Item<br>Wyszczególnienie | Hen genotype (line) or name of commercial hybrid<br>Genotyp kur (symbol rodu) lub nazwa mieszańców towarowych | Storage time, days<br>Czas przechowywania, dni | | |
|---|---|---|---|---|
| | | 0<br>(x ±SD) | 28<br>cold room<br>chłodny pokój<br>(14–16°C)<br>(x ±SD) | 28<br>refrigerator<br>chłodziarka<br>(4–5°C)<br>(x ±SD) |
| Shell thickness, µm<br>Grubość skorupy, µm | Z-11 | 327 ±32 | 334 ±20 | 338 ±21 |
| | A-33 | 353 ±31 | 332 ±40 | 332 ±20 |
| | Hy-Line Brown | 361 ±21 | 364 ±24 | 368 ±24 |
| Shell strength, N<br>Wytrzymałość, N | Z-11 | 42.65 ±10.90 | 48.10 ±8.04 | 49.55 ±7.49 |
| | A-33 | 43.34 ±11.38 | 45.54 ±12.72 | 41.64 ±8.47 |
| | Hy-Line Brown | 40.99 ±13.18 | 40.99 ±13.18 | 44.93 ±7.74 |
| Weight of shell, g<br>Masa skorupy, g | Z-11 | 6.04 ±0.45 | 6.12 ±0.39 | 6.21 ±0.41 |
| | A-33 | 6.65 ±0.54 | 6.85 ±0.65 | 7.01 ±0.42 |
| | Hy-Line Brown | 6.42 ±0.34 | 6.26 ±0.45 | 6.36 ±0.28 |
| Shell density, mg · $cm^{-2}/cm^2$<br>Gęstość skorupy, mg · $cm^{-2}/cm^2$ | Z-11 | 74.21 ±7.94 B | 88.55 ±8.64 A | 90.36 ±6.64 A |
| | A-33 | 81.72 ±6.87 B | 93.17 ±9.50 A | 93.51 ±6.64 A |
| | Hy-Line Brown | 82.35 ±4.51 | 82.17 ±8.19 | 83.07 ±4.15 |

For explanations, see Table 1.
Objaśnienia pod tabelą 1.

Regardless of bird's genotype, the physical properties of the shell from both fresh and stored eggs were at a level typical of eggs from hens kept under standard rearing conditions [Krawczyk 2009, Biesiada-Drzazga 2009]. After 28 days of storage, no significant changes were found in shell quality in the group of Hy-Line commercial hybrids, whereas in Z-11 and A-33 hens shell density increased ($P \leq 0.05$), but this had no effect on shell breaking strength (Table 2). During the storage, changes in shell weight of eggs from both protected breeds were small and statistically not significant. Meanwhile, the study of Yilmaz and Bozkurt [2009] shows that with an increasing egg storage time, shell weight gradually decreases but its density increases. It should be noted that in the populations of hens covered by the gene-pool protection programme, breeding work to improve productive traits, including egg quality, has been terminated many years ago, which means that the eggs from these hens differ in many aspects from those of highly productive commercial hybrids [Krawczyk 2009].

## CONCLUSIONS

1. Regardless of bird's genotype, egg weight was found to decrease and egg yolk percentage to increase as a result of 28-day storage of the eggs.
2. Storage of eggs contributes to a deterioration in thick albumen quality, as reflected in the decrease in the height of thick albumen and Haugh units.
3. Storage of eggs caused no significant changes in shell breaking strength.
4. The rate at which eggs of Greenleg Partridge (line Z-11) and Rhode Island White (line A-33) hens age during 28 days of both refrigerated and cold room storage is higher compared to that in commercial hybrids used for intensive production of consumable eggs.

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## WPŁYW RASY KUR I WARUNKÓW PRZECHOWYWANIA JAJ NA ICH JAKOŚĆ

**Streszczenie.** Celem badań była ocena jakości jaj przechowywanych w różnych warunkach przez 28 dni od zniesienia, a pochodzących od dwóch ras kur objętych programem ochrony zasobów genetycznych i mieszańców towarowych. Materiał badawczy stanowiły jaja pochodzące od kur zielononóżka kuropatwiana (ród Z-11) i rhode island white (ród A-33) oraz mieszańców towarowych Hy-Line. Od każdej rasy pobrano po 60 jaj w klasie wagowej M, które podzielono na trzy grupy. Grupę I stanowiły jaja świeże, które na drugi dzień po zniesieniu zważono i poddano ocenie jakości. W grupie II jaja przechowywano przez 28 dni w chłodnym pomieszczeniu o średniej temperaturze 14°C i wilgotności powietrza 39-46%. Grupę III stanowiły jaja przechowywane w chłodziarce przez 28 dni, w średniej temperaturze 5,5°C i wilgotności 29-36%. Stwierdzono, że w wyniku 28-dniowego przechowywania jaj, bez względu na genotyp kur ulega zmniejszeniu masa jaj a zwiększa się procentowy udział żółtka w jajach. Przechowywanie jaj wpływa na obniżenie wysokości białka gęstego oraz wartości jednostek Haugha (jH). Przechowywanie jaj nie spowodowało istotnych zmian w zakresie wytrzymałości skorup na zgniecenie. Stwierdzono znacznie mniejszy wpływ przechowywania na obniżanie się cech jakość jaj od kur Hy-Line w porównaniu z jajami od kur populacji chronionych tj. zielononóżka kuropatwiana (Z-11) i rhode island white (A-33).

**Słowa kluczowe:** kura, jajo, jakość, genotyp, zdolność przechowalnicza

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